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Management of imidazolinone-tolerant (IT) rice in drill- and water-seeded rice

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MANAGEMENT OF IMIDAZOLINONE TOLERANT (IT) RICE IN DRILL- AND WATER-SEEDED RICE

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ABSTRACT

Field studies were conducted over two years in drill- and water-seeded rice to evaluate weed control and crop response with imazethapyr programs. Barnyardgrass [*Echinochloa crus-galli* (L.) Beauv.] was evaluated with imazethapyr applied alone at various rates and timings. Imazethapyr controlled barnyardgrass 95 to 97% with a soil application at 87 or 70 g/ha fb 53 or 70 g/ha EPOST or LPOST. A single EPOST application of imazethapyr at 140 g/ha controlled barnyardgrass and rice yield was equal to or above those treatments receiving two applications of imazethapyr. Research was also conducted at Crowley, LA and Rayne, LA to evaluate the addition of a herbicide with broadleaf activity into imazethapyr programs applied alone early postemergence (EPOST) and in combination with imazethapyr postemergence (POST). Weeds evaluated included barnyardgrass, red rice (*Oryza sativa* L.), alligatorweed [*Alternanthera philoxeroides* (Mart.) Griseb.], and hemp sesbania [*Sesbania exaltata* (Raf.) Rydb. ex A.W. Hill]. Treatments consisting of imazethapyr applied at 87 g/ha alone to the soil fb a POST imazethapyr application at 53 g/ha controlled barnyardgrass above 90% late season in all studies, expect in water-seeded rice when an imazethapyr application was made at the three- to four-leaf rice stage. Red rice control with a total imazethapyr program was equivalent to, or higher, than other treatments in both drill- and water-seeded studies. Single imazethapyr applications resulted in reduced control of red rice indicating two applications of imazethapyr are required to obtain adequate control. Alligatorweed control increased with soil applications of imazethapyr. However, alligatorweed control with imazethapyr as the only herbicide in a weed control program was inconsistent and suggested only suppression. Treatments receiving a broadleaf herbicide application increased hemp sesbania control as compared with the total imazethapyr program; however, treatments with bensulfuron and triclopyr were inconsistent at controlling hemp sesbania. In drill-seeded studies, hemp sesbania was less of a problem and red rice had a greater impact on rice yield. Rice yields with total imazethapyr programs were equal to, or higher than, other treatments. However, in water-seeded studies, hemp sesbania growth was favored and yields from rice treated with broadleaf herbicides were higher than total imazethapyr programs.

CHAPTER ONE

INTRODUCTION

Rice (*Oryza sativa*) is a staple source of nutrition for half of the world's population (Anonymous 2000). In the United States, rice cultivation occurs in Arkansas, California, Louisiana, Mississippi, Missouri, and Texas. A total of 478,333 acres of rice was planted in Louisiana in 2000 and over half of the acreage was located in south Louisiana[1].

In order to maximize rice yields and achieve the best economical return, producers use integrated weed management programs that are best accomplished through the use of cultural, mechanical, and chemical practices (Jordan and Sanders 1999). The most common weeds in South Louisiana are barnyardgrass [*Echinochloa crus-galli* (L.) Beauv], broadleaf signalgrass [*Brachiaria platyphylla* (Griseb.) Nash], red rice (*Oryza satvia* L.) hemp sesbania [*Sesbania exaltata* (Raf.) Rydb. Ex A.W. Hill], alligatorweed [*Althernanthera philoxeroides* (Mart.) Griseb.], spreading dayflower (*Commelina diffusa* L.), ducksalad [*Heternanthera limosa* (Sw.) Willd.], and Indian jointvetch (*Aeschynomene indica* L.)

Barnyardgrass, a highly competitive weed in rice, is common throughout the world (Smith 1988). In Arkansas, season-long competition from barnyardgrass and red rice reduced rice grain yields more than other rice weeds including broadleaf signalgrass, ducksalad, hemp sesbania, and spreading dayflower. Stauber et al. (1991) reported barnyardgrass competition reduced 'Lemont' and 'Newbonnet' rice grain yields by 301 and 257 kg/ha, respectively.

Propanil [N-(3,4-dichlorophenyl) propanamide] has been the most prominent herbicide used for control of barnyardgrass in rice

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[1] Saichuk, J. K. 2001. Personal Communication.

production (Smith 1974). It is a broad-spectrum postemergence herbicide labeled for use in rice in 1961 (Ahrens 1994), and selects between grasses and rice based on physiological processes (Baltazar and Smith 1994). Predominantly in the southern U.S., barnyardgrass was controlled by a standard treatment of propanil applied at 3.4 kg/ha postemergence (POST) (Smith 1974). However, resistant barnyardgrass was reported in Arkansas in 1989 (Baltazar and Smith 1994), and confirmation was made in Mississippi, Texas, and Louisiana (Carey et al. 1995).

The most troublesome weed to south Louisiana rice producers is red rice. It is considered the same species as white rice (Hoagland and Paul 1978). Although no differences have been seen in nutritional value between red rice and other rice cultivars, there are some distinguishable characteristics (Diarra et al. 1985a). Red rice grain varies from a deep red to pink color, and the kernels are brittle and easily shatter during the milling process. Red rice tillers profusely, produces greater biomass, and grows significantly taller compared with commercial rice (Diarra et al. 1985a; Noldin et al 1999a). Kwon et al. (1992) reported that average red rice heights were 25 and 38% taller than common rice cultivars Newbonnet and Lemont, respectively. These traits aid red rice in survival and dispersal (Constantin 1960; Noldin et al 1999a). Seeds of red rice can remain dormant in the soil for up to 12 years (Goss and Brown 1939).

As early as 1846, red rice was considered a weed in rice (Dodson 1900). It was recognized as one of the most problematic weeds in several rice producing states in 1993 (Dowler 1994). Navarro (1985) reported that red rice densities of 4, 16, 32, and 300 m^{-2}, rice cultivar yield was decreased by 20, 43, 57, and 91% respectively. Since rice cultivars and red rice are both recognized as *Oryza* sativa, there are few options available in commercial rice for control of red rice. Herbicide options are restricted to molinate (*S*-ethyl hexahydro-1*H*-azepine-1-carbothioate) (Know et al. 1988; Smith 1981). Initial programs were designed to partially control red rice through the use of molinate in addition to cultural practices such as water-seeding rice, where pin-point flood water management can be implemented. Preplant incorporated (PPI) applications of molinate in water-seeded rice production has been shown to suppress red rice. Molinate evaluated four weeks after a preplant incorporated treatment suppressed red rice 92 to 100%; however, rice cultivars were injured 39 to 63% (Noldin 1999b). Options are more limited in drill-seeded rice.

Rotation to glyphosate [*N*-(phosphonomethyl)glycine]-resistant soybean has been the most successful tool for control of red rice; however, results can be inconsistent (Askew et al. 2000; Khodayari et al. 1987) Some researchers suggest that red rice control can be obtained with low rates of glyphosate using Roundup Ready® soybeans (Guy 1996), but since glyphosate provides no residual activity, it is not effective in providing season-long control (Askew et al 1998). Due to the confirmation of propanil resistant-barnyardgrass and the difficulty in controlling red rice, producers are now searching for new herbicides to combat this problem.

In 1993, Dr. Tim Croughan of the Louisiana State University AgCenter Rice Research Station developed a rice plant that exhibited tolerance to the imidazolinone herbicide family (Croughan 1994). Since rice lines were developed through seed mutatgenesis, they are considered nontransgenic. Imidazolinone herbicides inhibit the enzyme acetolactate synthase (ALS, E.C. 4.1.3.18) (Stidham 1991) and are favored globally due to their low use rates, broad spectrum weed control, low toxicity to mammals, and low environmental impact (Hartnett et al. 1993; Saari et al. 1994).

Imazethapyr {(±)–2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid} is a weak acid belonging to the imidazolinone family of herbicides that has been selected for use in imidazolinone-tolerant (IT) rice (Wepplo 1991). Imazethapyr is readily absorbed through roots and foliage making it ideal for preplant incorporated (PPI), preemergence (PRE), or postemergence (POST) applications (Cantwell et al. 1989). Imazethapyr POST controls existing susceptible weeds while enhancing the control of weeds germinating later in the season (Hart et al. 1991). It is registered for use in soybean [*Glycine max* (L.) Merr] and peanut (*Arachis hypoaea* L.) to control grass and broadleaf weed species (Cantwell et al. 1989; Grichar 1994).
With the introduction of IT rice and the use of imazethapyr, producers will have an effective management tool for controlling barnyardgrass and red rice while maximizing rice yield potential (Dillon et al. 1999; Liscano et al. 1999; Masson and Webster 2001).

Prior to the introduction of IT rice, Noldin et al. (1999b) conducted a study to evaluate the sensitivity of several rice cultivars and red rice ecotypes to imazethapyr. ‘Mars’ and ‘Maybelle’ rice were injured 80 to 88% with imazethapyr at 70 g/ha postemergence (POST) while red rice control was 71 to 84%. Preliminary research conducted on IT rice reported injury, 16 to 48% with the use of imazethapyr applied POST at 70, 105, 140 and 175 g/ha (Steele et al. 1999). Sanders et al. (1998) reported 30% rice injury with sequential post-flood treatments of imazethapyr. Field applications of imazethapyr at the two- to three-leaf stage in a drill-seeded and at rice pegging in water-seeded rice, injured rice less than 16% (Masson and Webster 2001; Webster and Masson 2001). Several other researchers have reported less than 5% injury from imazethapyr applications to IT rice (Kendig et al. 2001; Levy et al 2001; Masson et al. 2001). As new IT rice lines are continually being developed, injury continues to decrease compared with earlier IT lines.

Research conducted in Tennessee indicated that application timing of imazethapyr was more essential than rate for controlling susceptible weeds in soybean (Harrison et al. 1989). Imazethapyr applied at less than 70 g/ha controlled barnyardgrass and seedling johnsongrass [*Sorghum halepense* (L.) Pers.] 90% or better, but only when weeds were treated at the one-leaf stage (Klingaman et al. 1992).

In rice, imazethapyr at 70 g/ha PRE controlled propanil-resistant and propanil–susceptible barnyardgrass, and broadleaf signalgrass greater than 97% (Scherder et al. 2001). Soil applications of imazethapyr at 70 and 87 g/ha controlled red rice less than 30% (Kurtz and Street 1999). Researchers in Missouri observed that as rates of soil applied imazethapyr increased from 70 to 140 g/ha, control of barnyardgrass and red rice increased from approximately 60 to 90% (Kendig et al. 2000; Ohmes et al. 2001). Masson et al. (2001) reported 90 to 93% barnyardgrass control with PPI and PRE applications of imazethapyr at 140 g/ha.

Early season red rice control was less than 82% with single surface and single POST applications of imazethapyr at rates varying from 70 to 175 g/ha (Steele et al. 1999). Research in four rice producing states indicated that grass control with imazethapyr applied to the soil was less than foliar applications, but a single POST application has been reported to be inconsistent (Hackworth et al. 1998). Webster and Masson (2001) reported imazethapyr applied at 70 and 140 g/ha on two- to three-leaf grasses controlled barnyardgrass 24 and 31%, respectively. A second study resulted in 93% control with imazethapyr applied at 140 g/ha on two- through four-leaf barnyardgrass but a reduction in control was observed with applications made to four- to five-leaf barnyardgrass (Masson et al. 2001).

Sequential POST applications of imazethapyr at a reduced rate of 35 g/ha resulted in red rice control below 80% (Ohmes et al. 2001), but a single soil application of imazethapyr at 70, 105, and 140 g/ha fb a POST application at 70 g/ha on two- to three-leaf rice controlled barnyardgrass 88 to 96% in water-seeded rice (Masson and Webster 2001). Preliminary studies reported that sequential applications of imazethapyr would be required for effective control of barnyardgrass (Liscano et al. 1999) and red rice (Dillon et al. 2001), especially with high weed populations (Webster and Masson 2001). Soil moisture may also impact weed control in IT rice production. Zhang et al. (2001) reported saturated soils at 50% moisture following imazethapyr PPI reduced control of barnyardgrass and red rice compared with 13 to 25% soil moisture but control with imazethapyr POST was not influenced by soil moisture.

Previous research has demonstrated the efficacy of imazethapyr on grass weed species particularly barnyardgrass [*Echinochloa crus-galli* (L.) Beauv.] and red rice (*Oryza sativa* L.); however, imazethapyr alone is not considered a complete weed control program in IT rice due to the lack of control of some weeds such as ducksalad and other broadleaf weeds (Lee et al. 1991). Variable control has been documented on yellow nutsedge where control was 28 to 100% with postemergence (POST) applications of imazethapyr at 18, 36, 54, and 72 g/ha (Richburg et al. 1995). Researchers have also demonstrated the weakness of imazethapyr on weeds that belong to the Fabaceae, or legume, family (Judd et al.

1999). In peanuts, imazethapyr applied at various rates from 18 to 72 g/ha controlled sicklepod [*Senna obtusifolia* (L.) Irwin and Barneby] zero to 33% and Flordia beggarweed [*Desmodium tortuosum* (Sw.) DC.] zero percent (Richburg et al. 1995). Minimal control with the use of imazethapyr in IT rice has been reported for hemp sesbania [*Sesbania exaltata* (Raf.) Cory] and Indian jointvetch (*Aeschynomene indica* L.) (Dillon et al. 1999; Masson and Webster 2001; Scherder et al. 2001; Zhang et al. 2001). In a water-seeded study conducted in Louisiana, soil applications of imazethapyr at 105 and 140 g/ha fb POST at 70 g/ha resulted in 74% control of Indian jointvetch (Masson and Webster 2001). Hemp sesbania and Indian jointvetch favor wet, saturated soils making rice production an ideal environment for establishment and growth (Godfrey and Wooten 1981; Lorenzi and Jeffery 1987). However, tank mixtures have shown to be beneficial in controlling a broader spectrum of weeds.

Initially imazethapyr was applied at 87 g/ha PPI or PRE followed by 53 g/ha POST to minimize injury observed with POST applications (Webster 2001[1]). Due to the initial concerns surrounding the most effective imazethapyr rate, research was established to evaluate imazethapyr at 140 g/ha applied in single or various rates applied PRE fb POST to total 140 g/ha. However, imazethapyr alone is not considered a complete weed control program in IT rice if broadleaf weeds are present. Imazethapyr provides minimal control of such weeds as hemp sesbania and Indian jointvetch. Research was conducted to evaluate herbicides with broadleaf activity incorporated into an imazethapyr program. Imazethapyr was applied to the soil surface fb an

[1] Eric P. Webster. Personal communication. Associate Professor of Weed Science, Louisiana State University, Baton Rouge, 70816.

EPOST application of a herbicide with broadspectrum activity fb imazethapyr LPOST. This study was conducted to determine which herbicide would have the best fit applied EPOST by controlling weeds that escaped the soil application of imazethapyr. Studies were also conducted to evaluate which herbicides worked best in an imazethapyr POST tank mixtures to control a broadspectrum of grass and broadleaf weeds. All studies were conducted in both drill- and water-seeded rice production systems.

CHAPTER 2

IMAZETHAPYR AT DIFFERENT RATES AND TIMINGS IN DRILL- AND WATER-SEEDED IMIDAZOLINONE-TOLERANT RICE

Introduction

In 1993, Dr. Tim Croughan of the Louisiana State University AgCenter Rice Research Station developed a rice plant through a chemical induced mutation that exhibited tolerance to the imidazolinone herbicide family (Croughan 1994). Imidazolinone herbicides inhibit the enzyme acetolactate synthase (ALS, E.C. 4.1.3.18) (Stidham and Singh) 1991). Imazethapyr {(±)–2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid} is a weak acid belonging to the imidazolinone family of herbicides (Wepplo 1991) that has been selected by the manufacturer for use in imidazolinone-tolerant (IT) rice. Imazethapyr is readily absorbed through roots and foliage making it ideal for preplant incorporated (PPI), preemergence (PRE), or postemergence (POST) applications (Cantwell et al. 1989). Imazethapyr POST controls existing susceptible weeds while enhancing the control of weeds germinating later in the season (Hart et al. 1991). Imazethapyr is registered for use in soybean [*Glycine max* (L.) Merr.] and peanut (*Arachis hypoaea* L.) to control grass and broadleaf weed species (Cantwell et al. 1989; Grichar 1994; Richburg et al. 1993).

In Arkansas, season-long competition from barnyardgrass [*Echinochloa crus-galli* (L.) Beauv.] and red rice (*Oryza sativa* L.) reduced rice grain yields more than other rice weeds including broadleaf signalgrass [*Brachiaria platyphylla* (L.) Beauv.], ducksalad [*Heteranthera limosa* (Sw.) Willd], hemp sesbania [*Sesbania exaltata* (Raf.) Rydb. ex A.W. Hill), and spreading dayflower (*Commelina diffusa* Burm. f.) (Smith 1988). Stauber et al. (1991) reported barnyardgrass competition reduced ‘Lemont’ and ‘Newbonnet’ rice grain yields by 301 and 257 kg/ha, respectively.

In rice production, propanil [N-(3,4-dichlorophenyl) propanamide] has been the most prominent herbicide used for barnyardgrass control (Smith 1974). However, in 1991 the confirmation of propanil-resistant barnyardgrass in Arkansas (Baltazar and Smith 1994) and in Louisiana, Mississippi, and Texas (Carey et al. 1995), coupled with the difficulty of controlling red rice, has producers searching for effective herbicide programs. With the introduction of IT rice, producers will have an effective management tool for controlling barnyardgrass and red rice while maximizing rice yield potential (Dillon et al. 1999; Liscano et al. 1999; Masson and Webster 2001).

Research conducted in Tennessee indicated that application timing of imazethapyr was more critical than rate for controlling susceptible weeds in soybean (Harrison et al. 1989). Imazethapyr applied at rates lower than 70 g/ha controlled barnyardgrass and seedling johnsongrass [*Sorghum halepense* (L.) Pers.] 90% or better, but only when weeds were treated at the one-leaf stage (Klingaman et al. 1992).

In rice, imazethapyr at 70 g/ha PRE controlled propanil-resistant and –susceptible barnyardgrass, and broadleaf signalgrass greater than 97% (Scherder et al. 2001). Researchers in Missouri observed that as rates of soil applied imazethapyr increased from 70 to 140 g/ha, control of barnyardgrass and red rice increased from approximately 60 to 90% (Kendig et al. 2000; Ohmes et al. 2001). Masson et al. (2001) reported 90 to 93% barnyardgrass control with PPI and PRE applications of imazethapyr at 140 g/ha.

Research in four rice producing states indicated that grass control with imazethapyr applied to the soil was less than foliar applications (Hackworth et al. 1998), but control with a single POST application has been reported to be inconsistent. Webster and Masson (2001) reported imazethapyr applied at 70 and 140 g/ha controlled two- to three-leaf barnyardgrass 24 and 31%, respectively. A second study resulted in 93% control with imazethapyr applied at 140 g/ha on two- to four-leaf barnyardgrass, but a reduction in control was observed with applications made to four- to five-leaf barnyardgrass (Masson et al. 2001).

Sequential POST applications of imazethapyr at a reduced rate of 35 g/ha resulted in red rice control below 80% (Ohmes et al. 2001), but a single soil application of imazethapyr at 70, 105, or 140 g/ha fb POST at 70 g/ha on two- to three-leaf rice controlled barnyardgrass 88 to 96% in water-seeded rice (Masson and Webster 2001). Preliminary studies reported that sequential applications of imazethapyr would be required for effective control of barnyardgrass (Liscano et al. 1999) and red rice (Dillon et al. 2001), especially with high weed populations (Webster and Masson 2001).

Initially imazethapyr was applied in split applications to total 140 g/ha per growing season (Webster, personal communication[1]). Prior to 2001 the imazethapyr program was anticipated to consist of PPI or PRE fb POST applications at 70 g/ha each. The projected rate was then changed to 87 g/ha PPI or PRE fb 53 g/ha POST in 2001. After reviewing preliminary data and considerable debate, it was concluded following the 2001 growing season that the original rates would be the most effective imazethapyr program. In 2002, imazethapyr received registration for use in commercial drill-seeded IT rice at 70 g/ha PPI or PRE fb 70 g/ha POST.

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[1] Eric P. Webster. Personal communication. Associate Professor of Weed Science, Louisiana State University, Baton Rouge, 70816.

Due to the initial concerns surrounding the most effective imazethapyr rate, the objective of this research was to evaluate weed control and crop response to imazethapyr at the total maximum use rate of 140 g/ha applied either in single or sequential applications in drill- and water-seeded rice systems.

Materials and Method

Drill-seeded. A study was established in 2000 and 2001 at the Rice Research Station located near Crowley, LA. Soil was a Crowley silt loam (fine montmorillinitic, thermic Typic Albaqualf), with 6.4 pH and 1.4% organic matter. Seedbed preparation consisted of a fall disking and a spring disking followed by (fb) two passes in opposite directions using a two-way bed conditioner with rolling baskets and S-tine harrows set at a depth of 6 cm. Study area was laser-leveled in the winter to a slope gradient of 0.25 following initial disking. Plots consisted of eight 19-cm spaced rows, 5 m long. IT rice lines, '93 AS-3510' and 'CL 141', were drilled seeded at 112 g/ha at a depth of 1.5 cm on May 30, 2000 and May 18, 2001, respectively.

The experimental design for both studies was a randomized complete block with four replications. Treatments included imazethapyr PRE at 0, 35, 53, 70, 87, 105, and 140 g/ha fb a two to three leaf rice, early postemergence (EPOST), or four to five leaf rice, late postemergence (LPOST), application of imazethapyr at 140, 105, 87, 70, 53, 35, and 0 g/ha; respectively. A nonionic surfactant[2] at 0.25% (v/v) was included with EPOST and LPOST treatments.
A nontreated was added for comparison purposes.

[2] Nonionic surfactant Latron AG-98® is a mixture of alkylaryl polyoxyethylene glycols. Rohm and Haas. 100 Independence Mall West, Philadelphia, PA 19106.

Before permanent flood establishment, the experimental area was surface irrigated three times, immediately after seeding, at the two- to three-leaf stage, and three- to four-leaf stage. Soil fertility management consisted of 280 kg/ha of 7-21-21 fertilizer preplant and 280 kg/ha of 46-0-0 urea nitrogen immediately before permanent flood. Standard agronomic and pest management practices were employed during the growing season to maximize yield.

Herbicide applications were made with a CO_2-pressurized backpack sprayer calibrated to deliver 140 L/ha spray volume at 186 Kpa. Test area was naturally infested with barnyardgrass at a density of 40 plants/m^2 and EPOST applications were made at two- to four-leaf and LPOST applications at six-leaf to two-tiller. Barnyardgrass control and crop injury were visually evaluated 21 and 48 days after LPOST application. Rice height at harvest was determined by measuring the plant from the ground level to the tip of the extended panicle. Rice was harvested with a small-plot combine and percent moisture was determined. Rough rice yield was adjusted to 12% moisture. Visual weed control and rice injury were based on a scale of 0 to 100%, where 0 = no control or injury and 100 = complete control or plant death.

Water-seeded. The water-seeded study followed the same procedures as the drill-seeded study with the exception of imazethapyr application and seeding method. All PRE applications were replaced with a surface application that consisted of imazethapyr applied to the soil surface (SURF) prior to seedling flood establishment. Twenty-four h after the SURF application of imazethapyr, a 5 cm flood was established. Rice seeds were submerged in water-filled container for approximately 24 h, and the seeds were removed and allowed to drain for 12 h to initiate the germination process. Pregerminated seeds were aerially broadcast into the standing flood at a seeding rate of 168 kg/ha. After 24 h, the field was drained to allow seedling establishment. IT rice lines, ‘93 AS-3510’ and ‘CL 141’, were planted on May 26, 2000 and May 10, 2001, respectively.

Herbicide applications were made to three- to five-leaf, EPOST, and six-leaf to two- tiller stage, LPOST. Barnyardgrass density was 35 plants/m^2. Barnyardgrass control and crop injury were visually evaluated at 21 and 48 days after LPOST application. Rice height was recorded at maturity.

Data from drill- and water-seeded studies were subjected to analysis of variance, testing all possible interactions of herbicide treatment and year. Data were subjected to PROC GLM and means were separated using Fisher’s Protected LSD at the 5% probability level (SAS 1990). Arcsine transformations of data were not used since the transformations did not change data interpretations. All possible interactions of herbicide treatment and year, were tested and tables for appropriate interactions were constructed.

Results and Discussion

Drill-seeded. A year by herbicide treatment interaction occurred for barnyardgrass control at 21 days after LPOST treatment (DAT) (Table 2.1). No differences in barnyardgrass control were observed between 2000 and 2001 with treatments receiving imazethapyr PRE at 87, 70, 53, 35, and 0 g/ha fb EPOST at 53, 70, 87, 105, and 140 g/ha, respectively. With a delay in initial application, Masson et al. (2001) reported less than 70% barnyardgrass control with imazethapyr at 140 g/ha applied at the five-leaf stage. LPOST applications were made to six-leaf to two-tiller barnyardgrass in 2000 and control was 75 and 69% with 105 and87 g/ha applied PRE fb a LPOST application compared with no more than 55% with lower rates of imazethapyr applied PRE at 21 DAT. In contrast,

Table 2.1 Barnyardgrass control in drill-seeded rice with imazethapyr applied preemergence (PRE), early postemergence (EPOST), and late postemergence (LPOST) and evaluated at 21 and 49 days after LPOST treatment (DAT).

Imazethapyr timings[a] and rates		Barnyardgrass control		
		21 DAT		
		2000	2001	49 DAT[b]
(g ai/ha)		%		
PRE	EPOST[c]			
140	0	66	66	88
105	35	88	85	97
87	53	88	95	97
70	70	89	93	97
53	87	89	94	96
35	105	90	94	97
0	140	88	95	96
PRE	LPOST			
105	35	75	79	95
87	53	69	89	95
70	70	53	88	97
53	87	55	85	96
35	105	50	76	94
0	140	50	78	86
LSD (0.05)		8		6

[a]EPOST treatment applied at two- to four-leaf stage and LPOST to six-leaf to two-tiller barnyardgrass.

[b]Data averaged over years

[c]Nonionic surfactant added to postemergence treatments at 0.25% (v/v).

barnyardgrass control in 2001 was 85 to 89% with imazethapyr applied PRE at 87, 70, and 53 g/ha fb LPOST at 53, 70 and 87 g/ha.

Because a herbicide treatment interaction existed, but not a year by herbicide treatment interaction, for barnyardgrass control at 49 DAT, data were averaged over years (Table 2.1). At 49 DAT, barnyardgrass control was 94 to 97% with no differences being observed among treatments for two applications of imazethapyr or a single EPOST application at 140 g/ha. A single application of imazethapyr at 140 g/ha PRE or LPOST controlled barnyardgrass 88 and 86%, respectively. A single PRE application of imazethapyr at 140 g/ha provided residual activity for 21 to 28 DAT; therefore, reduction in control was attributed to later emerging barnyardgrass. The decrease in control with a single LPOST application of imazethapyr was due to the larger size of barnyardgrass and increased population. Webster and Masson (2001) reported control with imazethapyr applied at 140 g/ha to two- to three leaf barnyardgrass was 31% with densities of 125 to 150 plants/m^2.

Injury has been reported with a POST imazethapyr application to IT rice in water-seeded production (Masson and Webster 2001). Injury generally occurs on rice with newly emerged green tissue through the three-leaf stage. However injury was 0 to 5% injury at 42 DAT (Data not shown).

Because a herbicide treatment interaction existed, but not a year by herbicide treatment, for rice height, data were averaged over year (Table 2.2). Rice height was recorded at harvest and was 70 to 80 cm in the herbicide-treated plots. Although differences were observed, the data suggested rice height has little impact on yield.

A year by treatment interaction occurred for rough rice yield (Table 2.2). In 2000, rice yields were higher for all treatments compared with the same treatment in 2001. This was due to heavy

Table 2.2 Drill-seeded rice height and rough rice yield at harvest with imazethapyr applied preemergence (PRE), early postemergence (EPOST), and late postemergence (LPOST).

Imazethapyr rates and timings[a]		Height[b]	Yield	
			2000	2001
g ai/ha		cm	kg/ha	
PRE	EPOST[c]			
140	0	78	3740	1450
105	35	77	6460	3310
87	53	74	5890	2960
70	70	79	5570	3890
53	87	77	6130	3450
35	105	80	6010	3770
0	140	79	5940	3920
PRE	LPOST			
105	35	75	5780	2530
87	53	78	5780	2920
70	70	74	6210	2220
53	87	78	5970	3260
35	105	70	5930	3330
0	140	71	5440	1080
Nontreated		50	396	0
LSD (0.05)		5	700	

[a]EPOST treatment applied at two- to four-leaf stage and LPOST to six-leaf to two-tiller barnyardgrass.

[b]Data averaged over years

[c]Nonionic surfactant added to postemergence treatments at 0.25% (v/v).

rainfall at rice maturity and severe disease pressure on the CL 141 line. The wet conditions delayed harvest and caused severe lodging of rice resulting in reduced harvest efficiency. In 2000, rice treated with a single application of imazethapyr at 140 g/ha EPOST resulted in a yield of 5490 kg/ha, which was equivalent to all other treatments with imazethapyr applied PRE fb an EPOST or LPOST applications. However, in 2001, delaying the POST application of imazethapyr to the LPOST timing resulted in reduced rice yields with 35, 53, 70 g/ha LPOST. This was due to the lower rates LPOST having reduced activity on the large barnyardgrass present at that time. In the drill-seeded system a single EPOST application of 140 g/ha resulted in barnyardgrass control and rice yields equivalent to PRE fb EPOST treatments.

Water-seeded. Control of barnyardgrass at 21 DAT was 91 to 96% with no differences observed among treatments (Table 2.3). However, a herbicide treatment by year interaction occurred at 49 DAT for barnyardgrass control. In 2000, barnyardgrass control was 88% with imazethapyr applied SURF at 140 g/ha and was less than all other treatments which controlled barnyardgrass 93 to 95%. Masson et al. (2000) reported similar results with at least 90% barnyardgrass control with imazethapyr applied SURF, after seeding, or at pegging fb a POST application. Barnyardgrass control in 2001 at 49 DAT was 91 to 97% with a single imazethapyr application at 140 g/ha EPOST and treatments receiving two applications of imazethapyr, except barnyardgrass control was reduced with imazethapyr at 105 g/ha SURF fb 35 g/ha EPOST. A reduction in barnyardgrass control was also observed with imazethapyr applied at 140 g/ha to the SURF. Imazethapyr SURF provided residual activity for two to three weeks after application; therefore, a POST application was required to control the late emerging barnyardgrass that followed the SURF application. With imazethapyr applied at 105

Table 2.3 Barnyardgrass control in water-seeded rice with imazethapyr applied to the surface (SURF), early postemergence (EPOST), and late postemergence (LPOST) and was evaluated at 21 and 49 days after LPOST treatment (DAT).

Imazethapyr rates and timings[a]		Barnyardgrass control		
			49 DAT	
		21 DAT[b,c]	2000	2001
g ai/ha		%		
SURF	EPOST[d]			
140	0	93	88	78
105	35	93	95	86
87	53	94	93	95
70	70	94	95	95
53	87	96	95	97
35	105	93	95	97
0	140	92	95	91
SURF	LPOST			
105	35	94	94	91
87	53	91	95	97
70	70	94	95	96
53	87	94	94	91
35	105	94	94	95
0	140	92	95	89
LSD (0.05)		NS	5	

[a]SURF treatment applied prior to seedling flood, EPOST at three- to four-leaf stage and LPOST to six-leaf to two-tiller barnyardgrass.

[c]Data averaged over years

[c]Nonionic surfactant added to postemergence treatments at 0.25% (v/v).

g/ha SURF fb 35 g/ha EPOST, the imazethapyr rate was to low to compensate for the size of the barnyardgrass which was at the three- to five-leaf stage at time of POST application.

No differences were observed with total plant heights recorded at maturity (data not shown). Rice injury was 0 to 5% at 7 DAT, but no injury was observed at other evaluation date (data not shown).

Imazethapyr was effective in both drill- and water-seeded IT rice programs. Late season control of barnyardgrass was 95 to 97% with imazethapyr applied to the soil at 87 or 70 g/ha fb 53 or 70 g/ha EPOST or LPOST. Furthermore, a single EPOST application of imazethapyr at 140 g/ha controlled barnyardgrass and rice yield was equal to or above those treatments receiving two applications. However, producers should consider a soil application of imazethapyr to provide residual activity should adverse weather conditions prevent an application prior to barnyardgrass reaching the five-leaf stage.

CHAPTER 3

WEED CONTROL PROGRAMS FOR DRILL- AND WATER-SEEDED IMIDAZOLINONE-TOLERANT RICE

Introduction

In 1993, a rice plant was developed at the Louisiana State University AgCenter Rice Research Station that exhibited tolerance to the imidazolinone family of herbicides (Croughan 1994). Imazethapyr {(±)–2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid} is the herbicide that is labeled for use with imidazolinone-tolerant (IT) rice, and will be used as a management tool for red rice.

Red rice is a problematic weed in several rice producing states including Arkansas, Louisiana, and Texas (Dowler 1994). Red rice tillers profusely, produces greater biomass, and grows significantly taller compared with commercial rice (Diarra et al. 1985a; Noldin et al 1999a). These traits aid red rice in survival and dispersal (Constantin 1960; Noldin et al 1999a).

Few options are available in commercial rice production for control of red rice. The use of chemicals and cultural practices have been employed for red rice control (Kwon et al. 1988; Smith 1981). A preplant incorporated (PPI) application of molinate (*S*-ethyl hexahydro-1*H*-azepine-1-carbothioate) in combination with water-seeded rice production has been shown to suppress red rice. However, options are more limited in drill-seeded rice. Rotation to glyphosate [*N*-(phosphonomethyl)glycine]-resistant soybean has been the most successful tool for red rice control; however, results can be inconsistent (Askew et al. 2000; Khodayari et al. 1987)

Prior to the introduction of IT rice, Noldin et al. (1999b) conducted a study to evaluate the sensitivity of several rice cultivars and red rice ecotypes to imazethapyr. 'Mars' and 'Maybelle' rice were injured 80 to 88% with imazethapyr at 70 g ai/ha postemergence (POST) while red rice control was 71 to 84%. Preliminary research conducted on IT rice showed severe injury (16 to 48%) with the use of imazethapyr applied POST at rates 70, 105, 140 and 175 g/ha (Steele et al. 1999). Sanders et al. (1998) reported 30% rice injury with sequential postflood treatments of imazethapyr. Field applications of imazethapyr at the two- to three-leaf stage in drill-seeded rice and at rice pegging in water-seeded caused less than 16% crop injury (Masson and Webster 2001; Webster and Masson 2001). Several other researchers have reported less than 5% injury from imazethapyr applications to IT rice (Kendig et al. 2001; Levy et al 2001; Masson et al. 2001). As new IT rice lines were developed, injury decreased compared with earlier IT lines.

Soil applications of imazethapyr at 70 and 87 g/ha controlled red rice less than 30% (Kurtz and Street 1999). Early season red rice control was less than 82% with single surface and single POST applications of imazethapyr at rates varying from 70 to 175 g/ha (Steele et al. 1999). Imazethapyr PRE fb POST consistently controlled red rice with minimal rice injury (Hackworth et al. 1998; Kurtz and Street 1999; White and Hackworth 1999). Zhang et al. (2001) reported saturated soils at 50% moisture following imazethapyr PPI reduced control of barnyardgrass and red rice compared with 13 to 25% soil moisture. Control with imazethapyr POST was not influenced by soil moisture.

The efficacy of imazethapyr on grass weed species has been demonstrated; however, imazethapyr alone is not considered a complete weed control program in IT rice due to the lack of control of some broadleaf weeds. Hemp sesbania and Indian jointvetch belong to the

Fabaceae family and favor wet, saturated soils making rice production an ideal environment for growth (Godfrey and Wooten 1981; Lorenzi and Jeffery 1987). Lack of control of both weed species has been documented with the use of imazethapyr in IT rice (Dillon et al. 1999; Masson and Webster 2001; Scherder et al. 2001; Zhang et al. 2001). Masson and Webster (2001) reported Indian jointvetch control less than 74% with imazethapyr applied at 105 and 140 g/ha to the soil surface or at pegging fb a POST application at 70 g/ha in water-seeded rice. Control of hemp sesbania and Indian jointvetch was less than 10% with single soil applications of imazethapyr at rates of 35 to 140 g/ha (Pellerin et al. 2001). However, research has indicated the potential for POST imazethapyr tank-mixes to increase control of hemp sesbania and Indian jointvetch.

The objective of this study was to evaluate herbicide programs in drill- and water-seeded IT rice to maximize control of broadleaf and grass weeds and the impact of these programs on rice yield.

Materials and Method

Drill-seeded. A study was conducted at the LSU AgCenter Rice Research Station located near Crowley, LA and a producer location near Rayne, LA in 2000 and 2001. At both locations a Crowley silt loam soil (fine montmorillinitic, thermic Typic Albaqualf), with 6.2 to 6.4 pH and 1.0 to 1.4% organic matter was present. Seedbed preparation for both locations consisted of a fall and spring disking followed by (fb) a two-way bed conditioner equipped with rolling baskets and S-tine harrows passed twice in opposite directions at a depth of 6 cm. IT ‘93 AS-3510’ rice and ‘CL 121’ rice were drill-seeded in 2000 and 2001, respectively. The Crowley location was planted on May 24, 2000 and May 7, 2001 and the Rayne location on June 2, 2000 and May 25, 2001. Plot size was eight-18 cm rows, 5 m long at both locations.

The experimental design was a randomized complete block with four replications. Treatments included imazethapyr PRE at 87 g/ha, or no PRE, with one of the following herbicides applied early postemergence (EPOST) on two- to three-leaf rice: 42 g/ha bensulfuron 2-[[[[[(4,6-dimethoxy-2-pyrimidinyl)amino]carbonyl]amino]sulfonyl]methyl]benzoic acid; a package mixture[1] of 561 g/ha bentazon 3-(1-methylethyl)-(1H)-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide + 281 g/ha acifluorfen 5-[2-chloro-4-(trifluoromethyl)phenoxy]-2-nitrobenzoic acid; 28 g/ha carfentrazone X,2-dichloro-5-[4-(difluromethyl)-4,5-dihydro-3-methyl-5-oxo-1H-1,2,4-triazol-1-yl]-4-fluorobenzenepropanic acid; 53 g/ha halosulfuron 3-chloro-5-[[[[(4,6-dimethoxy-2-pyrimidinyl)amino]carbonyl]amino]sulfonyl]-1-methyl-1H-pyrazole-4-carboxylic acid; a package mixture[2] of 1.68 kg/ha propanil N-(3,4-dichlorophenyl)propanamide + 1.68 kg/ha molinate S-ethyl hexahydro-1H-azepine-1-carbothioate; 280 g/ha triclopyr [(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid; 22 g/ha V-10029 {sodium 2,6-bis[(4,6-dimethoxypyrimidin-two-yl)oxy]benzoate} followed by (fb) imazethapyr at 53 g/ha late postemergence (LPOST) on four- to five-leaf rice. For comparison, imazethapyr PRE at 87 g/ha fb imazethapyr LPOST at 53 g/ha, imazethapyr PRE at 87 g/ha, and imazethapyr LPOST at 53 g/ha were included. Crop oil concentrate[3] at 1% (v/v) was added to EPOST

[1] Storm herbicide label. BASF Corporation, P.O. Box 13528, Research Triangle Park, NC 27709.

[2] Arrosolo herbicide label. RICECO Corporation, 5100 Poplar Avenue, Suite 2428, Memphis, TN 38137.

[3] Crop oil concentrate Agri-Dex ®is nonionic spray adjuvant consisting of a blend of heavy range paraffin base petroleum oil, polyol fatty acid esters, and polyethoxylated derivatives. Helena Chemical Company. 6075 Poplar Ave., Suite 500, Memphis, TN 38119.

treatments containing bensulfuron. A nonionic surfactant[4] at 0.25% (v/v) was included with EPOST treatments containing bentazon + acifluorfen, carfentrazone, halosulfuron, and triclopyr and all LPOST treatments of imazethapyr. A silicon based surfactant[5] at 0.125% (v/v) was added to EPOST treatments containing of V-10029.

The entire study was surface irrigated three times prior to permanent flood establishment, immediately after seeding, at the two- to three-leaf rice stage, and at the three- to four-leaf rice stage. The permanent flood was established four days after LPOST application. Soil fertility management consisted of 280 kg/ha of 7-21-21 (N-P-K) fertilizer preplant and 280 kg/ha of 46-0-0 urea nitrogen immediately before permanent flood establishment. Standard agronomic and pest management practices were implemented throughout the growing season to maximize yield.

A CO_2-pressurized backpack sprayer calibrated to deliver 140 L/ha spray volume at 186 Kpa was used to apply all herbicides. EPOST treatments were applied when barnyardgrass and red rice were five to 15 cm with two- to four-leaves, hemp sesbania was eight to 18 cm with three- to six-leaves, and alligatorweed was five to 10 cm with six- to eight-leaves. LPOST treatments were applied when barnyardgrass and red rice were 20 to 33 cm with six-leaves to two-tillers, hemp sesbania was 25 to 36 cm with fourteen- to sixteen-leaves, and alligatorweed was 20 to 30 cm with thirty- to fifty-leaves. Barnyardgrass, red rice, hemp

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[4] Nonionic surfactant Latron AG-98® is a mixture of alkylaryl polyoxyethylene glycols. Rohm and Haas. 100 Independence Mall West, Philadelphia, PA 19106.

[5] Silicon based surfactant Kinetic® is a blend of polyalkyleneoxide modified polydimethylsiloxane and polyoxypropylene-polyoxyethylene block copolymers. Helena Chemical Company. 6075 Poplar Ave., Suite 500, Memphis, TN 38119.

sesbania, and alligatorweed densities were 50, 150, 20, and 30 plants/m^2, respectively.

Water-seeded. The water-seeded study followed the same procedures as the drill-seeded study with the exception of imazethapyr application and seeding method. All PRE applications were replaced with a surface application that consisted of imazethapyr applied to the soil surface (SURF) 24 hours (h) prior to seedling flood establishment. One hundred kilograms of IT rice was placed in a mesh bag and submerged in water for 24 h. The bag was removed and allowed to drain for 12 h to promote seed germination. Pregerminated seeds were then broadcast by airplane into a standing flood at Crowley on May 26, 2000 and May 10, 2001 and at the Rayne location on June 2, 2000, and May 26, 2001. IT lines planted were 93 AS-3510 in 2000, and CL-121 and ‘CL-141’ in 2001 at Crowley and Rayne, respectively. The flood was removed 24 h after planting to initiate seedling establishment. The entire area was surface irrigated 7 d after planting, at the two- to three-leaf and three- to four-leaf rice stages with permanent flood being established at five- to six-leaf rice stage.

Herbicide applications were made at the EPOST timing on barnyardgrass and red rice that were eight to 18 cm with three- to six-leaves, hemp sesbania was five to ten cm with two- to six-leaves, and alligatorweed was five to ten cm with six- to eight-leaves. At the LPOST timing barnyardgrass and red rice were 25 to 38 cm with four-leaves to two-tillers, hemp sesbania was 20 to 30 cm with seven- to eleven-leaves, and alligatorweed was 10 to 20 cm with ten- to fifteen-leaves.

For both seeding methods visual weed control and crop injury were recorded weekly and estimated on a scale of 0 (no control or injury) to 100% (complete plant death). Grass weed control evaluated included barnyardgrass at 21 and 49 days after LPOST treatment (DAT) and red rice at 21 and 42 DAT. Broadleaf weed control evaluated included hemp sesbania at 21 and 35 DAT and alligatorweed at 28 and 42 DAT. Plant height was recorded at harvest and determined by measuring the plant from ground level to the tip of the extended panicle.

Rice was harvested with a small-plot combine and percent moisture was obtained and rough rice yield was adjusted to 12% moisture content. Data from each study were subjected to analysis of variance, testing all possible interactions of herbicide treatment and year. All data were subjected to PROC GLM and means were separated using Fisher's Protected LSD at the 5% probability level. Arcsine transformations of data were not used since the transformations did not change data interpretations. All possible interactions of herbicide treatment and year, or location were tested and tables for appropriate interactions were constructed.

Results and Discussion

Drill-seeded. Barnyardgrass control was evaluated at the Crowley location in 2000 and 2001. A year by herbicide treatment interaction occurred at 21 DAT (Table 3.1). The treatment consisting of imazethapyr applied at 87 g/ha PRE fb 53 g/ha LPOST was considered the standard and was used as a comparison treatment. At 21 DAT, the standard imazethapyr program controlled barnyardgrass 58 and 95% in 2000 and 2001, respectively. An increase barnyardgrass control was observed in 2001 at 21 DAT compared with 2000 for all treatments except propanil plus molinate. The increase in control was probably attributed to an increase in rainfall between EPOST and LPOST applications from 3 to 13" in 2000 and 2001, respectively. Drier soil conditions were also observed following PRE application of imazethapyr

Table 3.1 Evaluation of weed control programs for barnyardgrass at 21 and 49 d after late postemergence (LPOST) treatment (DAT) at Crowley, LA and alligatorweed at 28 and 42 DAT at Rayne, LA in drill-seeded imidazolinone-tolerant rice.

			Barnyardgrass				
			21 DAT[b]			Alligatorweed[c]	
Herbicide program		Timing[a]	2000	2001	49 DAT[c]	28 DAT	42 DAT
	g ai/ha		%				
Imazethapyr	87	PRE	68	94	96	83	93
bensulfuron + COC[d]	42	EPOST					
imazethapyr + NIS[e]	53	LPOST					
Bensulfuron + COC	42	EPOST	45	80	89	73	80
Imazethapyr + NIS	53	LPOST					
Imazethapyr	87	PRE	78	97	97	76	82
bentazon + aciflurofen + NIS	842	EPOST					
imazethapyr + NIS	53	LPOST					
Bentazon + aciflurofen + NIS	842	EPOST	50	88	90	54	64
imazethapyr + NIS	53	LPOST					
Imazethapyr	87	PRE	70	97	97	78	74
carfentrazone + NIS	28	EPOST					
imazethapyr + NIS	53	LPOST					
Carfentrazone + NIS	28	EPOST	43	95	90	56	64
imazethapyr + NIS	53	LPOST					
Imazethapyr	87	PRE	70	94	97	83	92
halosulfuron + NIS	53	EPOST					
imazethapyr + NIS	53	LPOST					

(Table 3.1 continued)

Halosulfuron + NIS	53	EPOST	49	84	86	64	75
imazethapyr + NIS	53	LPOST					
Imazethapyr	87	PRE	94	91	98	77	78
propanil + molinate + NIS	3370	EPOST					
imazethapyr	53	LPOST					
Propanil + molinate + NIS	3370	EPOST	91	90	98	66	59
imazethapyr + NIS	53	LPOST					
Imazethapyr	87	PRE	74	95	98	60	66
triclopyr + NIS	280	EPOST					
imazethapyr + NIS	53	LPOST					
Triclopyr + NIS	280	EPOST	42	84	80	61	62
imazethapyr + NIS	53	LPOST					
Imazethapyr	87	PRE	95	94	98	70	88
V-10029 + SBS[f]	22	EPOST					
imazethapyr + NIS	53	LPOST					
V-10029 + SBS	22	EPOST	95	88	97	74	82
imazethapyr + NIS	53	LPOST					
Imazethapyr	87	PRE	58	95	97	63	80
imazethapyr + NIS	53	LPOST					
Imazethapyr	87	PRE	36	81	65	54	59
Imazethapyr + NIS	53	LPOST	43	65	79	48	46
LSD (0.05)			——— 5 ———		10	18	14

[a]PRE, preemergence; EPOST, early postemergence; LPOST, late postemergence.

[b]A treatment by year interaction occurred for barnyardgrass control at 21 DAT

[c]A treatment interaction occurred for barnyardgrass control at 49 DAT and alligatorweed at 28 and 42 DAT.

[d]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant

in 2000. In 2000, barnyardgrass control was less than 80% for all treatments except with propanil plus molinate and V-10029 which controlled barnyardgrass 91 to 95%, regardless of imazethapyr applied PRE. The increase in barnyardgrass control was attributed to the grass activity that has been reported with propanil plus molinate and V-10029 (Crawford and Jordan 1995; and Webster et al. 1999). In 2001, with the exception of propanil plus molinate, and carfentrazone, an increase in barnyardgrass control for individual treatments was observed with imazethapyr applied PRE compared with no soil application of imazethapyr.

Because a treatment interaction, but not a treatment by year interaction existed at 49 DAT data were averaged over years for barnyardgrass control (Table 3.1). The imazethapyr comparison treatment controlled barnyardgrass 97%. Regardless of a soil application, no differences were observed between carfentrazone, propanil plus molinate, and V-10029. Control increased with a PRE application of imazethapyr fb bensulfuron, bentazon + acifluorfen, halosulfuron and triclopyr EPOST. Propanil plus molinate and V-10029 have activity on barnyardgrass and achieved 97 to 98% control; however, the other herbicides applied EPOST have little to no activity on barnyardgrass and may require two applications of imazethapyr to achieve adequate control. A single application of imazethapyr PRE did not provide season-long barnyardgrass control (65%), and by delaying the initial application to the LPOST timing, barnyardgrass became too large and control was 79%. This level of control of barnyardgrass with imazethapyr can negatively impact yield due to increased competition (Masson et al. 2001).

Alligatorweed was evaluated at Rayne in 2000 and 2001. Because a treatment interaction, but not a treatment by year interaction existed at 28 and 42 DAT, data were averaged over years (Table 3.1). At 28 DAT, the standard imazethapyr program controlled alligatorweed 63%. Imazethapyr applied PRE fb bensulfuron or halosulfuron EPOST fb imazethapyr LPOST controlled alligatorweed 83%. This control was higher than the standard program but no difference was observed with all PRE fb EPOST fb LPOST programs with the exception of triclopyr EPOST at 60%. No differences were observed between treatments with imazethapyr as the only herbicide in a weed control program with alligatorweed control of 48 to 63%. At 42 DAT, imazethapyr at 87 g/ha PRE fb imazethapyr at 53 g/ha LPOST controlled alligatorweed 80%. No herbicide program increased alligatorweed control compared with imazethapyr PRE fb LPOST. However, imazethapyr fb triclopyr fb imazethapyr resulted in decreased alligatorweed control compared with the standard.

Hemp sesbania was evaluated at the Crowley location in 2000 and 2001 at 21 and 35 DAT (Table 3.2). Since a treatment interaction but not a treatment by year interaction existed, data were averaged over years. The standard imazethapyr treatment controlled hemp sesbania 24% at 21 DAT, which was lower than all other treatments. Researchers in Louisiana reported similar results with split applications of imazethapyr totaling 140 g/ha controlling hemp sesbania less than 65% (Pellerin et al. 2001). However, the addition of an EPOST application of propanil plus molinate or V-10029 increased control to 96% while control was lower with an EPOST application of bensulfuron at 86%. At 35 DAT, hemp sesbania control was 34% with the standard imazethapyr treatment. Control increased to 80 and 86% with the addition of an EPOST application of bensulfuron and triclopyr, respectively. The addition of V-10029 EPOST increased hemp sesbania control to 97%. Webster et al. (l999) reported 88 to 95% control of Indian jointvetch

Table 3.2 Evaluation of weed control programs for hemp sesbania control at 21 and 35 d after late postemergence (LPOST) treatment (DAT) averaged over 2000 and 2001 at Crowley, LA in drill-seeded imidazolinone-tolerant rice.

Herbicide programs	g ai/ha	Timings[a]	Hemp sesbania[b] 21 DAT	35 DAT
			%	
Imazethapyr	87	PRE	86	80
bensulfuron + COC[c]	42	EPOST		
imazethapyr + NIS	53	LPOST		
Bensulfuron + COC	42	EPOST	87	80
Imazethapyr + NIS	53	LPOST		
Imazethapyr	87	PRE	93	90
bentazon + aciflurofen + NIS	842	EPOST		
imazethapyr + NIS	53	LPOST		
Bentazon + aciflurofen + NIS	842	EPOST	94	92
imazethapyr + NIS	53	LPOST		
Imazethapyr	87	PRE	92	91
carfentrazone + NIS	28	EPOST		
imazethapyr + NIS	53	LPOST		
Carfentrazone + NIS	28	EPOST	94	95
imazethapyr + NIS	53	LPOST		
Imazethapyr	87	PRE	91	90
halosulfuron + NIS	53	EPOST		
imazethapyr + NIS	53	LPOST		
Halosulfuron + NIS	53	EPOST	93	92
imazethapyr + NIS	53	LPOST		
Imazethapyr	87	PRE	94	94
propanil + molinate + NIS	3370	EPOST		
imazethapyr	53	LPOST		
Propanil + molinate + NIS	3370	EPOST	96	91
imazethapyr + NIS	53	LPOST		
Imazethapyr	87	PRE	90	86
triclopyr + NIS	280	EPOST		
imazethapyr + NIS	53	LPOST		
Triclopyr + NIS	280	EPOST	89	85
imazethapyr + NIS	53	LPOST		
Imazethapyr	87	PRE	96	97
V-10029 + SBS	22	EPOST		
imazethapyr + NIS	53	LPOST		

(Table 3.2 continued)

V-10029 + SBS	22	EPOST	94	93
imazethapyr + NIS	53	LPOST		
Imazethapyr	87	PRE	24	34
imazethapyr + NIS	53	LPOST		
Imazethapyr	87	PRE	24	34
Imazethapyr + NIS	53	LPOST	26	40
LSD (0.05)			8	11

[a]PRE, preemergence; EPOST, early postemergence; LPOST, late postemergence

[b]A treatment interaction occurred for hemp sesbania at 21 and 35 DAT.

[c]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant

with V-10029 applied in a single application at the three- to four-leaf rice stage. Researchers have also reported a single PRE application of imazethapyr at 87 g/ha controlled hemp sesbania and Indian jointvetch less than 10%, but control increased to above 90% with a MPOST tank-mix of imazethapyr plus a herbicide with broadleaf activity (Pellerin et al. 2001).

Red rice control was evaluated in 2001 at both locations (Table 3.3). Data were averaged over locations at 21 and 42 DAT since a treatment interaction was observed but not a location by treatment interaction. At 21 DAT, the standard imazethapyr treatment controlled red rice 88%, which is comparable with published reports for red rice control with imazethapyr applied to the soil fb a POST application (Kurtz and Street 1999; Masson and Webster 2001; Steele et al. 2002; White and Hackworth 1999). The addition of an EPOST herbicide into a imazethapyr program did not reduce or increase red rice control as compared to the standard treatment. However, single applications of imazethapyr PRE or LPOST controlled red rice less than 75%. Other research has shown that single applications of imazethapyr to the soil at 70 g/ha controlled red rice less than 65% (Kurtz and Street 1999; Ottis et al. 2001). At 42 DAT, the standard imazethapyr treatment controlled red rice 86% and no differences were observed in control with the addition of EPOST herbicides to the treatment. Differences in red rice control, however, were observed with the standard imazethapyr treatment compared with treatments with no imazethapyr PRE and EPOST applications of bensulfuron, triclopyr, propanil plus molinate, halosulfuron, and V-10029. Treatments consisting of single applications of imazethapyr PRE or LPOST controlled red rice less than 25%. This data is consistent with control observed in Mississippi with a single application of imazethapyr at 70 or 87 g/ha PRE with less than

Table 3.3 Evaluation of weed control programs for red rice control at 21 and 42 d after late postemergence (LPOST) treatment (DAT) and rice yield at Crowley and Rayne, LA in 2001 in drill-seeded imidazolinone-tolerant rice.

			2001			
			Red rice[b]		Yield[c]	
Herbicide programs	g ai/ha	Timing[a]	21 DAT	42 DAT	Crowley	Rayne
			%		kg/ha	
Imazethapyr	87	PRE	85	86	2290	3000
bensulfuron + COC[d]	42	EPOST				
imazethapyr + NIS	53	LPOST				
Bensulfuron + COC	42	EPOST	80	50	1980	760
Imazethapyr + NIS	53	LPOST				
Imazethapyr	87	PRE	88	84	3410	1960
bentazon + aciflurofen + NIS	842	EPOST				
imazethapyr + NIS	53	LPOST				
Bentazon + aciflurofen + NIS	842	EPOST	88	79	3120	710
imazethapyr + NIS	53	LPOST				
Imazethapyr	87	PRE	88	90	3430	2380
carfentrazone + NIS	28	EPOST				
imazethapyr + NIS	53	LPOST				
Carfentrazone + NIS	28	EPOST	81	82	2500	1400
imazethapyr + NIS	53	LPOST				
Imazethapyr	87	PRE	87	87	2800	2330
halosulfuron + NIS	53	EPOST				
imazethapyr + NIS	53	LPOST				

(Table 3.3 continued)

Halosulfuron + NIS	53	EPOST	80	71	1490	1600
imazethapyr + NIS	53	LPOST				
Imazethapyr	87	PRE	85	81	3020	2680
propanil + molinate + NIS	3370	EPOST				
imazethapyr	53	LPOST				
Propanil + molinate + NIS	3370	EPOST	80	62	2380	1680
imazethapyr + NIS	53	LPOST				
Imazethapyr	87	PRE	87	80	3370	2270
triclopyr + NIS	280	EPOST				
imazethapyr + NIS	53	LPOST				
Triclopyr + NIS	280	EPOST	73	55	1820	1930
imazethapyr + NIS	53	LPOST				
Imazethapyr	87	PRE	86	88	3510	2840
V-10029 + SBS	22	EPOST				
imazethapyr + NIS	53	LPOST				
V-10029 + SBS	22	EPOST	81	67	3110	2600
imazethapyr + NIS	53	LPOST				
Imazethapyr	87	PRE	88	86	740	710
imazethapyr + NIS	53	LPOST				
Imazethapyr	87	PRE	53	11	0	360
Imazethapyr + NIS	53	LPOST	74	24	0	1180
Nontreated					0	520
LSD (0.05)			6	12	700	

[a]PRE, preemergence; EPOST, early postemergence; LPOST, late postemergence.
[b]A treatment interaction occurred for red rice at 21 and 42 DAT.
[c]A herbicide treatment by location interaction occurred for rice yield.
[d]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant

30% red rice control (Kurtz and Street 1999). However, control increased with the addition of an EPOST application compared with single applications of imazethapyr.

A herbicide treatment by location interaction occurred for rice yield (Table 3.3). In 2001 at both locations, rice yields were less than 3,600 kg/ha for all treatments due to excessive rain at maturity, heavy infestations of hemp sesbania and red rice in plots which reduced control, and severe disease pressure on CL 121 and CL 141 lines. These factors resulted in a delay in harvest and excessive lodging resulting in a reduction in yield. Rice treated with imazethapyr at 87 g/ha PRE fb 53 g/ha LPOST resulted in a rice yield of 740 kg/ha and rice treated with single applications of imazethapyr PRE or LPOST resulted no yield at Crowley. All other treatments increased rice yields. Bentazon plus acifluorfen and V-10029 EPOST resulted in similar yields regardless of PRE imazethapyr applications, This was probably due to the broadspectrum activity of bentazon plus acifluorfen, and V-10029 on the broadleaf weeds present in this study which resulted in reduced season-long weed competition. Treatments with triclopyr, propanil plus molinate, carfentrazone, and halosulfuron required two applications of imazethapyr to obtain yields similar to programs with bentazon plus acifluorfen and V-10029.

At the Rayne location, rice yield with V-10029 and triclopyr were the only EPOST applications that were similar regardless of imazethapyr PRE applications. Rice yields with treatments containing V-10029 EPOST did not differ compared with the same treatments near Crowley. All other EPOST applications required two applications of imazethapyr to obtain rice yield similar to V-10029 EPOST fb imazethapyr LPOST. At the Rayne location, imazethapyr LPOST resulted in a rice yield of 1180 kg/ha and this was probably due to the increased red rice control at 21

DAT which allowed the rice to become more competitive during the growing season. However, imazethapyr PRE fb LPOST resulted in no yield at the Crowley location due to a heavy infestation of hemp sesbania.

No differences were observed for rice plant height recorded at harvest. Rice injury never exceeded 5% (data not shown).

Water-seeded. In 2000, a location interaction was observed for barnyardgrass control at 28 DAT. Barnyardgrass control was 95 and 89% for the Crowley and Rayne locations, respectively (data not shown). At 42 DAT, data were averaged over location since a treatment interaction was observed but not a location by treatment interaction (Table 3.4). The standard imazethapyr program consisting of 87 g/ha SURF fb 53 g/ha LPOST controlled barnyardgrass 95%. No differences were observed for all treatments regardless of the number of imazethapyr applications. However, barnyardgrass control was lower with a single application of imazethapyr at 53 g/ha LPOST. A reduction in control was observed because the imazethapyr rate was too low to compensate for the population density and barnyardgrass size at time of application. Masson et al. (2001) reported 140 g/ha imazethapyr LPOST controlled barnyardgrass 50 and 70% at locations near Crowley, LA and St. Joseph, LA.

Alligatorweed was only evaluated at the Rayne location. Data were averaged over year since a treatment interaction was observed, but not a year by treatment interaction at 28 and 42 DAT (Table 3.4). At 28 DAT, the standard imazethapyr treatment controlled alligatorweed 35%. An increase in control was observed with treatments receiving imazethapyr SURF and LPOST in addition to a herbicide with broadleaf activity EPOST. At 42 DAT, those treatments consisting of SURF fb EPOST fb LPOST, except triclopyr, controlled alligatorweed 78 to 92% and were higher than the standard treatment with 60% control. A soil

Table 3.4 Evaluation of weed control programs for barnyardgrass at 42 d after late postemergence (LPOST) treatment (DAT) at Crowley and Rayne, LA in 2001 and alligatorweed control at 28 and 42 DAT at Rayne, LA in water-seeded imidazolinone-tolerant rice.

			Barnyardgrass[b]	Alligatorweed[b]	
Weed control programs	g ai/ha	Timings[a]	42 DAT	28 DAT	42 DAT
			%		
Imazethapyr	87	SURF	95	82	92
bensulfuron + COC[c]	42	EPOST			
imazethapyr + NIS	53	LPOST			
Bensulfuron + COC	42	EPOST	96	76	86
Imazethapyr + NIS	53	LPOST			
Imazethapyr	87	SURF	97	57	78
bentazon + aciflurofen + NIS	842	EPOST			
imazethapyr + NIS	53	LPOST			
Bentazon + aciflurofen + NIS	842	EPOST	97	39	70
imazethapyr + NIS	53	LPOST			
Imazethapyr	87	SURF	97	69	91
carfentrazone + NIS	28	EPOST			
imazethapyr + NIS	53	LPOST			
Carfentrazone + NIS	28	EPOST	93	25	53
imazethapyr + NIS	53	LPOST			
Imazethapyr	87	SURF	96	76	92
halosulfuron + NIS	53	EPOST			
imazethapyr + NIS	53	LPOST			
Halosulfuron + NIS	53	EPOST	96	38	81
imazethapyr + NIS	53	LPOST			

(Table 3.4 continued)

Imazethapyr	87	SURF	97	68	84
propanil + molinate + NIS	3370	EPOST			
imazethapyr	53	LPOST			
Propanil + molinate + NIS	3370	EPOST	96	46	73
imazethapyr + NIS	53	LPOST			
Imazethapyr	87	SURF	96	60	71
triclopyr + NIS	280	EPOST			
imazethapyr + NIS	53	LPOST			
Triclopyr + NIS	280	EPOST	95	55	74
imazethapyr + NIS	53	LPOST			
Imazethapyr	87	SURF	95	69	83
V-10029 + SBS	22	EPOST			
imazethapyr + NIS	53	LPOST			
V-10029 + SBS	22	EPOST	96	58	79
imazethapyr + NIS	53	LPOST			
Imazethapyr	87	SURF	95	35	60
imazethapyr	53	LPOST			
Imazethapyr	87	SURF	96	48	68
Imazethapyr	53	LPOST	92	26	40
LSD (0.05)			3	22	16

[a]SURF, surface prior to seedling flood establishment; EPOST, early postemergence; LPOST, late postemergence.

[b]A treatment interaction occurred for barnyardgrass at 42 DAT and alligatorweed at 28 and 42 DAT.

[c]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant

application of imazethapyr was not required with treatments consisting of bensulfuron, halosulfuron, and V-10029 EPOST fb imazethapyr LPOST which increased alligatorweed control compared with the standard.

Hemp sesbania was evaluated at the Crowley location in 2000 and 2001 (Table 3.5). Data were averaged over years at 21 and 35 DAT since a treatment interaction was observed but not a location by treatment interaction. At 21 DAT, the standard treatment of imazethapyr SURF fb imazethapyr LPOST controlled hemp sesbania 13%. Control increased with the addition of a broadleaf herbicides EPOST. Propanil + molinate, carfentrazone, bentazon + acifluorfen, or halosulfuron EPOST fb imazethapyr LPOST controlled hemp sesbania 89 to 93% and control was higher than bensulfuron and triclopyr regardless of imazethapyr SURF application. At 35 DAT, similar trends were observed with 6% hemp sesbania control with the standard treatment and 81 to 89% with all treatments receiving a EPOST application of a herbicide with broadleaf activity, except bensulfuron and triclopyr. Zhang et al. (2001) reported no control of hemp sesbania with single applications of imazethapyr at 35 and 53 g/ha PPI or POST. Hemp sesbania is known to favor wet conditions which could possibly create a problem in water-seeded rice production systems if not controlled (Lorenzi and Jeffery 1987).

A herbicide treatment by location interaction occurred for red rice control at 21 and 42 DAT in 2001 (Table 3.6). Imazethapyr applied at 87 g/ha PRE fb 53 g/ha LPOST 83 and 93% at the Crowley and Rayne locations, respectively, at 21 DAT. At Crowley, no difference in control was observed for a single SURF application of imazethapyr at 87 g/ha compared with the standard program, but at the Rayne location a reduction in control was observed. In respect to each location, the addition of a herbicide with broadleaf activity EPOST did not increase

Table 3.5 Evaluation of weed control programs for hemp sesbania control at 21 and 35 d after late postemergence (LPOST) treatment (DAT) at Crowley, LA in water-seeded imidazolinone-tolerant rice.

			Hemp sesbania[b]	
Weed control programs	g ai/ha	Timings[a]	21 DAT	35 DAT
			%	
Imazethapyr	87	SURF	66	60
bensulfuron + COC[c]	42	EPOST		
imazethapyr + NIS	53	LPOST		
Bensulfuron + COC	42	EPOST	75	61
Imazethapyr + NIS	53	LPOST		
Imazethapyr	87	SURF	89	81
bentazon + aciflurofen + NIS	28	EPOST		
imazethapyr + NIS	53	LPOST		
Bentazon + aciflurofen + NIS	842	EPOST	89	87
imazethapyr + NIS	53	LPOST		
Imazethapyr	87	SURF	91	88
carfentrazone + NIS	842	EPOST		
imazethapyr + NIS	53	LPOST		
Carfentrazone + NIS	28	EPOST	94	85
imazethapyr + NIS	53	LPOST		
Imazethapyr	87	SURF	93	89
halosulfuron + NIS	53	EPOST		
imazethapyr + NIS	53	LPOST		
Halosulfuron + NIS	53	EPOST	89	81
imazethapyr + NIS	53	LPOST		
Imazethapyr	87	SURF	93	88
propanil + molinate + NIS	3370	EPOST		
imazethapyr	53	LPOST		
Propanil + molinate + NIS	3370	EPOST	90	84
imazethapyr + NIS	53	LPOST		
Imazethapyr	87	SURF	49	50
triclopyr + NIS	280	EPOST		
imazethapyr + NIS	53	LPOST		
Triclopyr + NIS	280	EPOST	56	53
imazethapyr + NIS	53	LPOST		
Imazethapyr	87	SURF	87	80
V-10029 + SBS	22	EPOST		
imazethapyr + NIS	53	LPOST		

(Table 4.2 continued)

V-10029 + SBS	22	EPOST	88	84
imazethapyr + NIS	53	LPOST		
Imazethapyr	87	SURF	13	6
imazethapyr	53	LPOST		
Imazethapyr	87	SURF	4	4
Imazethapyr	53	LPOST	16	10
LSD (0.05)			14	17

[a]SURF, surface prior to seedling flood establishment; EPOST, early postemergence; LPOST, late postemergence

[b]A treatment interaction occurred for hemp sesbania at 21 and 35 DAT.

[c]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant

Table 3.6 Evaluation of weed control programs for red rice control at 21 and 42 d after lat postemergence (LPOST) treatment (DAT) at Crowley and Rayne, LA in water-seeded imidazolinone-tolerant rice.

			Red rice[b]			
			21 DAT		42 DAT	
Weed control programs	g ai/ha	Timings[a]	Crowley	Rayne	Crowley	Rayne
			%			
Imazethapyr	87	SURF	84	95	97	94
bensulfuron + COC[c]	42	EPOST				
imazethapyr + NIS	53	LPOST				
Bensulfuron + COC	42	EPOST	84	78	64	78
Imazethapyr + NIS	53	LPOST				
Imazethapyr	87	SURF	81	95	98	94
bentazon + aciflurofen + NIS	842	EPOST				
imazethapyr + NIS	53	LPOST				
Bentazon + aciflurofen + NIS	842	EPOST	73	75	78	80
imazethapyr + NIS	53	LPOST				
Imazethapyr	87	SURF	86	95	97	94
carfentrazone + NIS	28	EPOST				
imazethapyr + NIS	53	LPOST				
Carfentrazone + NIS	28	EPOST	75	76	80	90
imazethapyr + NIS	53	LPOST				
Imazethapyr	87	SURF	84	93	96	90
halosulfuron + NIS	53	EPOST				
imazethapyr + NIS	53	LPOST				

(Table 3.6 continued)

Halosulfuron + NIS	53	EPOST	80	75	73	86
imazethapyr + NIS	53	LPOST				
Imazethapyr	87	SURF	85	95	97	96
propanil + molinate + NIS	3370	EPOST				
imazethapyr	53	LPOST				
Propanil + molinate + NIS	3370	EPOST	83	68	70	89
imazethapyr + NIS	53	LPOST				
Imazethapyr	87	SURF	83	90	97	84
triclopyr + NIS	280	EPOST				
imazethapyr + NIS	53	LPOST				
Triclopyr + NIS	280	EPOST	83	54	60	73
imazethapyr + NIS	53	LPOST				
Imazethapyr	87	SURF	83	95	97	89
V-10029 + SBS	22	EPOST				
imazethapyr + NIS	53	LPOST				
V-10029 + SBS	22	EPOST	81	60	78	75
imazethapyr + NIS	53	LPOST				
Imazethapyr	87	SURF	83	93	93	94
imazethapyr	53	LPOST				
Imazethapyr	87	SURF	84	59	43	65
Imazethapyr	53	LPOST	73	68	58	40
LSD (0.05)			7		8	

[a]SURF, surface prior to seedling flood establishment; EPOST, early postemergence; LPOST, late postemergence

[b]A herbicide treatment by location interaction occurred for red rice at 21 and 42 DAT in 2001.

[c]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant

or decrease red rice control. Treatments receiving a SURF application of imazethapyr at 87 g/ha controlled red rice 81 to 86% with no differences observed at Crowley. Red rice control at the Rayne location was 90 to 95% with a SURF fb a LPOST imazethapyr application regardless of EPOST herbicide used. An increase in control was observed for all treatments receiving a SURF application compared with those treatments lacking the initial SURF application of imazethapyr.

At 42 DAT, the standard program controlled red rice 93 and 94% at Crowley and Rayne, respectively. No differences in red rice control were observed within treatments receiving a SURF fb EPOST fb LPOST application, except for a decrease with triclopyr and V-10029 at the Rayne location compared with the Crowley location. In Crowley, all treatments receiving a SURF fb EPOST fb LPOST controlled red rice 96 to 97%, which was higher than all EPOST fb LPOST treatments. At the Rayne location, similar results were observed with SURF fb EPOST fb LPOST treatments; however, no difference was observed with treatments without a SURF application with propanil plus molinate or carfentrazone EPOST fb imazethapyr LPOST at the Rayne location. A decrease in red rice control occurred at both locations with single imazethapyr applications at 87 g/ha SURF or 53 g/ha LPOST. In this study, the reduction in control was attributed to a lower rate of imazethapyr being unable to control red rice in the four-leaf to two-tiller stage at time of application. Crop injury was less than 5% throughout the season for all treatments (Data not shown). Rice heights were recorded at crop maturity (Table 4.4). Rice measured 73 cm with the standard imazethapyr treatment with triclopyr EPOST fb imazethapyr LPOST being the only treatment with a lower reduced height.

A herbicide treatment by location interaction occurred for rice yield in 2001 (Table 3.7). Heavy rains near harvest, high red rice infestation in the nontreated and reduced control plots caused severe lodging, and severe disease on CL 121 and CL 141 rice lines impacted harvest efficiency. At the Crowley location, rice yield for rice receiving the standard treatment was 940 kg/ha with no differences observed with single applications of imazethapyr PRE or LPOST. Low rice yields were due to a poor rice stand caused by high, uncontrolled hemp sesbania population that shaded rice and competed season-long for light and nutrients in plots receiving imazethapyr only. Regardless of imazethapyr SURF, the addition of a herbicide with broadleaf activity EPOST controlled hemp sesbania which reflected in higher rice yields compared with the standard. Rice yields for treatments receiving propanil plus molinate, and imazethapyr SURF fb carfentrazone or V-10029 fb imazethapyr LPOST were 4,140 to 4,680 kg/ha and were higher than other treatments due to effective grass and broadleaf control. Previous researchers reported low densities of red rice at 5 plants/m^2 and hemp sesbania at 3 plants/m^2, reduced commercial rice and soybean yields by 22 to 25%, respectivley (Diarra 1985b; McWhorter and Anderson 1993). In this study, treatments that did not control red rice or hemp sesbania with no SURF application of imazethapyr resulted in rice yields less than other treatments. This was apparent when bensulfuron or triclopyr were applied EPOST. At the Rayne location, rice yield with the standard treatment was 2,930 kg/ha and higher than treatments receiving single applications of imazethapyr PRE or LPOST. Unlike Crowley, red rice was more problematic than hemp sesbania at this location. The decrease in rice yields with imazethapyr PRE or LPOST was attributed to reduced red rice control.

In conclusion, the effectiveness of imazethapyr will depend on weed spectrum and densities. Although previous research indicated an increase in barnyardgrass control of 73% with imazethapyr applied alone

Table 3.7 Rice height and rice yield at maturity were recorded in 2000 and 2001, respectively, at Crowley and Rayne, LA in water-seeded imidazolinone-tolerant rice.

Weed control programs	Timings[a]	g ai/ha	Height	Yield[b] Crowley	Yield[b] Rayne
			cm	kg/ha	kg/ha
Imazethapyr	87	SURF	77	3750	2460
bensulfuron + COC[c]	42	EPOST			
imazethapyr + NIS	53	LPOST			
Bensulfuron + COC	42	EPOST	77	2600	2800
Imazethapyr + NIS	53	LPOST			
Imazethapyr	87	SURF	79	3840	2970
bentazon + aciflurofen + NIS	28	EPOST			
imazethapyr + NIS	53	LPOST			
Bentazon + aciflurofen + NIS	28	EPOST	72	3890	2280
imazethapyr + NIS	53	LPOST			
Imazethapyr	87	SURF	76	4680	2290
carfentrazone + NIS	28	EPOST			
imazethapyr + NIS	53	LPOST			
Carfentrazone + NIS	28	EPOST	77	3920	2110
imazethapyr + NIS	53	LPOST			
Imazethapyr	87	SURF	79	3340	3130
halosulfuron + NIS	53	EPOST			
imazethapyr + NIS	53	LPOST			
Halosulfuron + NIS	53	EPOST	77	3550	3070
imazethapyr + NIS	53	LPOST			

(Table 3.7 continued)

Imazethapyr	87	SURF	75	4290	3060
propanil + molinate + NIS	3370	EPOST			
imazethapyr	5377	LPOST			
Propanil + molinate + NIS	3370	EPOST	78	4210	2040
imazethapyr + NIS	53	LPOST			
Imazethapyr	87	SURF	77	3150	1540
triclopyr + NIS	280	EPOST			
imazethapyr + NIS	53	LPOST			
Triclopyr + NIS	280	EPOST	65	2560	2770
imazethapyr + NIS	53	LPOST			
Imazethapyr	87	SURF	77	4140	2680
V-10029+ SBS	22	EPOST			
imazethapyr + NIS	53	LPOST			
V-10029 + SBS	22	EPOST	77	3750	3120
imazethapyr + NIS	53	LPOST			
Imazethapyr	87	SURF	73	940	2930
imazethapyr	53	LPOST			
Imazethapyr	87	SURF	69	1210	1530
Imazethapyr	53	LPOST	69	610	1700
LSD (0.05)			8	550	

[a]SURF, surface prior to seedling flood establishment; EPOST, early postemergence; LPOST, late postemergence

[b]A herbicide treatment by location interaction occurred for rice yield in 2001.

[c]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant

EPOST to 90 and 93% when tank mixed with pendimethalin [*N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine] and propanil, respectively (Liscano et al. 1999), the standard program with imazethapyr applied alone at 87 g/ha to the soil surface fb 53 g/ha LPOST controlled barnyardgrass above 95% late season in drill- and water-seeded IT rice. The standard program controlled red rice equivalent to, or higher, than other treatments evaluated while single imazethapyr applications resulted in reduced control indicating two applications of imazethapyr are required. Other researchers have also recommended sequential applications of imazethapyr for increased control of grass weeds such as barnyardgrass and red rice (Kurtz and Street 1999; Masson et al. 2001; Steele et al. 2002). However, imazethapyr applied alone is not a complete weed control program and failed to control all weeds evaluated. Alligatorweed control increased with soil applications of imazethapyr, but control with the standard program varied from 35 to 82% which indicates an inconsistency in control with imazethapyr and suggested only suppression of alligatorweed. Regardless of rice production system, the standard imazethapyr program with halosulfuron applied EPOST controlled alligatorweed 92%; however, with carfentrazone EPOST control was 74% in drill-seeded rice and increased to 91% in water-seeded. This study also demonstrated the weakness of imazethapyr on weeds belonging to the Fabaceae family such as hemp sesbania. In drill- and water-seeded IT rice, hemp sesbania control never exceeded 25% with the single or sequential applications of imazethapyr. Treatments receiving a broadleaf herbicide application EPOST increased control compared with the standard imazethapyr program; however, treatments with bensulfuron and triclopyr were inconsistent at controlling hemp sesbania. The lack of hemp sesbania control was reflected in the rice yields at the

Crowley location in 2000 and 2001. Yield reductions as high as 48% and 53% have been reported in irrigated soybeans and cotton with 2 hemp sesbania plants/m^2 (Bryson 1987; King and Purcell 1997). Rice yield for rice treated with the standard imazethapyr treatment was less than 950 kg/ha while an increase in rice yield was obtained for rice receiving an EPOST application. After surface irrigating and rainfall, the water-seeded studies held moisture for a longer duration of time as compared with the drill-seeded rice. Although direct comparisons can not be made it was evident that this allowed differences in red rice and hemp sesbania control to be observed according to the rice production system. Red rice populations were suppressed by the addition of saturated soils increasing control in the water-seeded studies. However, hemp sesbania control was higher in drill-seeded studies because wet conditions favor hemp sesbania growth. In this case water-seeded rice, and the efficacy of EPOST herbicides were restricted. However, programs consisting of imazethapyr PRE at 87 g/ha fb an EPOST application of carfentrazone at 28 g/ha, propanil plus molinate at 3370 g/ha, or V-10029 at 22 g/ha fb imazethapyr at 53 g/ha LPOST were the most consistent for controlling red rice and hemp sesbania which was reflected in higher yields.

CHAPTER 4

HERBICIDE COMBINATIONS WITH IMAZETHAPYR IN DRILL- AND WATER-SEEDED IMIDAZOLINONE-TOLERANT RICE PRODUCTION

Introduction

Imidazolinone-tolerant (IT) rice exhibits tolerance to the imidazolinone class of herbicides which inhibit the enzyme acetolactate synthase (ALS, E.C. 4.1.3.18) (Stidham and Singh 1991) and was developed through seed mutatgenesis allowing rice lines to be considered nontransgenic (Croughan 1994). Imazethapyr {(±)–2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid}, trade name NewPath®, has been labeled for use in drill-seeded IT rice at 70 g ai/ha applied to the surface as a preplant incorporated (PPI) or preemergence (PRE) application followed by (fb) 70 g/ha postemergence (POST)[1]. Previous research has demonstrated the efficacy of imazethapyr on grass weed species particularly barnyardgrass [*Echinochloa crus-galli* (L.) Beauv.] and red rice (*Oryza sativa* L.). Soil applications of imazethapyr at 70, 105, or 140 g/ha fb 70 g/ha POST controlled barnyardgrass 88% or better (Masson and Webster 2001). Single applications at 140 g/ha foliar applied controlled barnyardgrass (Masson et. al 2001). Several red rice biotypes collected from rice-growing areas in the southern U.S. were controlled at least 85% with 70 g/ha of imazethapyr (Gealy and Black 1999). Webster and Masson (2001) reported red rice control was above 95% with imazethapyr applied at 70 and 140 g/ha to rice in the two- to three-leaf stage.

However, researchers have demonstrated the weakness of imazethapyr on some broadleaf weeds and sedges. Variable control has

[1] NewPath herbicide label. BASF Corporation, P.O. Box 13528, Research Triangle Park, NC 27709.

been documented for yellow nutsedge (28 to 100%) with imazethapyr POST at 18, 36, 54, and 72 g/ha (Richburg et al. 1995). Researchers have also demonstrated the weakness of imazethapyr on those weeds in the Fabaceae, or legume, family (Judd et al. 1999). In peanuts, imazethapyr applied at various rates from 18 to 72 g/ha controlled sicklepod [*Senna obtusifolia* (L.) Irwin and Barneby] and Flordia beggarweed [*Desmodium tortuosum* (Sw.) DC.] 0 to 33% (Richburg et al. 1995). Minimal control with imazethapyr in IT rice has been reported for hemp sesbania [*Sesbania exaltata* (Raf.) Cory] and Indian jointvetch (*Aeschynomene indica* L.) (Dillon et al. 1999; Scherder et al. 2001; Zhang et al. 2001) In a water-seeded study conducted in Louisiana, soil applications of imazethapyr at 105 and 140 g/ha fb 70 g/ha POST resulted in 74% control of Indian jointvetch (Masson and Webster 2001). Rice production, especially water-seeded production, promote the establishment and growth of hemp sesbania and Indian jointvetch because both weeds favor wet, saturated soils (Lorenzi and Jeffery 1987).

Herbicide combinations have shown to be beneficial in controlling broader weed spectrums. In 1990, imazethapyr applied PPI or PRE in pinto beans (*Phaseolus vulgaris* L.) at 0.05 and 0.07 kg/ha controlled barnyardgrass less than herbicide combinations of imazethapyr plus metolachlor [2-chloro-*N*-(2-ethyl-6-methylphenyl)-*N*-(2-methoxy-1-methylethyl], pendimethalin [*N*-(1-ethylpropyl)-3,4-diemethyl-2,6-dinitrobenzenamine], trifluralin [2,6-dinitro-*N*,*N*-dipropyl-4-(trifluoromethyl) benzenamine], or EPTC (*S*-ethyl dipropyl carbamothioate) (Arnold et al. 1993). At 50 g/ha imazethapyr controlled common lambsquarters (*Chenopodium album* L.) 30% (Cantwell et al. 1989), but Wall (1995) reported an increase in control with imazethapyr applied with bentazon [3-(1-methylethyl)-(1*H*)-2,1,3-benzothiadiazin-4(3*H*)-one 2,2-dioxide] regardless of imazethapyr rate.

In soybean (*Glycine max* L. Merr.), an increase in control resulted with the combination of imazethapyr and glyphosate as compared to glyphosate alone for *Ipomoea* sp., Palmer amaranth (*Amaranthus palmeri* S. Wats), and velvetleaf (*Abutilon theophrasti* Medikus). However, due to reduced activity on weeds in the Fabaceae family with imazethapyr, no change was observed with hemp sesbania and sicklepod (Starke and Oliver 1998). Imazethapyr in combination with bentazon increased common ragweed (*Ambrosia artemisiifolia* L.), velvetleaf, and common lambsquarters (*Chenopodium album* L.) control (Bauer et al. 1995; Hager and Renner 1994). Increases in pitted morningglory (*Ipomean lacunose* L.) and johnsongrass [*Sorghum halepense* (L.) Pers.] control have been reported with imazethapyr combined with imazaquin {2[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-3-quinolinecaroxylic acid} (Riley and Shaw 1989).

In rice production, combinations of propanil [*N*-(3,4-dichlorophenyl)propanamide] plus pendimethalin POST were used for residual control of broadleaf and grass weeds (Richard and Street 1984). Propanil plus thiobencarb or butachlor controlled barnyardgrass greater than standard treatment of propanil alone at 4.5 kg/ha (Smith and Khodayari 1985).

Previous research indicated the lack of control of some broadleaf weeds with imazethapyr and the preference of herbicide combinations by some producers due to reductions in application cost and an increase control of a broader weed spectrum (Hydrick and Shaw 1994). Therefore, the objective of this study was to evaluate combinations of imazethapyr plus a herbicide with broadleaf activity. Studies were conducted in drill- and water-seeded IT rice to evaluate weed control and subsequent effect on rice yield in each planting system.

Materials and Method

Drill-seeded. A study was conducted at the Rice Research Station located near Crowley, LA and a producer location near Rayne, LA in 2000 and 2001. The soil at both locations was a Crowley silt loam (fine montmorillinitic, thermic Typic Albaqualf), with 6.4 pH and 1.4% organic matter. Seedbed preparation at both locations included a fall disking fb a spring disking and two passes in the opposite direction using a two-way bed conditioner equipped with rolling baskets and S-tine harrows set to operate at 6 cm deep. IT '93 AS-3510' and 'CL 121' rice were drill-seeded in 2000 and 2001, respectively. The Crowley location was planted on May 24, 2000 and May 7, 2001 and the Rayne location on June 2, 2000 and May 25, 2001. Plot consisted of eight 19-cm spaced rows, 5 m long.

The study consisted of a two-factor factorial arrangement of treatments in a randomized complete block design with four replications. Factors A consisted of imazethapyr PRE at 87 g/ha, or no PRE. Factor B consisted of postemergence (POST) application at three- to four-leaf rice of imazethapyr at 53 g/ha in combination with one of the following herbicides: bensulfuron {2-[[[[[(4,6-dimethoxy-2-pyrimidinyl)amino]carbonyl]amino]sulfonyl]methyl]benzoic acid}, a package mixture[2] of 561 g/ha bentazon [3-(1-methylethyl)-(1H)-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide] + 281 g/ha acifluorfen {5-[2-chloro-4-(trifluoromethyl)phenoxy]-2-nitrobenzoic acid} , carfentrazone {X,2-dichloro-5-[4-(diflurometh yl)-4,5-dihydro-3-methyl-5-oxo-1H-1,2,4-triazol-1-yl]-4-fluorobenzenepropanic acid}, halosulfuron {3-chloro-5-[[[[(4,6-dimethoxy-2-pyrimidinyl)amino]carbonyl]amino]sulfonyl]-1-

[2] Storm herbicide label. BASF Corporation, P.O. Box 13528, Research Triangle Park, NC 27709.

methyl-1H-pyrazole-4-carboxylic acid}, a package mixture[3] of 1.68 kg/ha propanil [N-(3,4-dichlorophenyl)propanamide] + 1.68 kg/ha molinate (S-ethyl hexahydro-1H-azepine-1-carbothioate), triclopyr [(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid, or V-10029 {sodium 2,6-bis[(4,6-dimethoxypyrimidin-two-yl)oxy]benzoate}. Factors and herbicide rates are listed in Table 4.1. Crop oil concentrate[4] at 1% (v/v) was added to POST treatments containing bensulfuron. A nonionic surfactant[5] at 0.25% (v/v) was included with EPOST treatments containing bentazon plus acifluorfen, carfentrazone, halosulfuron, triclopyr and single POST treatments of imazethapyr. A silicon based surfactant[6] at 0.125% (v/v) was added to POST treatments containing of V-10029.

The study was surface irrigated three times before permanent flood establishment; twenty-four h after PRE application, at the two- to three-leaf rice stage, and at the three- to four-leaf rice stage. Soil fertility management consisted of 280 kg/ha of 7-21-21 fertilizer preplant and 280 kg/ha of 46-0-0 urea nitrogen applied immediately before permanent flood establishment. Standard agronomic and pest management practices were implemented throughout the growing season to maximize yield.

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[3] Arrosolo herbicide label. RICECO Corporation, 5100 Poplar Avenue, Suite 2428, Memphis, TN 38137.

[4] Crop oil concentrate Agri-Dex ®is nonionic spray adjuvant consisting of a blend of heavy range paraffin base petroleum oil, polyol fatty acid esters, and polyethoxylated derivatives. Helena Chemical Company. 6075 Poplar Ave., Suite 500, Memphis, TN 38119.

[5] Nonionic surfactant Latron AG-98® is a mixture of alkylaryl polyoxyethylene glycols. Rohm and Hass. 100 Independence Mall West, Philadelphia, PA 19106.

[6] Silicon based surfactant Kinetic® is a blend of polyalkyleneoxide modified polydimethylsiloxane and polyoxypropylene-polyoxyethylene block copolymers. Helena Chemical Company. 6075 Poplar Ave., Suite 500, Memphis, TN 38119.

Table 4.1 Factors for herbicide programs in drill- and water-seeded imidazolinone-tolerant rice and corresponding treatment number.

Factor A[a]	Factor B[b]		
Soil Applied	Postemergence combinations	Rate (g ai/ha)	Treatment Number
Imazethapyr	Imazethapyr plus	53	
(87 g/ha)	Bensulfuron + COC[c]	42	1
	Bentazon + aciflurofen + NIS	842	2
	Carfentrazone + NIS	28	3
	Halosulfuron + NIS	53	4
	Propanil + molinate + NIS	3370	5
	Triclopyr + NIS	280	6
	V-10029 + SBS	22	7
	No broadleaf herbicide		8
	No POST		9
None	Imazethapyr plus	53	
	Bensulfuron + COC	42	10
	Bentazon + aciflurofen + NIS	842	11
	Carfentrazone + NIS	28	12
	Halosulfuron + NIS	53	13
	Propanil + molinate + NIS	3370	14
	Triclopyr + NIS	280	15
	V-10029 + SBS	22	16
	No broadleaf herbicide		17
	No POST		18

[a]A soil application preemergence in drill-seeded rice and surface application 24 h prior to seeding flood establishment in water-seeded rice.

[b]Applied postemergence on three- to four-leaf rice.

[c]COC, crop oil concentrate, NIS, nonionic surfactant; SBS, silicon based surfactant.

[d]Combination of no soil applied followed by no tank mixture was not included in statistical analysis and was used only as a comparison treatment.

All herbicide applications were made with a CO_2-pressurized backpack sprayer calibrated to deliver 140 L/ha spray volume at 186 Kpa. POST treatments were applied when barnyardgrass and red rice were 18 to 25 cm tall with four-leaves to one-tiller, hemp sesbania was 15 to 20 cm tall with eight- to ten-leaves, and alligatorweed [*Alternanthera philoxeroides* (Mart.) Griseb.] was 10 to 20 cm tall with ten- to fifteen-leaves. The average densities for weeds at both locations were 70, 100, 20 and 30 m^2 for barnyardgrass, red rice, hemp sesbania and alligatorweed, respectively.

Water seeded. The water-seeded study followed the same procedures as the drill-seeded study with the exception of imazethapyr application and seeding method. All PRE applications were replaced with a surface (SURF) application that consisted of imazethapyr applied SURF 24 hours (h) prior to seedling flood establishment. One hundred kilograms of IT rice was placed in a mesh bag and submerged in water for 24 h. The bag was removed and allowed to drain for 12 h to promote seed germination. Pregerminated seeds were then broadcasted by airplane into a standing 6 cm flood at Crowley on May 26, 2000 and May 10, 2001 and at the Rayne location on June 2, 2000, and May 26, 2001. IT lines planted were 93 AS-3510 rice in 2000, and CL-121 rice and ‘CL-141’ rice in 2001 at Crowley and Rayne, respectively. The flood was removed 24 h after planting to initiate seedling establishment. The entire study was surface irrigated one week after planting, at the two- to three-leaf rice stage and three- to four-leaf rice stage with permanent flood establishment at five- to six-leaf rice.

All herbicide applications were made using a CO_2-pressurized backpack sprayer calibrated to deliver 140 L/ha spray volume at 186 Kpa. POST treatments were applied when barnyardgrass and red rice were 20 to 30 cm tall, or four- leaves to two-tillers, hemp sesbania was 20 to 25 cm, or six- to nine-leaves, and alligatorweed was 10 to 20 cm, or ten- to fifteen-leaves. Average densities of barnyardgrass, red rice, hemp sesbania, and alligatorweed were 60, 100, 20, and 30m^2, respectively.

For both seeding methods visual weed control and crop injury were estimated on a scale of 0 (no control or injury) to 100% (complete plant death). Grass weeds evaluated included barnyardgrass control at 14 and 35 days after LPOST treatment (DAT) and red rice control at 21 and 35 DAT. Broadleaf weeds evaluated included hemp sesbania control at 14 and 35 DAT and alligatorweed control at 14 and 35 DAT. Plant height was recorded at harvest and determined by measuring the plant from ground level to the tip of the extended panicle.

Rice was harvested with a small-plot combine and percent moisture was obtained and rough rice yield was adjusted to 12% moisture content. All data were subjected to the Mixed Procedure (SAS Institute 1999), with year, or location, being used as a random-effects parameter testing all possible interactions of herbicide treatments. Means were separated using Difference of Least Square at the 5% probability level. Tables for appropriate interactions were created.

Results and Discussion

Drilled-seeded. Barnyardgrass was evaluated at the Crowley location. A PRE by POST interaction occurred at 14 and 35 days after POST treatment (DAT). Means are presented in Table 4.2 and the PRE by POST interactions are listed in Table 4.3 for barnyardgrass. At 14 DAT, the total imazethapyr program consisting of imazethapyr at 87 g/ha PRE fb imazethapyr at 53 g/ha POST controlled barnyardgrass 92% and the addition of a tank-mix partner POST did not enhance control. However, control was higher with a PRE application fb POST compared with

Table 4.2 Control of barnyardgrass at 14 and 35 d after postemergence (POST) treatment (DAT), red rice at 35 DAT, and alligatorweed at 21 DAT for weed control programs in drill-seeded imidazolinone-tolerant rice.

Postemergence herbicide treatments	Rate	% Control PRE[a]	% Control No PRE
	g ai/ha	Barnyardgrass 14 DAT	
Imazethapyr plus[b]	53		
Bensulfuron + COC[c]	42	91	59
Bentazon + aciflurofen + NIS	842	89	63
Carfentrazone + NIS	28	90	59
Halosulfuron + NIS	53	86	63
Propanil + molinate + NIS	3370	93	74
Triclopyr + NIS	280	89	58
V-10029 + SBS	22	91	76
No tank-mix		92	67
No POST		78	0
		Barnyardgrass 35 DAT	
Imazethapyr plus	53		
Bensulfuron + COC	42	94	64
Bentazon + aciflurofen + NIS	842	94	49
Carfentrazone + NIS	28	94	44
Halosulfuron + NIS	53	92	32
Propanil + molinate + NIS	3370	87	83
Triclopyr + NIS	280	90	39
V-10029 + SBS	22	95	63
No tank-mix		94	0
No POST		52	9
		Red rice 35 DAT	
Imazethapyr plus	53		
Bensulfuron + COC	42	66	49
Bentazon + aciflurofen + NIS	842	74	58
Carfentrazone + NIS	28	76	50
Halosulfuron + NIS	53	77	56
Propanil + molinate + NIS	3370	72	60
Triclopyr + NIS	280	73	33
V-10029 + SBS	22	81	57
No tank-mix		73	61
No POST		0	0

(Table 4.2 continued)

		Alligatorweed 21 DAT	
Imazethapyr plus	53		
Bensulfuron + COC	42	90	81
Bentazon + aciflurofen + NIS	842	87	76
Carfentrazone + NIS	28	79	76
Halosulfuron + NIS	53	90	79
Propanil + molinate + NIS	3370	87	82
Triclopyr + NIS	280	87	81
V-10029 + SBS	22	85	76
No tank-mix		83	68
No POST		66	0

[a]PRE, preemergence application of imazethapyr at 87 g ai/ha following planting.

[b]POST, postemergence application at three- to four-leaf rice which consisted of imazethapyr at 53 g ai/ha with each of the herbicides listed under POST herbicide treatment.

[c]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant.

Table 4.3 Weed control programs for imidazolinone-tolerant drill-seeded rice with preemergence (PRE)[a] by postemergence (POST)[b] timing interactions for barnyardgrass at 14 and 35 d after POST treatment (DAT), red rice at 35 DAT, and hemp sesbania at 21 DAT.

Postemergence herbicide treatment	Rate[c]	Imazethapyr PRE at 87 g/ha									No imazethapyr PRE							
		1[d]	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Barnyardgrass interactions at 14 DAT[e]																
Imazethapyr PRE	87																	
Imazetharpy plus	53																	
1 Bensulfuron + COC[f]	42																	
2 Bentazon + aciflurofen + NIS	842	NS																
3 Carfentrazone + NIS	28	NS	NS															
4 Halosulfuron + NIS	53	NS	NS	NS														
5 Propanil + molinate + NIS	3370	NS	NS	NS	NS													
6 Triclopyr + NIS	280	NS	NS	NS	NS	NS												
7 V-10029 + SBS	22	NS	NS	NS	NS	NS	NS											
8 No tank mix		NS	NS	NS	NS	NS	NS	NS										
9 No POST		D1	D2	D2	D3	D2	D2	D2	D3									
No imazetahpyr PRE																		
10 Bensulfuron + COC	42	D3	D3	D3	D3	D3	D3	D3	D3	D3								
11 Bentazon + aciflurofen + NIS	842	D3	D3	D3	D3	D3	D3	D3	D3	D3	NS							

(Table 4.3 continued)

12 Carfentrazone + NIS	28	D3	D3	D3	D3	D3	D3	D3	D3	D3	NS	NS						
13 Halosulfuron + NIS	53	D3	D3	D3	D3	D3	D3	D3	D3	D3	NS	NS	NS					
14 Propanil + molinate + NIS	3370	D2	D3	D3	D2	D3	D3	D3	D3	NS	D3	D2	D3	D2				
15 Triclopyr + NIS	280	D3	D3	D3	D3	D3	D3	D3	D3	D3	NS	NS	NS	NS	D3			
16 V-10029 + SBS	22	D3	D2	D3	D1	D3	D3	D2	D3	NS	D3	D2	D3	D2	NS	D3		
17 No tank mix		D3	D3	D3	D3	D3	D3	D3	D3	D1	NS	NS	NS	NS	NS	D1	D1	
18 No POST		D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3
		Barnyardgrass interactions at 35 DAT																
Imazethapyr PRE	87																	
Imazethapyr plus	53																	
1 Bensulfuron + COC	42																	
2 Bentazon + aciflurofen + NIS	842	NS																
3 Carfentrazone + NIS	28	NS	NS															
4 Halosulfuron + NIS	53	NS	NS	NS														
5 Propanil + molinate + NIS	3370	NS	NS	NS	NS													
6 Triclopyr + NIS	280	NS	NS	NS	NS	NS												
7 V-10029 + SBS	22	NS	NS	NS	NS	NS	NS											
8 No tank mix		NS	NS	NS	NS	NS	NS	NS										
9 No POST		D3	D3	D3	D3	D2	D2	D3	D3									
No imazethapyr PRE																		
10 Bensulfuron + COC	42	D2	D2	D2	D2	D1	D2	D2	D2	NS								
11 Bentazon + aciflurofen + NIS	842	D3	D3	D3	D3	D3	D3	D3	D3	NS	NS							
12 Carfentrazone + NIS	28	D3	D3	D3	D3	D3	D3	D3	D3	NS	D1	NS						

(Table 4.3 continued)

13 Halosulfuron + NIS	53	D3	D3	D3	D3	D3	D3	D3	D3	D1	D2	NS	NS					
14 Propanil + molinate + NIS	3370	NS	NS	NS	NS	NS	NS	D2	NS	D1	NS	D2	D3	D3				
15 Triclopyr + NIS	280	D3	D2	D3	D3	D3	D3	D3	D3	NS	D1	NS	D2	NS	D3			
16 V-10029 + SBS	22	D2	D2	D2	D2	D1	D2	D2	D2	NS	NS	NS	NS	D2	D1	D1		
17 No tank mix		NS	D1	D1	NS	NS	NS	D1	NS	D1	NS	D1	D2	D3	NS	D2	NS	
18 No POST		D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D1	D2	NS	D3	D1	D3	D3
		Red rice interactions at 35 DAT																
Imazethapyr PRE	87																	
Imazethapyr plus	53																	
1 Bensulfuron + COC	42																	
2 Bentazon + aciflurofen + NIS	842	NS																
3 Carfentrazone + NIS	28	NS	NS															
4 Halosulfuron + NIS	53	NS	NS	NS														
5 Propanil + molinate + NIS	3370	NS	NS	NS	NS													
6 Triclopyr + NIS	280	NS	NS	NS	NS	NS												
7 V-10029 + SBS	22	D1	NS	NS	NS	NS	NS											
8 No tank mix		NS	NS	NS	NS	NS	NS	NS										
9 No POST		D3	D3	D3	D3	D3	D3	D3	D3									
No imazethapyr PRE																		
10 Bensulfuron + COC	42	D1	D3	D3	D3	D2	D3	D3	D2	D3								
11 Bentazon + aciflurofen + NIS	842	NS	D1	D2	D2	D1	D1	D2	NS	D3	NS							
12 Carfentrazone + NIS	28	D1	D3	D3	D3	D2	D3	D3	D1	D3	NS	NS						

(Table 4.3 continued)

13 Halosulfuron + NIS	53	NS	D2	D2	D2	D1	D1	D3	NS	D3	NS	NS	NS					
14 Propanil + molinate + NIS	3370	NS	D1	D1	D1	NS	D1	D2	NS	D3	NS	NS	NS	NS				
15 Triclopyr + NIS	280	D3	D3	D3	D3	D3	D3	D3	D3	D3	D1	NS	D1	D3	D3			
16 V-10029 + SBS	22	NS	D1	D2	D2	D1	D1	D3	NS	D3	NS	NS	NS	NS	NS	D3		
17 No tank mix		NS	NS	D1	D1	NS	NS	D2	NS	D3	NS	NS	NS	NS	NS	D3	NS	
18 No POST		D3	D3	D3	D3	D3	D3	D3	D3	NS	D3	D3	D3	D3	D3	D3	D3	D3
		Alligatorweed interactions at 21 DAT																
Imazethapyr PRE	87																	
Imazetahpry plus	53																	
1 Bensulfuron + COC	42																	
2 Bentazon + aciflurofen + NIS	842	NS																
3 Carfentrazone + NIS	28	NS	NS															
4 Halosulfuron + NIS	53	NS	NS	NS														
5 Propanil + molinate + NIS	3370	NS	NS	NS	NS													
6 Triclopyr + NIS	280	NS	NS	NS	NS	NS												
7 V-10029 + SBS	22	NS	NS	NS	NS	NS	NS											
8 No tank mix		NS	NS	NS	NS	NS	NS	NS										
9 No POST		D3	D3	D1	D3	D2	D2	D2	D2									
No imazethapyr PRE																		
10 Bensulfuron + COC	42	NS	NS	NS	NS	NS	NS	NS	NS	D2								
11 Bentazon + aciflurofen + NIS	842	D1	NS	NS	D1	NS	NS	NS	NS	NS	NS							
12 Carfentrazone + NIS	28	D1	NS	NS	D1	NS	NS	NS	NS	NS	NS	NS						
13 Halosulfuron + NIS	53	D1	NS	NS	D1	NS	NS	NS	NS	D1	NS	NS	NS					

(Table 4.3 continued)

14 Propanil + molinate + NIS	3370	NS	NS	NS	NS	NS	NS	NS	NS	D2	NS	NS	NS	NS				
15 Triclopyr + NIS	280	NS	NS	NS	NS	NS	NS	NS	NS	D2	NS	NS	NS	NS	NS			
16 V-10029 + SBS	22	D1	NS	NS	D1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS		
17 No tank mix		D3	D2	D1	D3	D2	D2	D2	D2	NS	D1	NS	NS	D1	D1	D1	NS	
18 No POST		D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3

[a]PRE, preemergence application of imazethapyr at 87 g ai/ha following planting.
[b]POST, postemergence application at three- to four-leaf rice which consisted of a tank-mix of imazethapyr at 53 g ai/ha with each of the herbicides listed under POST herbicide treatment.
[c]Rate of POST herbicide treatments are in g ai/ha.
[d]Numbers correspond to numbered treatments listed in postemergence herbicide treatment column.
[e]Abbreviations: NS, non-significant ≥ 0.05; D1 < 0.05 to 0.01; D2 < 0.009 to 0.001; D3 < 0.0009.
[c]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant.

treatments with only a PRE or POST application. A similar trend was observed at 35 DAT with no differences being observed among treatments receiving a PRE fb POST application. Although Masson et al. (2001) reported 91% with imazethapyr at 140 g/ha PRE, in this study a single application of 87 g/ha imazethapyr PRE controlled barnyardgrass 52%. However, imazethapyr PRE fb imazethapyr at 53 g/ha POST increased control to 94%. Imazethapyr tank-mixed with propanil plus molinate POST controlled barnyardgrass 83% which was equal to all treatments consisting of imazethapyr PRE fb a POST, except that control increased with imazethapyr PRE fb imazethapyr POST plus V-10029 to 95%. No other single POST application controlled barnyardgrass similar to the PRE fb POST programs. This is similar to research by Webster and Masson (2001) who reported 53% control of barnyardgrass with imazethapyr applied alone on two- to three-leaf rice at 70 and 140 g/ha.

Red rice control was evaluated at Crowley and Rayne in 2001. At 21 DAT, no PRE by POST interaction occurred; however, a PRE interaction and a POST interaction occurred (Table 4.4). Red rice control averaged over POST was 79% with imazethapyr PRE, but decreased to 59% with no soil application. Previous researchers have reported 95% red rice control with sequential applications of imazethapyr at 70 g/ha PRE fb 70 g/ha POST (Steele et al. 2002). For the PRE interaction red rice control was averaged over POST treatments, it included a treatment consisting of imazethapyr PRE fb no POST application which achieved only 9% red rice control and consequently lowered the overall average. Red rice control averaged over PRE was 82% with the total imazethapyr rogram. The addition of a tank mix partner did not increase red rice control, but control was reduced with the addition of bensulfuron or triclopyr. At 35 DAT, a PRE by POST interaction was observed (Table 4.3) and means are listed in Table 4.2. With a PRE application of

Table 4.4 Control of red rice at 21 d after postemergence (POST) treatment (DAT) averaged over preemergence (PRE)[a] and POST[b] timings in drill-seeded imidazolinone-tolerant rice at Crowley and Rayne in 2001.

Postemergence Herbicide Treatments	Rate	21 DAT		
		PRE	No PRE	Means[c]
	g ai/ha	%		
Imazethapyr plus	53			
Bensulfuron + COC[d]	42	83	58	70 bc
Bentazon + aciflurofen + NIS	842	88	69	78 ab
Carfentrazone + NIS	28	90	65	78 ab
Halosulfuron + NIS	53	91	69	80 a
Propanil + molinate + NIS	3370	88	70	79 ab
Triclopyr + NIS	280	81	56	68 c
V-10029 + SBS	22	90	73	82 a
No tank mix		92	71	82 a
No POST		9	0	5 d
Means		79 a	59 b	

[a]PRE, preemergence application of imazethapyr at 87 g ai/ha following planting.

[b]POST, postemergence application at three- to four-leaf rice which consisted of imazethapyr at 53 g ai/ha with each of the herbicides listed under POST herbicide treatment.

[c]Means within a column and a row followed by the same letter were not different according to the t-test on difference of least square means at P = 0.05.

[d]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant.

imazethapyr, V-10029 tank mixed with imazethapyr controlled red rice 81% and was higher than the imazethapyr PRE fb imazethapyr plus bensulfuron POST and all treatments not receiving the initial soil application of imazethapyr. No differences in red rice control were observed with POST applications of propanil plus molinate and imazethapyr alone regardless of PRE application of imazethapyr. However, a decrease in red rice control was observed with other POST tank mixtures within treatments with a PRE application as compared with treatments with no PRE. These data also demonstrate that imazethapyr applied alone PRE fb POST application is as effective as programs incorporating another herbicide suggesting that other herbicides will not be needed when red rice is the targeted weed.

Alligatorweed was evaluated at 21 and 35 DAT at the Rayne location in 2000 and 2001. At 21 DAT, a PRE by POST interaction occurred (Table 4.3) with means listed in Table 4.2. No differences in alligatorweed control were observed among treatments receiving a soil application of imazethapyr plus those treatments consisting of bensulfuron, propanil plus molinate, and triclopyr as tank mix partners, regardless of PRE application. Imazethapyr PRE fb imazethapyr POST controlled alligatorweed 83% and was higher than single applications of imazethapyr PRE or POST. At 35 DAT, no PRE by POST interaction occurred; however, a PRE interaction and a POST interaction were observed (Table 4.5). Averaged over POST treatments, alligatorweed weed control was 73% with imazethapyr PRE and decreased to 50% with no soil application. Averaging over the soil application factor, any POST tank-mixture controlled alligatorweed 64 to 77% with no differences observed. Imazethapyr alone POST controlled alligatorweed 44% averaged over the soil application factor. These

Table 4.5 Control of alligatorweed at 35 d after postemergence (POST) treatment (DAT) averaged over preemergence (PRE)[a] and POST[b] timings in drill-seeded imidazolinone-tolerant rice at Rayne, LA in 2000 and 2001.

		35 DAT		
Postemergence herbicide treatments	Rate	PRE	No PRE	Means[c]
	g ai/ha	%		
Imazethapyr plus	53			
Bensulfuron + COC[d]	42	75	67	71 a
Bentazon + aciflurofen + NIS[e]	842	86	69	77 a
Carfentrazone + NIS	28	80	48	64 a
Halosulfuron + NIS	53	86	61	73 a
Propanil + molinate + NIS	3370	82	52	67 a
Triclopyr + NIS	280	78	58	68 a
V-10029 + SBS[f]	22	82	58	70 a
No tank mix		52	36	44 b
No POST		39	0	20 c
Means		73 a	50 b	

[a]PRE, preemergence application of imazethapyr at 87 g ai/ha following planting.

[b]POST, postemergence application at three- to four-leaf rice which consisted of imazethapyr at 53 g ai/ha with each of the herbicides listed under POST herbicide treatment.

[c]Means within a column and a row followed by the same letter were not different according to the t-test on difference of least square means at P = 0.05.

[d]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant.

data indicate only suppression of alligatorweed can be achieved with the treatments evaluated.

Hemp sesbania control was evaluated at the Crowley location in 2000 and 2001. Due to a POST interaction, and not a PRE or PRE by POST interaction, data were averaged over PRE application at 14 and 35 DAT (Table 4.6). Imazethapyr applied alone in a single or sequential application controlled hemp sesbania 5 to 10% at both evaluation dates. At 14 DAT, POST applications of imazethapyr in combination with bensulfuron or V-10029 controlled hemp sesbania less than other POST herbicides evaluated. However, V-10029 has shown 88 to 95% control of hemp sesbania at 28 DAT in drill-seeded rice (Webster et al. 1999). At 35 DAT, with halosulfuron or V-10029 POST controlled hemp sesbania 94% and equal to other POST tank mixtures except bensulfuron and triclopyr at 69 and 84%, respectively. Fagerness and Penner (1998) reported the greatest growth suppression of annual bluegrass (*Poa annua* L.) with V-10029 occurred 2 to 3 weeks after treatment. This supports the increase observed in this study with hemp sesbania from 14 to 35 DAT.

Rice yield was recorded at the Crowley and Rayne locations in 2001. No PRE by POST interaction occurred; however, for rice yield PRE and POST interactions were observed (Table 4.7). Rice yield averaged over POST was higher with a PRE application of imazethapyr compared with treatments not receiving an initial soil application. When averaged over the soil application factor, no differences were observed among treatments receiving a POST application. With no POST application of imazethapyr rice yield was reduced. These data indicate that two applications of imazethapyr are needed to control red rice and maximize yield. Yields were low due to heavy rains near harvest, severe lodging, and disease on ‘93 AS-3510’ and ‘CL 121’ rice lines.

Table 4.6 Control of hemp sesbania at 14 and 35 d after postemergence (POST) treatment (DAT) averaged over preemergence (PRE)[a] timing in drill-seeded imidazolinone-tolerant rice at Crowley, LA in 2000 and 2001.

Postemergence Herbicide Treatments[b]	Rate	14 DAT[c]	35 DAT
	g ai/ha	%	
Imazethapyr plus	53		
Bensulfuron + COC[d]	42	75 b	69 c
Bentazon + aciflurofen + NIS	842	92 a	88 ab
Carfentrazone + NIS	28	92 a	87 ab
Halosulfuron + NIS	53	87 a	94 a
Propanil + molinate + NIS	3370	92 a	93 ab
Triclopyr + NIS	280	84 a	84 b
V-10029 + SBS	22	72 b	94 a
No tank mix		9 c	10 c
No POST		5 c	6 d

[a]PRE, preemergence application of imazethapyr at 87 g ai/ha. immediately following planting

[b]POST, postemergence application at three- to four-leaf rice which consisted of imazethapyr at 53 g ai/ha with each of the herbicides listed under POST herbicide treatment.

[c]Means within a column followed by the same letter were not different according to the t-test on difference of least square means at P = 0.05.

[d]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant.

Table 4.7 Rice yield recorded at maturity and averaged over preemergence (PRE)[a] and postemergence (POST)[b] timings at Crowley and Rayne, LA in 2001 in drill-seeded imidazolinone-tolerant rice.

		Rice yield		
Postemergence herbicide treatments	Rate	PRE	No PRE	Means[c]
	g ai/ha		kg/ha	
Imazethapyr plus	53			
Bensulfuron + COC[d]	42	2410	2230	2320 a
Triclopyr + NIS	280	2320	2520	2420 a
Propanil + molinate + NIS	3370	1980	1480	1730 a
Carfentrazone + NIS	28	2690	1290	1989 a
Bentazon + aciflurofen + NIS	842	2430	1460	1950 a
Halosulfuron + NIS	53	2500	1160	1830 a
V-10029 + SBS	22	2614	910	1760 a
No tank mix		1980	1230	1600 a
No POST		200	0	100 b
Means		2130 a	1380 b	

[a]PRE, preemergence application of imazethapyr at 87 g ai/ha following planting.

[b]POST, postemergence application at three- to four-leaf rice which consisted of imazethapyr at 53 g ai/ha with each of the herbicides listed under POST herbicide treatment

[c]Means within a column and a row followed by the same letter were not different according to the t-test on difference of least square means at P = 0.05.

[d]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant.

Rice height was measured from the ground level to the tip of the extended panicle at crop maturity. Height was determined at both locations in 2000; however, no differences were observed between treatments (data not shown). Crop injury was also recorded at each evaluation. Injury was less than 10% at each evaluation date (data not shown).

Water-seeded. Barnyardgrass was evaluated at Crowley, LA in 2000 and 2001. At 14 DAT, a SURF and POST interaction was observed, but no SURF by POST interaction occurred (Table 4.8). Barnyardgrass control averaged over POST was higher with a SURF application of imazethapyr compared with treatments not receiving a soil application. Averaging barnyardgrass control over the soil application, an increase in control was observed with treatments containg imazethapyr in combination with another herbicide compared with imazethapyr only treatments. Previous researchers have reported an increase in barnyardgrass control from 73 to 93% and 90% with 70 g/ha of imazethapyr in combination with pendimethalin and propanil, respectively (Liscano and Williams 1999). At 42 DAT, similar results were observed with data averaged over SURF application due to a POST interaction (Table 4.9). Barnyardgrass control was 94 to 96% with imazethapyr fb a tank-mixture POST compared with reduced control of 47 to 79% with imazethapyr only programs.

Red rice control was evaluated at Crowley and Rayne locations in 2001. At 21 and 35 DAT, a SURF by POST interaction was observed and means are presented in Table 4.10. Interactions are listed in Table 4.11. At 21 DAT, programs consisting of a imazethapyr SURF fb a POST application, with the exception of triclopyr, controlled red rice 92 to 96% and were higher than those treatments with no SURF application. At 35 DAT, an im controlled red rice 90%. Steele et al. (2002) reported

Table 4.8 Control of barnyardgrass at 14 d after postemergence (POST) treatment (DAT) averaged over surface (SURF)[a] and POST[b] timings in water-seeded imidazolinone-tolerant rice at Crowley in 2000 and 2001.

		14 DAT		
Postemergence herbicide treatments	Rate	SURF	No SURF	Means[c]
	g ai/ha	%		
Imazethapyr plus	53			
Bensulfuron + COC[d]	42	95	95	95 a
Bentazon + aciflurofen + NIS	842	95	95	95 a
Carfentrazone + NIS	28	94	95	95 a
Halosulfuron + NIS	53	95	95	95 a
Propanil + molinate + NIS	3370	95	95	95 a
Triclopyr + NIS	280	95	95	95 a
V-10029 + SBS	22	95	95	95 a
No tank mix		93	87	90 b
No POST		95	0	48 c
Means		94 a	91 b	

[a]SURF application of imazethapyr at 87 g ai/ha prior to seedling flood establishment.

[b]POST, postemergence application at three- to four-leaf rice which consisted of imazethapyr at 53 g ai/ha with each of the herbicides listed under POST herbicide treatment.

[c]Means within a column and a row followed by the same letter were not different according to the t-test on difference of least square means at P = 0.05.

[d]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant.

Table 4.9 Control of barnyardgrass at 42 d after postemergence (POST) treatment (DAT) and hemp sesbania at 35 DAT averaged over surface (SURF)[a] and POST[b] timings in water-seeded imidazolinone-tolerant rice at Crowely, LA in 2000 and 2001.

Postemergence herbicide treatments	Rate	Barnyardgrass 42 DAT[c]	Hemp sesbania 35 DAT
	g ai/ha	%	
Bensulfuron + COC[d]	42	95 a	52 c
Bentazon + aciflurofen + NIS	842	94 a	82 ab
Carfentrazone + NIS	28	95 a	86 ab
Halosulfuron + NIS	53	96 a	86 ab
Propanil + molinate + NIS	3370	95 a	92 a
Triclopyr + NIS	280	95 a	51 c
V-10029 + SBS	22	94 a	76 b
No tank mix		79 b	25 d
No POST		47 c	3 e

[a]SURF application of imazethapyr at 87 g ai/ha SURF prior to seedling flood establishment.

[b]POST, postemergence application at three- to four-leaf rice which consisted of a tank-mix of imazethapyr at 53 g ai/ha with each of the herbicides listed under POST herbicide treatment.

[c]Means within a column followed by the same letter were not different according to the t-test on difference of least square means at P = 0.05.

[d]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant.

Table 4.10 Control of red rice at 21 and 35 d after postemergence (POST) treatment (DAT), alligatorweed at 14 DAT, and hemp sesbania at 14 DAT for weed control programs in water-seeded imidazolinone-tolerant rice.

		% Control	
Postemergence herbicide treatments	Rate	SURF	No SURF
	g ai/ha	Red rice 21 DAT	
Imazethapyr plus	53		
Bensulfuron + COC[c]	42	96	54
Bentazon + aciflurofen + NIS	842	96	79
Carfentrazone + NIS	28	94	67
Halosulfuron + NIS	53	94	77
Propanil + molinate + NIS	3370	95	61
Triclopyr + NIS	280	90	61
V-10029 + SBS	22	95	63
No tank mix		92	65
No POST		7	0
		Red rice 35 DAT	
Imazethapyr plus	53		
Bensulfuron + COC	42	81	51
Bentazon + aciflurofen + NIS	842	68	62
Carfentrazone + NIS	28	90	58
Halosulfuron + NIS	53	89	66
Propanil + molinate + NIS	3370	90	64
Triclopyr + NIS	280	65	61
V-10029 + SBS	22	84	59
No tank mix		90	53
No POST		23	0
		Alligatorweed 14 DAT	
Imazethapyr plus	53		
Bensulfuron + COC	42	88	83
Bentazon + aciflurofen + NIS	842	88	81
Carfentrazone + NIS	28	91	74
Halosulfuron + NIS	53	86	79
Propanil + molinate + NIS	3370	86	80
Triclopyr + NIS	280	88	79
V-10029 + SBS	22	89	77
No tank mix		83	79
No POST		55	0

(Table 4.10 continued)

		— Hemp sesbania, %, 14 DAT —	
Imazethapyr plus	53		
Bensulfuron + COC	42	80	80
Bentazon + aciflurofen + NIS	842	88	93
Carfentrazone + NIS	28	96	95
Halosulfuron + NIS	53	95	94
Propanil + molinate + NIS	3370	96	95
Triclopyr + NIS	280	88	89
V-10029 + SBS	22	94	91
No tank mix		41	53
No POST		34	0

[a]SURF application of imazethapyr at 87 g ai/ha prior to seedling flood establishment.

[b]POST, post emergence application at three- to four-leaf rice which consisted of imazethapyr at 53 g ai/ha with each of the herbicides listed under POST herbicide treatment.

[c]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant.

Table 4.11 Weed control programs for water-seeded imidazolinone-tolerant rice with surface (SURF)[a] by postemergence (POST)[b] timings interactions for red rice at 21 and 35 d after POST treatment (DAT), alligatorweed at 14 DAT, and hemp sesbania at 14 DAT.

Postemergence herbicide treatment	Rate[c]	Imazethapyr SURF at 87 g/ha									No imazethapyr SURF							
		1[d]	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Red rice interactions at 21 DAT[e]																
Imazethapyr SURF	87																	
Imazethapyr plus	53																	
1 Bensulfuron + COC[f]	42																	
2 Bentazon + aciflurofen + NIS	842	NS																
3 Carfentrazone + NIS	28	NS	NS															
4 Halosulfuron + NIS	53	NS	NS	NS														
5 Propanil + molinate + NIS	3370	NS	NS	NS	NS													
6 Triclopyr + NIS	280	NS	NS	NS	NS	NS												
7 V-10029 + SBS	22	NS	NS	NS	NS	NS	NS											
8 No tank mix		NS	NS	NS	NS	NS	NS	NS										
9 No POST		D3	D3	D3	D3	D3	D3	D3	D3									
No imazethapyr SURF																		
10 Bensulfuron + COC	42	D3	D3	D3	D3	D3	D3	D3	D3	D3								
11 Bentazon + aciflurofen + NIS	842	D1	D1	D1	D1	D1	NS	D1	NS	D3	D3							
12 Carfentrazone + NIS	28	D3	D3	D3	D3	D3	D2	D3	D3	D3	NS	NS						

(Table 4.11 continued)

13 Halosulfuron + NIS	53	D2	D2	D1	D1	D2	NS	D2	D2	D3	D3	NS	NS					
14 Propanil + molinate + NIS	3370	D3	D3	D3	D3	D3	D3	D3	D3	D3	NS	D2	NS	D1				
15 Triclopyr + NIS	280	D3	D3	D3	D3	D3	D3	D3	D3	D3	NS	D1	NS	D1	NS			
16 V-10029 + SBS	22	D3	D3	D3	D3	D3	D3	D3	D3	D3	NS	D1	NS	D1	NS	NS		
17 No tank mix		D3	D3	D3	D3	D3	D3	D3	D3	D3	NS	D1	NS	NS	NS	NS	NS	
18 No POST		D3	D3	D3	D3	D3	D3	D3	D3	NS	D3	D3	D3	D3	D3	D3	D3	D3
		Red rice interactions at 35 DAT																
Imazethapyr SURF	87																	
Imazethapyr plus	53																	
1 Bensulfuron + COC	42																	
2 Bentazon + aciflurofen + NIS	842	D1																
3 Carfentrazone + NIS	28	NS	D3															
4 Halosulfuron + NIS	53	NS	D2	NS														
5 Propanil + molinate + NIS	3370	NS	D3	D3	NS													
6 Triclopyr + NIS	280	D1	NS	D3	D3	D3												
7 V-10029 + SBS	22	NS	D1	NS	NS	NS	D2											
8 No tank mix		NS	D3	NS	NS	NS	D3	NS	D3									
9 No POST		D3	D3	D3	D3	D3	D3	D3	D3	D3								
No imazethapyr SURF																		
10 Bensulfuron + COC	42	D3	D1	D3	D3	D3	D1	D3	D3	D3	NS							
11 Bentazon + aciflurofen + NIS	842	D2	NS	D3	D3	D3	NS	D3	D3	D3	NS							
12 Carfentrazone + NIS	28	D3	NS	D3	D3	D3	NS	D2	D3	D3	NS	NS						
13 Halosulfuron + NIS	53	D1	NS	D3	D3	D3	NS	D2	D3	D3	D2	NS	NS					

(Table 4.11 continued)

14 Propanil + molinate + NIS	3370	D2	NS	D3	D3	D3	NS	NS	D3	D3	NS	NS	NS	NS				
15 Triclopyr + NIS	280	D2	NS	D3	D3	D3	NS	NS	D3	D3	NS	NS	NS	NS	NS			
16 V-10029 + SBS	22	D3	NS	D3	D3	D3	NS	NS	D3	D3	NS	NS	NS	NS	NS	NS		
17 No tank mix		D3	D1	D3	D3	D3	NS	NS	D3	D3	NS	NS	NS	NS	NS	NS	NS	
18 No POST		D3	D3	D3	D3	D3	D3	NS	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3
		Alligatorweed interactions at 14 DAT																
Imazethapyr SURF	87																	
Imazethapyr plus	53																	
1 Bensulfuron + COC	42																	
2 Bentazon + aciflurofen + NIS	842	NS																
3 Carfentrazone + NIS	28	NS	NS															
4 Halosulfuron + NIS	53	NS	NS	NS														
5 Propanil + molinate + NIS	3370	NS	NS	NS	NS													
6 Triclopyr + NIS	280	NS	NS	NS	NS	NS												
7 V-10029 + SBS	22	NS	NS	NS	NS	NS	NS											
8 No tank mix		NS	NS	NS	NS	NS	NS	NS										
9 No POST		D3	D3	D3	D3	D3	D3	D3	D3									
No SURF																		
10 Bensulfuron + COC	42	NS	NS	NS	NS	NS	NS	NS	NS	D3								
11 Bentazon + aciflurofen + NIS	842	NS	NS	NS	NS	NS	NS	NS	NS	D3	NS							
12 Carfentrazone + NIS	28	D1	D1	D2	D1	D1	D1	D1	NS	D2	NS	NS						
13 Halosulfuron + NIS	53	NS	NS	D1	NS	NS	NS	NS	NS	D3	NS	NS	NS					

(Table 4.11 continued)

14 Propanil + molinate + NIS	3370	NS	NS	NS	NS	NS	NS	NS	NS	D3	NS	NS	NS	NS				
15 Triclopyr + NIS	280	NS	NS	D1	NS	NS	NS	NS	NS	D3	NS	NS	NS	NS	NS			
16 V-10029 + SBS	22	NS	NS	D1	NS	NS	NS	D1	NS	D3	NS	NS	NS	NS	NS	NS		
17 No tank mix		NS	NS	D1	NS	NS	NS	NS	NS	D3	NS	NS	NS	NS	NS	NS	NS	
18 No POST		D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3
		Hemp sesbania interactions at 14 DAT																
Imazethapyr SURF	87																	
Imazethapyr plus	53																	
1 Bensulfuron + COC	42																	
2 Bentazon + aciflurofen + NIS	842	NS																
3 Carfentrazone + NIS	28	D3	NS															
4 Halosulfuron + NIS	53	D2	NS	NS														
5 Propanil + molinate + NIS	3370	D3	NS	NS	NS													
6 Triclopyr + NIS	280	NS	NS	NS	NS	NS												
7 V-10029 + SBS	22	D2	NS	NS	NS	NS	NS											
8 No tank mix		D3	D3	D3	D3	D3	D3	D3										
9 No POST		D3	D3	D3	D3	D3	D3	D3	NS									
No PRE																		
10 Bensulfuron + COC	42	NS	NS	D2	D2	D2	NS	D2	D3	D3								
11 Bentazon + aciflurofen + NIS	842	D2	NS	NS	NS	NS	NS	NS	D3	D3	D1							
12 Carfentrazone + NIS	28	D2	NS	NS	NS	NS	NS	NS	D3	D3	D2	NS						
13 Halosulfuron + NIS	53	D2	NS	NS	NS	NS	NS	NS	D3	D3	D2	NS	NS					

(Table 4.11 continued)

14	Propanil + molinate + NIS	3370	D2	NS	NS	NS	NS	NS	NS	D3	D3	D2	NS	NS	NS				
15	Triclopyr + NIS	280	NS	NS	NS	NS	NS	NS	NS	D3	D3	NS	NS	NS	NS	NS			
16	V-10029 + SBS	22	D1	NS	NS	NS	NS	NS	NS	D3	D3	D1	NS	NS	NS	NS	NS		
17	No tank mix		D3	D3	D3	D3	D3	D3	D3	D1	D3	D3	D3	D3	D3	D3	D3	D3	
18	No POST		D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3

[a]SURF application of imazethapyr at 87 g ai/ha prior to seedling flood establishment.

[b]POST, postemergence application at three- to four-leaf rice of herbicides listed with broadleaf activity in a tank mix with imazethapyr at 53 g ai/ha.

[c]Rate of POST herbicide treatments are in g ai/ha.

[d]Numbers correspond to numbered treatments listed in postemergence herbicide treatment column.

[e]Abbreviations: DAT, days after POST treatment; NS, non-significant ≥ 0.05; D1 < 0.05 to 0.01; D2 < 0.009 to 0.001; D3 < 0.0009.

[f]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant.

95% red rice imazethapyr only program consisting of a SURF fb a POST application controlled red rice 90%. Steele et al. (2002) reported 95% red rice with imazethapyr at 70 g/ha PRE fb 70 g/ha POST. In this study, the total imazethapyr program, 87 g/ha SURF fb 53 g/ha POST, controlled red rice higher than treatments receiving bentazon plus acifluorfen and triclopyr as tank-mix partners with imazethapyr POST, and treatments with a single SURF or POST application.

Alligatorweed control was evaluated in Rayne in 2000 and 2001. At 14 DAT, a SURF by POST interaction occurred and means are listed in Table 4.10. Interactions are listed in Table 4.11. The imazethapyr SURF followed by imazethapyr POST treatment controlled alligatorweed 83% and was equal to treatments receiving a POST application regardless of soil application of imazethapyr. Webster et al. (1999) reported 90 to 94% alligatorweed control with carfentrazone tank-mixes applied at two- to three-leaf rice in a water-seeded system. In this study, imazethapyr SURF fb imazethapyr plus carfentrazone controlled alligatorweed 91% and was higher than treatments with imazethapyr alone or in combination with plus carfentrazone, halosulfuron, triclopyr, and V-10029 with no SURF application. AT 35 DAT, a SURF and POST interaction occurred; however, no SURF by POST interaction occurred (Table 4.12). When averaged over POST treatments, an increase in alligatorweed control was observed with imazethapyr SURF compared with treatments with no soil application. Alligatorweed averaged over imazethapyr soil application indicated no differences in control among treatments receiving an application imazethapyr in combination with another herbicide POST. Imazethapyr only programs controlled alligatorweed less than all other treatments.

Hemp sesbania control was evaluated at Crowley in 2000 and 2001. At both evaluation dates, imazethapyr only programs resulted in reduced

Table 4.12 Control of alligatorweed at 35 d after postemergence (POST) treatment (DAT) averaged over surface (SURF)[a] and POST[b] timings in water-seeded imidazolinone-tolerant rice at Rayne in 2000 and 2001.

		35 DAT		
Postemergence herbicide treatments	Rate	SURF	No SURF	Means[c]
	g ai/ha		%	
Imazethapyr plus	53			
Bensulfuron + COC[d]	42	90	78	84 a
Bentazon + aciflurofen + NIS	842	89	69	79 a
Carfentrazone + NIS	28	85	74	80 a
Halosulfuron + NIS	53	81	68	74 a
Propanil + molinate + NIS	3370	89	81	85 a
Triclopyr + NIS	280	88	56	72 a
V-10029 + SBS	22	92	69	81 a
No tank mix		48	40	44 b
No POST		47	0	24 c
Means		79 a	61 b	

[a]SURF application of imazethapyr at 87 g ai/ha SURF prior to seedling flood establishment.

[b]POST, postemergence application at three- to four-leaf rice which consisted of imazethapyr at 53 g ai/ha with each of the herbicides listed under POST herbicide treatment.

[c]Means within a column and a row followed by the same letter were not different according to the t-test on difference of least square means at P = 0.05.

[d]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant.

hemp sesbania control compared with all other treatments. At 14 DAT, a PRE by POST interaction occurred and means are listed in Table 4.10. Interactions are listed in Table 4.11. Hemp sesbania control was 91 to 96% with no differences observed with tank mixtures of imazethapyr in combination with carfentrazone, halosulfuron, propanil plus molinate, and V-10029 regardless of an imazethapyr SURF application. Control above 90% has been reported with carfentrazone and halosuluron in drill-seeded rice (Mitchell and Gage 1999). Hemp sesbania was averaged over PRE due to a POST interaction at 35 DAT (Table 4.9). Control of hemp sesbania with POST tank mix partners bentazon plus acifluorfen, carfentrazone, halosulfuron, and propanil plus molinate was 82 to 92% and higher than treatments with bensulfuron and triclopyr. These data indicate bentazon plus acifluorfen, carfentrazone, halosulfuron, and propanil plus molinate additions in an imazethapyr weed control program to adequately control hemp sesbania due to the lack of control of this weed by imazethapyr only programs.

Rice yield was recorded at maturity at Crowley and Rayne in 2001. A SURF and POST interaction occurred, but no SURF by POST interaction was observed (Table 4.13). Rice yield averaged over POST treatments was higher with a SURF application of imazethapyr compared with treatments without a SURF application. When averaged over soil application, rice yield for treatments containing bentazon plus Acifluorfen, carfentrazone, and halosulfuron was 2420 to 2650 kg/ha with no differences observed. Rice yield for imazethapyr SURF fb POST was 1030 kg/ha and was lower when compared with all other POST applications.

Increases in weed control with the use of herbicide combinations have been documented in various crops including rice (Arnold et al.

Table 4.13 Rice yield averaged over surface (SURF)[a] timing and postemergence (POST)[b] at Crowley and Rayne,LA in 2001 in water-seeded imidazolinone-tolerant rice.

Postemergence herbicide treatments	Rate	Rice yield SURF	No SURF	Means[c]
	g ai/ha	kg/ha		
Imazethapyr plus	53			
Bensulfuron + COC[d]	42	3050	580	1820 c
Bentazon + aciflurofen + NIS	842	2990	1930	2460 ab
Carfentrazone + NIS	28	3080	2210	2650 a
Halosulfuron + NIS	53	3040	1800	2420 ab
Propanil + molinate + NIS	3370	2910	1180	2050 bc
Triclopyr + NIS	280	2370	890	1630 c
V-10029 + SBS	22	2580	1280	1930 bc
No tank mix		1330	720	1030 d
No POST		530	0	265 e
Means		2430 a	1180 b	

[a]SURF application of imazethapyr at 87 g ai/ha prior to seedling flood establishment.

[b]POST, postemergence application at three- to four-leaf rice which consisted of imazethapyr at 53 g ai/ha with each of the herbicides listed under POST herbicide treatment.

[c]Means within a column and a row followed by the same letter were not different according to the t-test on difference of least square means at P = 0.05.

[d]COC, crop oil concentrate; NIS, nonionic surfactant; SBS, silicon based surfactant.

1993; Liscano and Williams 1999; Wall 1995). In these studies however, increases in control were variable and dependent on weed spectrum and rice production system. The majority of treatments receiving a PRE fb POST controlled barnyardgrass higher than those treatments without a PRE application of imazethapyr. This study agrees with others that have reported an increase in grass control with two applications of imazethapyr (Masson et al. 2001; Steele et al. 2002). The imazethapyr only program controlled barnyardgrass at least 92% which was equal to treatments receiving a tank mixture POST. This indicates that in drill-seeded rice, a soil fb POST application of imazethapyr is effective at controlling barnyardgrass and that no other herbicide may be needed. However, in the water-seeded study, there was a decrease in barnyardgrass control with imazethapyr SURF fb POST as compared with POST tank mixtures. This suggests that the addition of another herbicide into the total imazethapyr program is beneficial in increasing barnyardgrass control. Low red rice control was a result from high populations (100 plants m^2) in both drill- and water-seeded rice. Regardless, the imazethapyr only program controlled red rice equal to treatments consisting of soil application fb POST combinations in both studies. This indicates that imazethapyr alone applied to the soil fb POST is effective for controlling red rice. Late season alligatorweed control suggests that imazethapyr applied alone PRE fb POST only suppresses alligatorweed and that a herbicide with broadleaf activity is required to increase control, regardless of rice seeding method. With hemp sesbania, control with imazethapyr PRE fb POST was 25% or less for drill- and water-seeded rice and all treatments including a herbicide with broadleaf activity increased control. Herbicide combinations bentazon plus acifluorfen, carfentrazone, halosulfuron, and propanil plus molinate controlled hemp sesbania 86 to

92% with no difference being observed for either seeding method. Heavy rains near harvest, high red rice infestation that caused severe lodging, and severe disease on CL 121 and CL 141 rice lines impacted harvest efficiency for drill- and water-seeded rice. When averaged over POST, rice yields were higher with treatments receiving a soil application compared with those without a soil application in drill- and water-seeded rice. This is the same trend observed with red rice control, which indicates that control of red rice is required to maximize yields. When averaged over PRE application, no differences were observed for rice yield with treatments containing a POST application. In water-seeded rice, higher rice yields were recorded with those herbicides that increased control of hemp sesbania including tank mix partners of bentazon plus acifluorfen, carfentrazone, and halosulfuron. Lower rice yields were recorded with bensulfuron and triclopyr as tank mix partners. In conclusion, producers will have to use a PRE fb POST application of imazethapyr to effectively control red rice. If broadleaf weeds such as hemp sesbania and alligatorweed are present, a herbicide with broadleaf activity will be required. These studies have shown that a soil application of imazethapyr fb a POST tank-mixture of imazethapyr plus bentazon plus acifluorfen, carfentrazone, halosulfuron, or propanil plus molinate controls the grass and broadleaf weeds evaluated in these studies effectively and maximized rice yield.

CHAPTER 5

SUMMARY

Field studies were established in 2000 and 2001 to evaluate weed control programs in imidazolinone-tolerant (IT) rice in drill- and water-seeded rice production systems. In all of the studies imazethapyr was applied to the soil surface as a preemergence (PRE) in drill-seeded rice or surface (SURF) prior to seedling flood established in water-seeded rice. Therefore, soil applications will be referred to as PRE/SURF to distinguish between drill- and water-seeded systems.

Research was conducted near Crowley, LA to evaluate weed control and crop response of imazethapyr at 140 g/ha applied in single or sequential applications in drill- and water-seeded rice systems. Imazethapyr was applied PRE/SURF at 0, 35, 53, 70, 87, 105, and 140 g/ha followed by (fb) a two- to three-leaf rice application, early postemergence (EPOST), or a four- to five-leaf rice application, late postemergence (LPOST) of imazethapyr applied at 140, 105, 87, 70, 53, 35, and 0 g/ha, respectively. Barnyardgrass [*Echinochloa crus-galli* (L.) Beauv] and crop response were evaluated in both production systems and rice yield was only recorded for the drill-seeded study. In drill-seeded rice, barnyardgrass control was 94 to 97% with no differences observed among treatments receiving two applications of imazethapyr or a single EPOST application at 140 g/ha. However, imazethapyr at 140 g/ha PRE or LPOST controlled barnyardgrass 88 and 86%, respectively. In 2000 and 2001, rice yield with imazethapyr PRE at 140 g/ha EPOST was equal to, or higher, than treatments receiving a soil fb EPOST or LPOST application. However, a reduction in rice yield was observed with a single application of imazethapyr at 140 g/ha PRE and LPOST in 2001. In water-seeded rice in 2000 and 2001, a reduction in barnyardgrass control was observed with imazethapyr applied at 140 g/ha SURF. In

2001, late season control was 91 to 97% with a single imazethapyr application at 140 g/ha EPOST and treatments receiving two imazethapyr applications, except with imazethapyr at 105 g/ha SURF fb 35 g/ha EPOST. A single application of imazethapyr to the soil provided residual activity for approximately 21 to 28 DAT allowing late emerging barnyardgrass to become problematic. By applying the initial application of imazethapyr at 140 g/ha LPOST, barnyardgrass control decreased due to increased size and high population densities. Optimal barnyardgrass control and rice yield can be achieved with imazethapyr applied to the soil fb POST application or a single EPOST application of 140 g/ha. However, with a single EPOST application of imazethapyr at 140 g/ha, timing is critical and must be applied prior to barnyardgrass reaching the four-leaf stage. Rice injury was 0 to 5% at early evaluation dates, but no injury was observed late season for drill- or water-seeded rice.

Research was conducted in 2000 and 2001 near Crowley and Rayne, LA to evaluate total herbicide programs in drill- and water-seeded IT rice. These studies evaluated broadleaf and grass weed control and the impact of the weed control programs on rice yield. In the first two studies, treatments included imazethapyr PRE/SURF at 87 g/ha, or no PRE/SURF, with one of the following herbicides early postemergence (EPOST): bensulfuron, bentazon plus acifluorfen, carfentrazone, halosulfuron, propanil plus molinate, triclopyr, and V-10029 fb imazethapyr at 53 g/ha late postemergence (LPOST). Imazethapyr PRE/SURF at 87 g/ha fb imazethapyr LPOST at 53 g/ha, a single application of imazethapyr PRE/SURF at 87 g/ha, and a single application of imazethapyr LPOST at 53 g/ha were added for comparison. In drill-seed production, barnyardgrass control was 97% with imazethapyr applied PRE fb imazethapyr LPOST with no differences observed with the addition of propanil plus molinate or V-10029 as an EPOST application with or without a surface application of imazethapyr. Propanil plus molinate and V-10029 have activity on barnyardgrass; however, the other herbicides applied EPOST have little to no activity on barnyardgrass. If one of the herbicides with reduced activity on barnyardgrass is in used in a total weed control program in IT rice two applications of imazethapyr may be needed to achieve adequate barnyardgrass control. Single applications of imazethapyr PRE or LPOST did not provide season-long control of barnyardgrass. Although no direct comparison can be made between the water- and drill-seeded studies, an extra surface irrigation was applied to the water-seeded study at 7 days after planting to prevent seedling desiccation and this may have aided control of barnyardgrass compared with the drill-seeded study. In drill- and water-seeded rice, red rice control with imazethapyr applied to the soil fb LPOST was greater than or equal to all other treatments evaluated. Single imazethapyr applications to the soil or LPOST resulted in reduced control of red rice. These results suggest that imazethapyr applied to the soil fb imazethapyr POST is required for red rice control and the addition of another herbicide may not be required. Alligatorweed control with soil fb POST applications of imazethapyr was 80%. Imazethapyr soil applied fb halosulfuron EPOST fb imazethapyr LPOST controlled alligatorweed 92% regardless of rice production system. Control of alligatorweed with imazethapyr as the only herbicide in a weed control program was inconsistent, and indicates that only suppression of alligatorweed can be achieved. Hemp sesbania control with imazethapyr applied in single or sequential applications never exceeded 25% in drill- and water-seeded rice. In every case the addition of another herbicide applied EPOST increased hemp sesbania control. The lack of hemp sesbania activity with weed control programs containing only imazethapyr resulted in reduced rice yields at the Crowley location in 2000 and 2001. Rice treated with the standard imazethapyr treatment yielded less than 950 kg/ha while an increase in yield was obtained for rice receiving an EPOST application. Programs consisting of imazethapyr PRE at 87 g/ha fb an EPOST application of carfentrazone at 28 g/ha, propanil plus molinate at 3370 g/ha, or V-10029 at 22 g/ha fb imazethapyr at 53 g/ha LPOST were the most consistent for controlling red rice and hemp sesbania which was reflected in higher yields.

Two other studies evaluated PRE/SURF, or no PRE/SURF application of imazethapyr at 87 g/ha fb a tank mixture of imazethapyr at 53 g/ha with one of the following herbicides: bensulfuron, bentazon plus acifluorfen, carfentrazone, halosulfuron, propanil plus molinate, triclopyr, and V-10029 POST at the three- to four-leaf stage. In drill- and water-seeded rice production, imazethapyr applied to the soil surface fb a imazethapyr POST controlled barnyardgrass and red rice equal to treatments consisting of a soil application fb imazethapyr plus the addition of another herbicide in a tank-mix POST. Alligatorweed control increased with a soil application of imazethapyr regardless of seeding method. However, with a soil application followed by imazethapyr alone POST, control was less than all treatments receiving a tank mixture. These data indicates that imazethapyr only suppress alligatorweed and will require a herbicide with broadleaf activity for increased control. The weakness of imazethapyr was demonstrated with 25% hemp sesbania control with imazethapyr PRE fb imazethapyr POST in drill- and water-seeded rice. The addition of bentazon plus acifluorfen, carfentrazone, halosulfuron, and propanil plus molinate to imazethapyr POST controlled hemp sesbania 86 to 92% with no difference observed. Rice yields were higher with treatments receiving a soil application compared with those without imazethapyr PRE/SURF in drill- and water-seeded rice. In water-seeded rice, higher rice yields were recorded when rice was treated with herbicides that control hemp sesbania, such as bentazon plus acifluorfen, carfentrazone, and halosulfuron.

In conclusion, these studies have shown that the effectiveness of imazethapyr is dependent on weed spectrum. Although barnyardgrass was controlled with a single application of imazethapyr at 140 g/ha EPOST, if red rice is the target weed in IT rice, a PRE fb POST application of imazethapyr will be required for effective control. If broadleaf weeds such as hemp sesbania and alligatorweed are present, a herbicide with broadleaf activity will be required. POST applications of carfentrazone or propanil plus molinate alone or tank-mixed with imazethapyr, prior to the five-leaf rice stage, controlled grass and broadleaf weeds evaluated effectively and maximized rice yield.

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VITA

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