COMPREHENSIVE RICE RESEARCH

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PROJECT TITLE: Weed Control in Rice

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OBJECTIVES OF THE PROPOSED RESEARCH:

1. To investigate the efficacy, timing and compatibility of new herbicides in water-seeded rice (including water management variations of water seeding).
2. To collaborate with plant breeders in developing herbicide-resistant technologies for water seeded rice.
3. To conduct the research necessary to maintain the safe and effective uses of existing herbicides integrated with appropriate cultural practices.
4. To continue the exploration of rice/weed competition, weed biology and cultural practices to minimize herbicide costs and environmental impacts.
5. To develop an understanding of herbicide resistance in weeds and provide diagnosis and effective alternatives to manage the problem.

OBJECTIVE 1. *To investigate the efficacy, timing and compatibility of new herbicides in water-seeded rice (including water management variations of water seeding).*

Command (clomazone) rate and timing studies

Command, a pigment synthesis inhibitor, is a grass herbicide and it was tested for a fourth season at the Rice Experiment Station (RES) and off station (Maben and Van Dyke Farms) for a second season in 2001. Our study location at Maben Farms is a site that is infested with a herbicide resistant biotype of early watergrass (*Echinochloa oryzoides*). Our other off station location at Van Dyke Farms is a site where rice is being grown on light, red soils where specific herbicide-soil interactions determine different herbicide behavior as compared to other rice soils in terms of effectiveness and safety. Command was applied this season in granular form at 449, 560, and 673 grams active ingredient per hectare (g ai/ha) into 16- by 25-ft levee plots onto a preflood surface (P.F.S.), and in flooded conditions at the day of seeding (D.O.S.), and at 0.5. 1.0, 2.0, and 3.0 leaf stage of rice (lsr) at the RES. At Maben Farms, Command was applied in granular form at 673 g ai/ha at the 0.5 lsr into flooded 10- by 20-ft stake plots that were ringed with aluminum (so as to prevent herbicide movement among plots) and into 0.5 acre flooded levee plots. At Van Dyke Farms, Command at the was applied at 337 and 673 g ai/ha at the 0.5 lsr in granular form into 10- by 20-ft stake plots that were also ringed with aluminum.

Command has repeatedly demonstrated high efficacy on watergrass control when applied at 673 g ai/ha at the 0.5 lsr and safety to rice increases with earlier applications. This is the first season of experimentation with the current granular formulation (5EGR (extruded granule)) and injury to rice (leaf whitening, stunting, and stand reduction) (Table 1) was higher than with the granular formulations tested the past at the RES. The high injury symptoms observed this season could be related to unusually hot spring temperatures when testing was being initiated at the RES. Watergrass control was also compromised (Table 1) as a result of crop injury which allowed for new flushes of watergrass to emerge in the absence of a competitive rice canopy.

The injury symptoms reported above are variable, however, in the 0.5 acre plots at Maben Farms the Command provided excellent watergrass control with good safety to rice. In the 10- by 20-ft stake plots that were ringed with aluminum in an adjacent experiment on this same site, Command efficacy was compromised (Table 2) due to pump failure immediately after initiating application. This resulted in the loss of flood water and herbicide two days after application. This demonstrates the importance to maintain a deep, static flood for 10 to 15 days for into water herbicide use for weed control in water seeded rice.

In another experiment which was conducted in a light, red soils site at Van Dyke farms Comand provided excellent watergrass control with a moderate level of injury at 337 g ai/ha (Table 3). However, at 673 g ai/ha the herbicide injured the crop badly. Because soil active herbicides (such as Command) have increased activity in lighter soils they generally perform with good weed control at reduced rates of active ingredient.

The mechanism of action of Command differs from the rest of the available grass herbicides, which proves it to be efficacious against herbicide resistant watergrass biotypes. For this reason Command can become very important to the water seeded rice industry in California. It is proposed that more research be conducted in various soil types and at various rates and timings so as to develop use strategies for the safe use of Command in water seeded rice.

Variety tolerance to Command (clomazone)

In order to ensure that Command will be safe for the California water seeded rice culture; we performed a variety tolerance study for a second season at the RES with twelve rice varieties that are predominantly grown in the state. We also evaluated in this study the potential injury that would occur to rice when rates are doubled by overlapping application swaths. Thus, we tested Command at the prescribed use rate of 673 g ai/ha and at twice that rate (2X) in applications into the water at the 0.5 lsr. These treatments were evaluated against a standard molinate (Ordram) application of 4480 g ai/ha at the 1-2 lsr. The study was set up as a randomized complete-block design with three replicates. The varieties were seeded into 8-ft-diameter plots that were ringed with aluminum sheet. Plots were maintained under a 4-inch static flood throughout the growing season. Evaluations were made throughout the course of the growing season for tolerance to the herbicide.

Toxicity symptoms to Command were observed in most cases and at both rates. Symptoms included foliar chlorosis and bleaching, stunting, and stand reduction. Akita, Calmochi-101, CH-201, M104, M-202, M-205, and S-102 suffered relevant stand reductions when treated with the 2X rate of Command (Table 4). For these varieties, stand reduction determined reduced stem densities that persisted throughout the season causing relevant yield reductions. Noticeably tolerant varieties were: A-201, CT-201, L-204, and L-205.

Command would be a very useful tool for early watergrass and sprangletop control. However, this herbicide may not be recommendable for use with certain varieties unless new use techniques are developed to reduce injury to rice. This experiment will be conducted again in a flooded levee plot system with a larger number of replications for higher precision.

Regiment (bispyribac-sodium) alone and in combination

Regiment has been tested at the RES for several seasons and also in farmers' fields where resistant watergrass is problematic. Regiment is a post emergent herbicide and when applied with a silicone surfactant is effective on watergrass, ricefield bulrush, and demonstrates good activity on California arrowhead. In order to increase its efficacy and spectrum of control we evaluated Regiment at the RES at 25 and 30 grams active ingredient per hectare (g ai/ha), and in tank-mix combinations with Super Wham (propanil) at 3360 and 4480 g ai/ha with the surfactant crop oil concentrate at 1.25% volume/volume (v/v). Applications were made at 4 lsr, and 1-2 tiller (til) stage of rice on 10- by 20-ft stake plots. Water was drained for the 4 lsr application timing and lowered to expose at least 70% of weed foliage at 1-2 tillers and water was returned back to normal flood depth within 48 hours after application. Combinations of Regiment and Abolish (thiobencarb) have demonstrated synergistic effects in rice weed control operations and result in an increase in the spectrum of control and safen the effects of Regiment to rice. We evaluated this tank-mix combination in a separate study at the RES, where we applied Regiment at 10, 15, 25, and 30 g ai/ha (with and without silicone surfactant) in various combinations with Abolish at 2240, 3360, and 4480 g ai/ha at the 5-6 lsr onto 10- by 20-ft stake plots. Water was drained for weed foliage exposure and returned 24 hours after application.

Regiment was also tested alone and in combination off-station for its efficacy on resistant early watergrass and for its efficacy in a light, red soil location also. Regiment was applied to resistant watergrass at 30 and 37 g ai/ha with the silicone surfactant Kinetic at Maben Farms at the 1-3 tiller stage over 10- by 20-ft stake plots. Regiment at 30 g ai/ha was also applied in tank mix combination with Abolish at 4480 g ai/ha and Super Wham at 4480 g ai/ha at the same timing at Maben Farms. At our light, red soils experiment site at Van Dyke Farms, Regiment was applied at 25 g ai/ha alone and in combination with Clincher (cyhalofop) at 210 g ai/ha or with Abolish at 3360 g ai/ha at the 5 lsr onto 10- by 20-ft stake plots with the water drained for application. Regiment was also applied in this site at either 25 or 30 g ai/ha alone and in combination with Abolish at 4480 g ai/ha or with Grandstand (trichlopyr) at 280 g ai/ha at the 1-3 tiller stage of growth with the water lowered to expose at least 70% of weed leaf foliage. In all cases water was returned to normal flood depth with 48 hours after application.

At the RES, Regiment with kinetic controls watergrass and ricefield bulrush (Tables 5, 6, 7 & 14) at 25 and 30 g ai/ha at the 4-6 lsr and 1-2 tiller stage of rice. When Regiment is in tank-mix combination with propanil, ricefield bulrush control remains good to excellent, however, the combination tends to be antagonistic (Tables 5 & 6) on watergrass control. Regiment when tank-mixed with Abolish appears to have synergistic effects and broadens the spectrum of control to include smallflower umbrellasedge and sprangletop (Table 7) while at the same time increasing the safety of Regiment to rice.

Regiment provided excellent control of resistant early watergrass and suppression of smallflower umbrellasedge (Table 2) at Maben Farms at 37 g ai/ha at the 1-3 tiller stage with the water lowered. Regiment at this rate stunts the growth of rice for a period of 10 to 14 days after treatment (DAT) at which time rice grows out of the treatment effects. At Van Dyke Farms (red soils), Regiment provided excellent watergrass and California arrowhead control (table 3) while the tank-mix applications with Abolish provided excellent broad-spectrum weed control with respective rates of 25 (Regiment) and 3360 (Abolish) g ai/ha. When Regiment was tank-mixed Grandstand antagonistic effects were demonstrated on watergrass control however broadleaf and sedge control remained high (Table 3).

Regiment at 25 and 30 g ai/ha at the 1-3 tiller stage of rice is a good watergrass, ricefield bulrush, and California arrowhead herbicide. Rates must be increased to 37 g ai/ha in fields where resistant watergrass is present. Applications of this material are not recommended (crop safety) much before the exertion of the first tiller of rice, unless Regiment is combined with Abolish. Even in this case, the mixture should not be applied prior to the 4 to 6 lsr. To ensure effectiveness, water must be lowered to expose at least 70% of the weed leaf foliage. Combinations of Regiment and Abolish can result in synergistic effects. For optimum results to be obtained with this tank-mix combination applications should be made at the 4 to 6 lsr with the water completely drained so that the herbicide will contact the ground. This is done to provide excellent weed foliage coverage and allow for any residual herbicidal activity to occur in the soil from the Abolish. This mixture has repeatedly provided excellent weed control and safety to rice with rates ranging from 15 to 25 g ai/ha with Regiment and 2240 to 3360 g ai/ha with Abolish.

Clincher (cyhalofop) rate, timing, mixtures and sequential combinations.

Clincher (cyhalofop) is an ACCase inhibitor for post-emergent control of watergrass and sprangletop. This is the fourth season of experimentation with Clincher here at the RES and the second season of off-station use in fields where resistant watergrass is present, also this was the first season of use in light, red soils. This season we tested Clincher at various rates and timings and in numerous combinations and sequential applications with other herbicides. This season Clincher was registered in California with section 18 registration however problems arose from of injury to non-target peach trees which resulted in the removal of all aerial applications with the herbicide. Some growers also reported antagonistic effects on watergrass and sprangletop control when mixtures of Clincher and propanil were used.

At the RES, Clincher was applied with a crop oil concentrate (C.O.C.) surfactant 140 and 210 g ai/ha at the 3 lsr, 210 g ai/ha at the 4 lsr and 1-2 tillers, 280 g ai/ha at the 1-2 tiller and mid-tiller stages, and 560 g ai/ha at the full-tiller stage of growth. These applications were made with the water drained for all applications prior to the exertion of a tiller, and with the water lowered to expose at least 70% of the weed leaf foliage for applications after the exertion of a tiller. Water was returned to normal flood depth within 48 hours after application. In effort to broaden the spectrum of control with Clincher, tank-mix applications were made with propanil and Shark (carfentrazone). Tank mix applications with propanil formulations (Super Wham and Stam) were made with Clincher at 210 g ai/ha and with propanil at 4480 g ai/ha to 10- by 20-ft stake plots at the 4 lsr and to 16- by 25-ft levee plots at the 5-6 lsr with the water drained. When tank-mixed with Shark, Clincher was applied at 210 g ai/ha with Shark at 112 g ai/ha to 16- by 25-ft levee plots with the water drained for application.

Clincher was applied alone and in tank-mix combination at our resistant early watergrass site at Maben Farms. Here Clincher was applied alone at 280 g ai/ha with the surfactant C.O.C. and at 210 g ai/ha when tank-mixed with 4480 g ai/ha of Super Wham. At this site applications were made over 10- by 20-ft stake plots with the water lowered for a 1-3 tiller application. Clincher was also applied alone and in combination at our light, red soil site at Van Dyke Farms. Here again Clincher was applied at 210 g ai/ha with C.O.C. and also tank-mixed with Grandstand at 280 g ai/ha, and in a three way tank-mix combination with Clincher at 210, Grandstand at 280, and Super Wham at 4480 g ai/ha. Clincher was applied sequentially with an application at 210 g ai/ha at the 5 lsr with water drained and followed up with an application of Regiment at 30 g ai/ha at 1-3 tillers with the water lowered over 10- by 20-ft stake plots. In all cases normal flood depth was returned within 48 hours after treatment.

At the RES, Clincher provides excellent watergrass and sprangletop control with applications at 210 g ai/ha to grass (Tables 8 & 9) prior to the exertion of the first tiller of rice (3-4 lsr) with the water drained for application. After the exertion of the first tiller of rice applications made at 280 g ai/ha provide very good watergrass and sprangletop control (Tables 8 & 9) with the water lowered to expose at least 70% of the weed leaf foliage. Tank-mixing with propanil formulations provided interesting results this season. When Clincher was applied at 210 g ai/ha with Stam (propanil EDF) at 4480 g ai/ha excellent weed control was obtained (Table 5). However, when the same amount of active ingredients were applied with another formulation of propanil (Super Wham (EC)) within the same test, antagonistic effects were observed (Table 5) on sprangletop. When Clincher was tank-mix applied with Shark at the respective rates of 210 and 112 g ai/ha at the 5-6 lsr excellent sedge and broadleaf control was observed however the mix yield antagonistic effects on watergrass control (Table 6).

Off station, Clincher provided poor control of the resistant early watergrass biotype at Maben Farms (Table 2) when applied at 280 g ai/ha with the surfactant C.O.C. at the 1-3 tiller stage with water lowered for application. Here the watergrass is resistant to the effects of ACCase inhibitors like Whip and Clincher. When Clincher was tank-mix applied with Super Wham at the respective rates of 210 and 4480 g ai/ha the herbicides provide additive weed control results with excellent watergrass and sedge control (Table 2). Clincher was also used alone at 210 g ai/ha for early grass control with the water drained at the 5 lsr and followed with a sequential application of Regiment at 30 g ai/ha at 1-3 tillers for the clean-up of missed grasses and sedge and broadleaf control. This sequential operation resulted in excellent (Table 3) broad-spectrum control.

Clincher is a good post emergent herbicide with high activity on susceptible watergrass and sprangletop. Because of its high level of safety to rice, Clincher can be effectively applied at 210 g ai/ha from 2 to 6 lsr and at 280 g ai/ha from 1 tiller to just before panicle initiation. It can also be applied in tank-mix and sequential applications for a broad-spectrum control program. In terms of antagonism the interactions, our observations this year suggested that with applications made at the 4 lsr in mixture with Super Wham resulted in antagonism for sprangletop control and perhaps even watergrass. When this same mixture was applied at the 1-3 tiller stage, antagonism on sprangletop and watergrass was rate dependant and only appeared when Super Wham in the mixture was used at 6720 g ai/ha. Super Wham incorporates a synergistic adjuvant, which is not present in the other propanil formulation used (Stam).

Shark (carfentrazone)

Shark has been tested for several years at the RES and it is once again back in use in California for foliar applications to control sedge and broadleaf rice weeds. Alternative forms of use are now being studied so as to broaden the window for application timing and increase application safety as an imposed 58 day water holding period drastically limit the use of the herbicide. In 2001 Shark was tested both on and off station using different application methods and in tank-mix and sequential operations.

This season at the RES, Shark was tested into the water in flooded 16- by 25-ft levee plots at the rates 112, 168, and 224 g ai/ha at the 2-3 lsr. In this study Shark was also tested in comparison and in combination with Londax (bensulfuron) at 53 g ai/ha; here these products were applied either as a direct-spray application (D.S.A., where the product was dissolved and the solution sprayed into floodwater) or as a direct-dry application (D.D.A., or product broadcast directly into floodwater). Shark was also tested at the RES and off station at Van Dyke Farms foliarly in tank-mix combination with Super Wham at 112 and 6720 g ai/ha, respectively, with the water drained for application at the 5-6 lsr. Sequential foliar applications of Shark 112 (g ai/ha) were tested in plots drained for a 5-6 lsr treatment that followed a previous application of Command (673 g ai/ha) at the 0.5 lsr with Command into floodwater, both at the RES and at Van Dyke Farms.

Shark demonstrated rate responsiveness with D.S.A. and D.D.A. applications at the RES with excellent sedge and broadleaf control (Table 10) being obtained with a 224 g ai/ha with both application methods. Combinations with Shark and Londax at 112 and 53 g ai/ha, respectively, also yielded excellent sedge and broadleaf weed control (Table 10) at the RES. Foliar tank-mix applications of Shark and propanil injured rice (leaf spotting and bronzing) and resulted in reduced (Table 3 & 6) weed control. Injury to rice resulted in a less competitive rice canopy, which allows for weed emergence. The sequential operation of Command at 673 g ai/ha at the 0.5 lsr followed by 112 g ai/ha of Shark at the 5-6 lsr resulted in promising weed control. Although this sequential application resulted in high early injury due to the Command, the Shark application cleaned up all the sedge and broadleaf weeds (Table 3 & 6) allowing for good recovery by the crop and yields were higher than average the yields for these.

Shark has demonstrated to be a useful sedge and broadleaf herbicide (effectiveness against smallflower umbrellasedge improves with into-the-water applications). Shark is particularly important to California rice since resistance to Londax (bensulfuron) is widespread. Shark can be applied as D.S.A. (direct-spray application) or D.D.A. (direct-dry application, which should help prevent drift damage to sensitive crops), in combination with other into water herbicides, and in sequential weed control operations, making it a valuable tool in California rice. We intend to continue our research with Shark looking to expand on application methods and combinations.

Duet (formulated combination of propanil + bensulfuron) rate and timing

Duet was tested in 2001 for a third season at the RES and for a second time off-station at a resistant early watergrass site for its efficacy on a broad spectrum of weeds. This season, Duet was tested as an 80 EDF (emulsified dry-flowable) formulation, where 5600 grams of product will deliver 4480 grams of propanil + 35 grams of bensulfuron. This season, we tested Duet at 5600 grams of product per hectare (g/ha) with 0.125% v/v C.O.C. on 10- by 20-ft stake plots that had the water drained for a 4 lsr application. In the same experiment, we also tested Duet at 8400 g/ha of product with 0.125% v/v C.O.C. at the 1-2 tiller stage with the water lowered to expose at least 70% of weed leaf foliage. Duet was also test at Maben Farms on a known resistant watergrass biotype at 8400 g/ha of product with 0.125% v/v C.O.C. at the 1-3 tiller stage in 10- by 20-ft stake plots with the water lowered to expose at least 70% of weed leaf foliage. In all cases the floodwater was returned to normal flood depth within 48 hours after treatment.

This season at the RES, Duet provided fair to good watergrass control and controlled sedges and broadleaf weeds excellently (Table 5) at both timings and rates. *Off station* at Maben Farms, Duet performed similarly (Table 2), control of the resistant early watergrass was equal to that obtained with Super Wham. Duet controlled sedges and broadleaf weeds excellently.

Duet, in its new 80EDF formulation is a very convenient, and allows for user friendly, safe and efficacious use of propanil and bensulfuron simultaneously in rice. It has repeatedly demonstrated to be a good watergrass and excellent broadleaf and sedge herbicide. The propanil component in the mixture will control smallflower umbrellasedge and ricefield bulrush with resistance to Londax (bensulfuron), while bensulfuron.

BAS 625H efficacy trials

BAS 625H is a cyclohexadione ACCase inhibitor that was tested for a third season at the RES in 2001 for its efficacy as a grass herbicide. We tested BAS 625H in two separate experiments on 10- by 20-ft stake plots at 100 and 150 g ai/ha with 1.25% v/v of C.O.C. on rice at the 3.0 and 4.0 lsr and also at the 1-2 tiller stage. At the 3.0 and 4.0 lsr treatment timings the water was drained for application and at the 1-2 tiller stage water was lowered to expose at least 70% of the weed leaf foliage. In both cases water was returned to normal flood depth within 48 hours after application. BAS 625H was compared to the other ACCase inhibitors: Clincher (cyhalofop), Ricestar (fenoxaprop + safener), and Whip 360 (fenoxaprop-P-ethyl).

BAS 625H was safer to rice than Ricestar, however it did not provide the safety or level of efficacy on watergrass control as Clincher (210 g ai/ha) (Tables 8 & 9). BAS 625H performed very well on sprangletop at all timings and rates and was generally safe to the rice. It has been stated (by manufacturer) that BAS 625H performs excellently on early watergrass (*Echinochloa oryzoides*), but is weak on late watergrass (*Echinochloa phyllopogon*).

IR-5878 efficacy study

IR-5878 is an ALS inhibitor that was tested for a fourth season at the RES for its broad-spectrum activity on rice weeds. This season, we tested IR-5878 in 16- by 26-ft levee plots that had the water drained for a 3.0 lsr application. IR-5878 was applied at 60, 75, and 120 g ai/ha. IR-5878 was also tested in combination with Super Wham (propanil) at the rates 60 and 3360 g ai/ha, respectively. All applications of IR-5878 included the surfactant Trend at 0.3% v/v. IR-5878 applications were compared to the herbicide Gulliver (azimsulfuron), another ALS inhibitor which is widely used in European rice growing regions. Gulliver was applied alone and in combination with Super Wham at the rates 20 and 3360 g ai/ha, respectively. All applications with Gulliver also included the surfactant Trend at 0.3% v/v. Flood water was returned to normal depth within 48 hours after application.

IR-5878 (120 g ai/ha) provided good watergrass and sedge control (Table 11). Injury symptoms (stunting) persisted for about 10 days, but the rice fully recovered thereafter. Gulliver performed equally on the watergrass and sedges.

IR-5878 was tested as an into water herbicide in the past with eratic performance. Applied foliarly as an early post emergent treatment, IR-5878 has a good fit in pin-point flood operations in California and in dry-seeding operations in the South.

Sempra (halosulfuron) foliar rate, timing, and combination trial at the RES

This is the second season of tests with Sempra (halosulfuron) at the RES. Sempra is an ALS inhibitor with a similar range of control as Londax (bensulfuron). However, Sempra tends to be more active on broadleaf and sedge weeds. We applied Sempra at 36, 53, and 70 g ai/ha at the 3.0 lsr and 1-2 tiller stage of rice on 10- by 20-ft stake plots. Water drained for the 3.0 lsr timing and lowered to expose at least 70% of the weed leaf foliage for the 1-2 tiller timing. Sempra was also applied at 36, 53, and 70 g ai/ha in combination with Super Wham for "single-shot", broad spectrum weed control at 3360 g ai/ha at the 3.0 lsr timing and at 6720 g ai/ha at the 1-2 tiller timing. Sequential applications of Sempra (36, 53, and 70 g ai/ha at the 1-2 tiller stage) were made following Clincher at 210 g ai/ha at the 3.0 lsr for early grass control. All applications of Sempra were compared to the standard application of Londax (bensulfuron) at 70 g ai/ha, whether alone, in combination with Super Wham, or sequentially with Clincher. Water was returned to normal depth within 48 hours after both application timings.

In this trial, we found that all applications of both Sempra and Londax performed weakly on the sedges and broadleaf weeds (Table 12) in this new site within the RES. Combinations with Super Wham at the 1-2 tiller stage resulted in good watergrass and excellent sedge control. Due to findings within other herbicide trials at the same site it we infer that the broadleaf and sedge weeds at this location maybe resistant to the effects of bensulfuron and other ALS inhibitors. Therefore, it can be stated that the fit for Sempra in California will be restricted to sites where resistance to bensulfuron does not occur.

Sempra (halosulfuron) into water rate and timing study at the RES.

Sempra, (halosulfuron) is an ALS inhibitor that is used to control broadleaf and sedge weeds in rice. In this trial, Sempra was applied into flooded 16- by 25-ft levee plots at the rates of 36, 53, and 70 g ai/ha at the 1-2 lsr timing, and at 53 and 70 g ai/ha at the 2-3 lsr timing. Sempra was also applied at the above rates in combination with 4480 g ai/ha of either Ordram (molinate) or Bolero (thiobencarb) at the 1-2 lsr. In this trial, Sempra was compared to the standard broadleaf and sedge herbicide Londax (bensulfuron) which was applied alone or in combination with Bolero at 70 g ai/ha at the same timings.

We found that Sempra suppressed watergrass and performed excellently on the sedges and broadleaf weeds (Table 13) at both the 1-2 and 2-3 lsr timings. When Sempra was combined with either Ordram or Bolero at the 1-2 lsr excellent weed control resulted. Sempra stunted the rice for the first 7 to 10 days after treatment, but it successfully grows out of the treatment symptoms.

OBJECTIVE 2. *To collaborate with plant breeders in developing herbicide-resistant technologies for water-seeded rice.*

Clearfield (imidazolinone-resistant) rice rate and timing study at the RES

The Clearfield (imidazolinone-resistant) rice system was used for the first time at the RES in 2001. Clearfield rice is one based on mutant breeding technology to develop a non-transgenic rice to be resistant to the effects of various broad-spectrum imidazolinone chemistries that would otherwise be lethal to rice. In this trial we used the imidazolinone herbicides Pursuit (imazethapyr) at rates of 70 and 140 g ai/ha and Raptor (imazethapox) at 53 g ai/ha. Both herbicides were used with the surfactants C.O.C. at 0.25% v/v and UN-32 (liquid fertilizer) at 4.67 liters/ha (L/ha) in 10- by 20-ft stake plots that had the water drained for a 3.0 lsr application. These herbicides were compared to Londax (bensulfuron) at 70 g ai/ha and Super Wham (propanil) at 3360 g ai/ha that were combined with the surfactant C.O.C. at 1.25% v/v and which were also applied at the 3.0 lsr. Regiment (bispyribac) was also applied in this trial for comparison to the imidazolinones and was applied at 30 g ai/ha with 0.125% v/v silicone surfactant at the 1-2 tiller stage with the water lowered to expose at least 70% of weed leaf foliage for application. Floodwater was returned to normal flood depth within 48 hours after each application timing.

In this trial, Pursuit provided excellent watergrass, sprangletop, and ricefield bulrush control at 140 g ai/ha (Table 14) but tended to be weak on smallflower umbrellasedge and redstem. Raptor also provided similar results as the Pursuit at 140 g ai/ha. Both Pursuit and Raptor stunted the rice for a period of 10 to 14 days after treatment, at which time the crop effectively grew out of the treatment symptoms. Londax performed poorly on smallflower umbrellasedge, and redstem, however it did provide good control of the ricefield bulrush. Super Wham provided excellent watergrass, sedge and broadleaf control but it did injure the rice (leaf burn and stunting) which persisted for 10 days after treatment. Regiment provided good watergrass and excellent ricefield bulrush control but was weak on the smallflower umbrellasedge and redstem.

The findings in this trial suggest that the smallflower umbrellasedge and the redstem are resistant to the effects of ALS inhibitors (such as bensulfuron) and to imidazolinone herbicides which have a similar mode of action as ALS inhibitors. Based on these results we find that the Clearfield rice system may have a tough time being completely effective in those areas where broadleaf and sedges have developed resistance to ALS inhibitors such as Londax. Therefore, research should be conducted both in the greenhouse and in the field on known resistant weeds to adequately determine the spectrums of control and patterns of resistance of these herbicides.

Outcrossing study between transgenic herbicide-resistant rice and conventional rice in California

The recent development of herbicide-resistant (transgenic) rice may be a tool necessary to provide California rice farmers with a means to overcome the crippling effects of herbicide resistance and the limited weed control options. The broad spectrum; non-selective chemistries of glyphosate and glufosinate used in this technology are not yet stifled by resistance in rice. These herbicides are also chemically and physiologically of no relation to any of those where resistance has developed making them a good fit to the concept of rotation of herbicide modes of action for the prevention of resistance and preservation of herbicide technologies.

One of the issues of transgenic commodities is the occurrence of gene flow or outcrossing. Outcrossing is the transfer of heritable traits through the cross-pollination of one related plant type to another. Herbicide-resistant rice could possibly of the transfer the trait for herbicide-resistance to conventional rice. Because of the ongoing concerns of the use and consumption of transgenic crops, knowing their potential for outcrossing (successful fertilization of a non-transgenic ovule by transgenic pollen) is particularly important for the identity preservation of crops. For this reason the state of California recently signed the California Rice Certification Act which will require various procedures (i.e.- isolation distance, etc.) to ensure the identity preservation (i.e.- proper channeling of seed to prevent bulk seed contamination among rice varieties) of rices of commercial impact (i.e.- sweet rice, arborio, colored, and transgenic rices).

The rate of outcrossing depends upon the type of pollination and breeding system of the crop. Cultivated rice is normally self-pollinated, however, some natural crossing does occur. Outcrossing is also correlated to many other factors, which include pollen dispersal, pollen viability, and fertility. All of these parameters are sensitive to climatic conditions (e.g.- relative humidity, temperature, dew point, and air pressure), which differ greatly from growing region to growing region. The distance at which pollen is dispersed from its source also depends upon a number of factors, such as wind speed and turbulence, height of pollen release, and insect pollinator movement.

The isolation distances given by seed-certification agencies are for the most part educated guesses. Some work has been completed on the natural crossing of rice, where a 60-year old study indicated that rice-rice outcrossing rates were less than 0.5%, however, this rate can be highly variable and the distance at which outcrossing has been detected in rice is only up to 30 feet. The isolation distance in California is ten feet between different conventional rice varieties. The current USDA standard for regulated transgenic varieties is 100 feet for aerial applications, 50 feet for ground seeding, and ten feet for precision (i.e.- hand sowing) seeding. In order to provide an accurate measure of the outcrossing potential of transgenic rice to conventional rice, a series of replicated, two-year field studies be conducted to monitor the potential outcrossing rate of transgenic rice to conventional rice in California. The outcome of this research is expected to help determine isolation distance standards to comply with the provisions of the California Rice Certification Act.

In the 2001-growing season, two experiments were initiated to monitor the potential of outcrossing (extent and distance of gene flow) of 'Liberty-Link M-202' and 'Round-Up Ready M-202' (transgenic rices) to conventional 'M-202' rice. In both transgenic rice varieties the gene for glufosinate (Liberty) or glyphosate (Round-Up) resistance has been incorporated into M-202 rice. The trials were planted at the Rice Experiment Station in Biggs, California. The layout of each experiment consists of four 15-ft-circles of transgenic M-202 (donor site); each surrounded with a circle with (55.5-ft radius) of conventional M-202 (acceptor site). The 0.089 ha^{-1} planting surrounding the donor site will be divided radially into 6 segments (slices) oriented north, northeast, southeast, south, southwest, and northwestern directions. It is expected that pollen flow will be most relative to the prevailing winds at the Rice Experiment Station which are on a north-south basis. Each circle has six 48-feet radii extending outward from the perimeter of the donor sites and on each radii stakes will be positioned to delineate seven concentric arcs within each segment at intervals of 1, 3, 6, 12, 24, 36, and 48 feet. The four circles (replications) will be separated from each other with a 25-ft buffer zone of contiguous rice to ensure that if any pollen flow is detected it will be from the central planting of transgenic M-202 and not from the neighboring replicate. Co-mingling of seed is eliminated by using 12 inch wide aluminum sheeting (which will be pushed into the soil at depths of 2 to 3 inches) to ring the 15-foot donor site.

Results for this experiment are currently being evaluated in labs at the California Crop Improvement Association at the University of California, Davis and Mid-West Seed Incorporated in Brookings, South Dakota. It is expected that results from this outcrossing study will be available soon after the turn into 2002.

OBJECTIVE 3. *To conduct the research necessary to maintain the safe and effective uses of existing herbicides.*

Effects of herbicide phytotoxicity on weed-free rice yields at the RES

Variable levels of visual injury symptoms on rice are often reported as a result of herbicide use. However, the effects on rice yields from such injury have been difficult to establish in field experiments because the confounding effects of crop injury and weed competition are difficult to separate. Evaluations of the impact of herbicides on crops must be conducted in the absence of weeds after manual or mechanical weed removal. Manually removing weeds in water-seeded rice without damaging rice plants is difficult. A study was conducted in the 2001 season to determine the effect of herbicides on rice yields in the absence of weeds by using a target-site herbicide-resistant rice cultivar. Thus, a weed-free situation was maintained using a non-selective herbicide (5-6 lsr) known to cause no injury on this rice cultivar.

Herbicides to be tested for injury to rice were applied at their recommended rates (X) and at twice the recommended rate (2X). The 2X rates simulate swath overlap during application. In this study we applied Bolero 15G (thiobencarb) at 4480 and 9660 g ai/ha at the 1-2 lsr; Command (clomazone) at 637 and 1346 g ai/ha (0.5 lsr), and Ordram (molinate) at 4480 g ai/ha (1-2 lsr). All the above applications were made into 16- by 25-ft flooded levee plots. At the 1-2 tiller stage the following herbicides were applied over the top of 16- by 25-ft flood levee plots that had the water lowered for application with their required surfactants (if necessary): Regiment (bispyribac, 30 and 60 g ai/ha); Shark (carfentrazone, 224 and 448 g ai/ha); Whip 360 (fenoxaprop-P-ethyl, 90 and 180 g ai/ha); Grandstand (trichlopyr, 420 and 840 g ai/ha); Super Wham (propanil, 6720 and 13440 g ai/ha); Clincher (cyhalofop, 280 and 560 g ai/ha); and Londax (bensulfuron, 70 and 140 g ai/ha).

Injury symptoms (results are shown on Table 16) recorded seven days after herbicide treatment (DAT) ranging from 0 to 83 % were significantly and negatively correlated with rice yields ($r = 0.70$, $P < 0.0006$). The following treatments scored injury levels (7 DAT) above 10%: Whip 360 at the X and 2X rates, Command (X and 2X), Bolero (2X), Super Wham (X and 2X), Regiment (2X), Shark (2X), and Londax (2X). The lowest yields were obtained with Shark (X), Whip 360 (2X), and Command (2X). Rice tiller reduction at 28 DAT was very severe with the 2X rates of Whip 360 and Command (58 and 84%, respectively); 50% rice tiller reduction was still visible with Command (2X) at the late tillering stage (42 DAT) of rice. Only Command 2X reduced yields significantly ($P < 0.05$) below the untreated control; Yields with Shark X and 2X were not statistically significant. The most innocuous double-rate application was that of Clincher. When applied at the 2X rate Bolero significantly injured the crop at early growth stages (Table 17) but the crop was able to grow out of the effects and produce yields comparable to that of the untreated/weed- free plots.

Early injury symptoms with Command include pigment bleaching, and stunting. Early injury was observed with Regiment 2X and yields were lowered, however, this effect could not be demonstrated statistically. Shark caused some initial leaf bronzing and spotting but rice recovered from these symptoms about 14 days after treatment. Grandstand at the 2X rate stunted the crop for about 10 to 14 days after treatment, but rice yielded equally at both rates. Foliar symptoms with Super Wham were somewhat similar to those of Shark. This study demonstrated that visual symptoms of injury on rice recorded shortly after herbicide application are correlated with yield reduction, although such reductions may not always be detected by statistical tests. Strip damage from overlapping application swaths can become notorious with Whip 360 and Command.

OBJECTIVE 4. *To continue the exploration if rice/weed competition, weed biology and cultural practices to minimize herbicide costs and environmental impact.*

Identifying new management opportunities

A two-year greenhouse study was completed in which we attempted to identify rice traits to enhance its competitiveness with weeds. This experiment focused on the role of above- and below-ground rice traits, and involves a series of rice cultivars including interspecific crosses between *Oryza sativa* and *O. nivara*. Previous experiments have demonstrated that at about 30 days after seeding rice is capable of suppressing the establishment of new watergrass cohorts, thus greatly reducing the need for late herbicide applications. Rice competitiveness can, thus, complement herbicide use and become also a tool for herbicide–resistance management, whereby weeds are complementary suppressed by non-chemical means. Integration of herbicides with non-chemical means of control is a most effective strategy to manage herbicide-resistance. Non-chemical options for weed control are difficult to implement in rice. However, the high adoption rate by farmers of new cultivars indicates that competitive cultivars could easily fit within current rice culture practices. Below ground competition is sought in rice to assist in weed suppression before canopy closure. Aboveground traits are sought for shortening the initial critical period of competition during which external weed control measures need to be applied. Result processing is in progress, and promising correlations between rice traits and watergrass suppressions suggest that enhancing rice competitiveness while maintaining good yields can be a feasible strategy.

OBJECTIVE 5. *To develop an understanding of herbicide resistance in weeds and provide diagnosis and effective alternatives to manage this problem*

Field management of herbicide-resistant early watergrass at Maben Farms

California rice is being subjected to an epidemic of herbicide resistance in watergrass (*Echinochloa* phyllopogon and *E. oryzoides*) populations. Watergrasses are the major weeds of rice and the development of herbicide resistance not only deprives farmers of essential tools for weed control, but also results in increased herbicide rates and frequency of application. This problem has, thus, serious economic and environmental implications. This experiment was implemented in a conventional rice grower's field in Glenn Co. where lack of watergrass control with molinate, thiobencarb, and fenoxaprop has been repeatedly observed. The objective of the 2001 activity was to conduct the third and final year of a medium-term field experiment initiated under this grant in 1999 to evaluate in a systems approach key management options for reducing herbicide selection pressure towards resistance, namely: 1) annual rotation to herbicides with different mechanisms of action or tank mixtures and sequential applications of herbicides with different mechanisms of action, and 2) the use of transgenic rice cultivars resistant to environmentally friendly broad-spectrum herbicides, and 3) reducing seed survival with appropriate straw management practices by initiating a comparison of the seed survival rate under straw cover, straw removal, and straw incorporated post-harvest management practices which are expected to affect the soil re-infestation with herbicide-resistant seed. This year's activities also involved continuing the tracking of treatment effects on seed bank populations, using the research site for a field demonstration by conducting a field day in collaboration with UC Cooperative Extension personnel, and making it available for researchers interested in concurrent issues.

Three separate trials were conducted on this site in 2001; the main herbicide and straw management trials were sampled, planted, treated and evaluated, and a herbicide screening trial was conducted which tested various herbicides alone and in combination for in-season control of this thiobencarbamate resistant early watergrass population. Also during this period, work was completed on the extraction and examination of watergrass seed taken from the fall 2000 and spring 2001 soil samples from the main and straw trials.

Results from seed-bank monitoring in the main trial show that under the three alternative herbicide strategies, new seed rain in 2000 was severely limited, weed pressure in 2001 was greatly reduced, and this resistant population of watergrass was being brought under control. In contrast, continuous molinate treatments have failed to limit reseeding sufficiently (8-times higher new seed rain in 2000) and seed-bank densities remain high. Extremely good control obtained this year with the alternative herbicide treatments and continued poor control with molinate is expected to widen this difference even further. First results from the straw trial indicate that winter survival of new seed where straw was incorporated was about 3 times the survival rate where straw was burned or chopped - 66%, 20%, and 23%, respectively. The survival of old seed was not affected by straw treatment. When straw cannot be burned, chopping and flooding appears to be a preferable alternative to incorporation for limiting the survival of resistant watergrass seed. Other fundamental population dynamics parameters such as seedling emergence (highly variable), summer survival (highly depth dependent) and recruitment (highly density dependent) have also been measured. These data are contributing greatly to the development of a more comprehensive model of watergrass dynamics that suggests how other alternative cultural practices and whole systems could potentially increase control, reduce expense, and/or decrease herbicide use.

List of recent publications

Fischer, A.J., H.V. Ramírez, K.D. Gibson, and B. Da Silveira Pinheiro (2001). Competitiveness of semidwarf upland rice cultivars against palisadegrass (*Brachiaria brizantha*) and signalgrass (*B. decumbens*). Agron. J. 93:967-973.

Gibson, K.D., J. E. Hill, T.C. Foin, B.P. Caton, and A.J. Fischer (2001). Water-seeded rice cultivars differ in abiltiy to interfere with watergrass. Agron. J. 93:326-332.

Gibson, K. D. and A. J. Fischer (2001). Relative Growth and Photosynthetic Response of Water-Seeded Rice and Echinochloa oryzoides (Ard.) Fritsch to Shade. International Journal of Pest Management (in press).

Gibson, K.D, A.J. Fischer, and T.C. Foin (2001). Shading and the growth and photosynthetic responses of *Ammannia coccinnea*. Weed Research 41:59-67.

Caton, B.P., A.M. Mortimer, T.C. Foin, J.E. Hill, K.D. Gibson and A.J. Fischer (2001). Weed shoot morphology effects on competitiveness for light in direct-seeded rice. Weed Research (in press).

Hill, J.E., A.J. Fischer, M. Ehlhardt (2002). Section on Weed Control in Rice for chapter (refereed) on Weed control in Agronomic Crops for the book Principles of Weed control in California. Thompson/California weed science Society (In press)

CONCISE GENERAL SUMMARY OF THIS YEAR'S RESULTS

This year, we conducted research on herbicide efficacy, including new compounds, combinations and sequential applications, and the use of non-transgenic herbicide-resistant Clearfield rice. We also initiated a study to determine the extent of gene flow from transgenic rice, and continued our service to rice growers by providing test for herbicide-resistance on watergrass and barnyard grass samples. Results from our research have also contributed to efforts by the rice industry for the registration of new herbicides. Besides experimentation at the Rice Experiment Station near Biggs, we also conducted two off-station trials, one on a watergrass-resistant site and another on light-textured red soils in the Pleasant Grove area. Thus, we continued our work with Command (clomazone), an herbicide with a new mode of action that controls herbicide-resistant watergrass and sprangletop. Command has been repeatedly efficacious on watergrass when applied at 673 g ai/ha at the 0.5 leaf-stage of rice growth (lsr). However, crop injury was severe in several experiments this season, which may be related to hot spring temperatures in late May and low water depths. Loss of crop foliage resulting from injury decreased rice competitiveness and allowed for new flushes of watergrass to emerge. In the light red soils, watergrass control was excellent with less injury to rice at 337 g ai/; soil active herbicides (such as Command) are more active in these soils and can perform at lower rates. Rice varieties Akita, Calmochi-101, CH-201, M104, M-202, M-205, and S-102 were remarkably more susceptible to Command than others. Command is expected to be available for testing at a larger scale under an experimental use permit in 2002. Regiment (bispyribac-sodium) at 25 and 30 g ai/ha applied at the 1-3 tiller stage of rice is a good watergrass, ricefield bulrush, and California arrowhead herbicide; water must be lowered to expose at least 70% of the weed foliage. Rates must be increased to 37 g ai/ha in fields with resistant watergrass. For safety to rice, Regiment should not be applied much before the exertion of the first tiller of rice. Combinations of Regiment and Abolish (thiobencarb), with rates ranging from 15 to 25 g ai/ha of Regiment and 2240 to 3360 g ai/ha of Abolish, appear to be synergistic for watergrass control and also safe for applications at the 4-6 lsr with water drained. Regiment could be available in 2002 under a Section 18 for resistant watergrass control. Clincher is a post-emergent herbicide highly active on susceptible watergrass and sprangletop. It is very safe on rice and can be applied at 210 g ai/ha from 2 to 6 lsr, and at 280 g ai/ha from 1 tiller to just before panicle initiation. It can also be applied in sequential applications for broad-spectrum control. Draining fields for post-emergent herbicide applications usually encourages new weed emergence. It is, therefore, important that the interval between drainage and re-flood be short to maximize the efficacy of the treatment. Problems with drift injury to peach trees resulted in the removal of all aerial applications with Clincher. Clincher will not control watergrass that is resistant to Whip (fenoxaprop). Ricestar (fenoxaprop + safener) at 90 g ai/ha has repeatedly demonstrated to be a good herbicide for the control of Sprangletop but has tended to be weak on watergrass in a water seeded rice system. Shark (carfentrazone) is a useful sedge and broadleaf herbicide that can be applied at 224 g ai/ha at the 2-3 lsr as direct-spray application (D.S.A) or as direct-dry application (D.D.A.), in combination with other into-water herbicides (Shark and Londax at 112 and 53 g ai/ha, respectively) and in sequential weed control operations. Shark at the 5-6 lsr also yielded promising weed control. Foliar tank-mix applications of Shark and propanil injured rice and lowered weed control due to foliar damage and loss of rice canopy competitiveness.

Tests on herbicide combinations yielded promising results as well as warnings on antagonistic mixtures. Regiment in tank-mix combination with propanil was antagonistic on watergrass control. But, Regiment mixed with Abolish synergized watergrass control, controlled smallflower umbrellasedge and sprangletop, and was safe to rice. Mixtures of Regiment with either Clincher or Grandstand (trichlopyr) antagonized watergrass control. Clincher (210 g ai/ha) applied at with Super Wham (propanil, 4480 g ai/ha) was antagonistic on sprangletop. However, Clincher applied at the 5 lsr followed by a sequential application of Regiment at the 1-3 tiller stage of rice resulted in excellent control of watergrass, sprangletop, and California arrowhead. Similarly Clincher followed by propanil or Sempra (halosulfuron) resulted in excellent broad-spectrum control. Shark (112 g ai/ha) mixed with Clincher (210 g ai/ha) and applied at the 5-6 lsr antagonized watergrass control, the same occurred with mixtures of Clincher and Grandstand.

We also continued experimentation with new herbicides and formulations. Duet (80EDF) applied at 5600 grams of product/ha (equivalent to 4480 g propanil + 35 g bensulfuron/ha) with rice at the 4 lsr, or at 8400 g/ha at the 1-2 tiller stage of rice with the water lowered to expose at least 70% of weed leaf foliage, provided fair to good watergrass control and excellent sedge and broadleaf control. Crop oil concentrate (1.25% v/v) was added to the mix. BAS 625H (an ACCase inhibitor) was safer to rice than Ricestar (fenoxaprop + a safener for rice), however, it was neither as safe nor as effective on watergrass as Clincher. BAS 625H may be more effective on early than on late watergrass; good sprangletop control was obtained. IR-5878 is an ALS inhibitor that applied as an early post emergent treatment provided good watergrass and sedge control. The combination of IR-5878 with Super Wham enhanced weed control, although some early rice stunting of rice was visible. Sempra (halosulfuron) used as a foliar spray or as into-the-water application performed similarly to Londax, although Sempra appeared to be somewhat more active allowing for the use of lower rates. Clearfield rice is an imidazolinone-resistant variety that was obtained through mutation breeding (not a transgenic cultivar). Imidazolinones are ALS inhibitors (mode of action), and we tested the efficacy of several ALS inhibitors in conjunction with Clearfield rice seeking broad-spectrum control with maximum safety on rice. Pursuit (imazethapyr) and Raptor (imazethapox) provided excellent watergrass, sprangletop, and ricefield bulrush control. Regiment controlled watergrass and ricefield bulrush. All herbicides, including Londax, tended to be weak on smallflower umbrellasedge and redstem, which may have become resistant to this and other ALS inhibitors in this field. Widespread resistance to Londax and, presumably, to other ALS inhibitors in California may be an obstacle for the deployment of this technology.

Finally, prompted by the needs of genetic purity preservation as established in the California Rice Certification Act, a large experiment was initiated this year to establish maximum distances of pollen flow from transgenic to non-transgenic rice.

Table 1. Command(clomazone) rate and timing study at the Res.

Treatment	Rate	Timing[2]	Injury 14 DAT	Weed Control[1] ECHPH 28 DAT	Weed Control[1] ECHPH 42 DAT	Yield[3]
	(g ai/ha)		-----	%	-----	(lb/A)
Untreated[4]	--	--	--	60	56	2200
clomazone	449	P.F.S.	1	48	50	5280
clomazone	560	P.F.S.	9	43	48	4710
clomazone	673	P.F.S.	3	56	51	4970
clomazone	449	D.O.S.	13	70	63	5570
clomazone	560	D.O.S.	40	66	58	4700
clomazone	673	D.O.S.	20	81	68	6000
clomazone	449	0.5 lsr	26	65	63	6330
clomazone	560	0.5 lsr	33	78	79	6990
clomazone	673	0.5 lsr	63	81	68	4590
clomazone	449	1.0 lsr	65	69	64	3040
clomazone	560	1.0 lsr	45	53	50	4380
clomazone	673	1.0 lsr	43	59	61	5820
clomazone	449	2.0 lsr	9	71	71	6920
clomazone	560	2.0 lsr	16	75	75	7480
clomazone	673	2.0 lsr	38	74	58	5890
clomazone	449	3.0 lsr	11	51	43	5390
clomazone	560	3.0 lsr	10	59	63	6890
clomazone	673	3.0 lsr	11	61	61	5950
molinate	4480	1-2 lsr	13	100	100	6740
LSD (0.05)						2410

[1] ECHPH (Late Watergrass).

[2] P.F.S. (Preflood surface), D.O.S. (Day of seeding), lsr (leaf stage rice), Til (Tillers of rice).

[3] Yiled adjusted to 14% moisture.

[4] Untreated weed control values represent % cover by respective weeds.

Table 2. Resistant watergrass herbicide testing at Maben Farms.

				Weed Control[1]			
			INJURY	ECHOR	CYPDI	SAGMO	
Treatment	Rate	Timing[2]	14 DAT	42 DAT	42 DAT	28 DAT	Yield[3]
	(g ai/ha)		%				(lb/A)
Untreated[4]	--	--	0	41	11	8	4790
molinate	4480	1.0 lsr	5	21	0	0	4220
thiobencarb (15GR)	4480	1.0 lsr	8	21	40	0	5220
clomazone	673	0.5 lsr	9	54	0	0	5370
thiobencarb (8EC)	4480	1-3 Til	1	18	0	25	4840
cyhalofop + C.O.C.	280 + 1.25% v/v	1-3 Til	0	66	4	0	6190
propanil + C.O.C.	6720 + 1.25% v/v	1-3 Til	5	83	100	100	6770
Duet[6] + C.O.C.	6720 + 1.25% v/v	1-3 Til	4	76	100	100	6810
propanil + thiobencarb (8EC)	4480 + 4480	1-3 Til	5	70	100	100	6860
propanil + cyhalofop + C.O.C.	4480 + 210 + 1 .25% v/v	1-3 Til	3	89	100	100	6840
bispyribac Na + Kinetic	30 + 0.125% v/v	1-3 Til	6	100	35	100	6770
bispyribac Na + Kinetic	37 + 0.125% v/v	1-3 Til	10	100	68	100	6750
bispyribac Na + thiobencarb (8EC)	30 + 4480	1-3 Til	5	98	61	100	7000
thiobencarb (15GR) fb.[5] bispyribac Na + Kinetic	4480 fb. 30 + 0.125% v/v	1.0 lsr fb. 1-3 Til	10	90	88	75	5650
bispyribac Na + propanil + Kinetic	30 + 4480 + 0.125% v/v	1-3 Til	5	83	100	100	6620
LSD							1150

[1] ECHOR (Early Watergrass), CYPDI (Smallflower Umbrellasedge), SAGMO (California Arrowhead).

[2] lsr (leaf stage rice), Til (Tillers of rice).

[3] Yiled adjusted to 14% moisture.

[4] Untreated weed control values represent % cover by respective weeds.

[5] fb. (followed by).

[6] Duet is a formulated herbicide; 5600 grams contains 4480 grams of propanil and 35 grams of bensulfuron.

Table 3. Light soil herbicide test at VanDyke Farms.

Treatment	Rate	Timing[2]	Injury	Weed Control[1]										Yield[3]
				ECHOR	LEFFA	CYPDI	SAGMO	AMMAU	ECHOR	LEFFA	CYPDI	SAGMO	AMMAU	
			7 DAT	28 DAT	28 DAT	28 DAT	28 DAT	28 DAT	42 DAT	42 DAT	42	42 DAT	42 DAT	
	(g ai/ha)		%											(lb/A)
Untreated[4]	--	--	0	8	5	10	14	8	8	5	19	9	6	8210
bispyribac Na + kinetic	25	5 lsr	8	91	35	84	75	100	95	40	88	100	100	8980
bispyribac Na + kinetic	30	1-3 Til	10	98	65	60	100	85	98	50	60	100	95	8800
bispyribac Na + kinetic	37	1-3 Til	10	94	33	76	95	100	99	30	61	100	78	8290
bispyribac Na + thiobencarb	25 + 3360	5 lsr	8	95	100	84	75	100	100	98	85	99	100	9350
bispyribac Na + thiobencarb	25 + 4480	1-3 Til	8	98	90	56	93	98	98	80	64	98	100	8830
bispyribac Na + thiobencarb	30 + 4480	1-3 Til	6	100	38	50	98	100	100	63	45	100	98	8880
bispyribac Na + propanil + kinetic	30 + 4480 + 0.125% v/v	1-3 Til	9	75	13	81	100	98	68	5	81	100	100	9070
bispyribac Na + cyhalofop + C.O.C.	25 + 210 + 1.25% v/v	5 lsr	6	94	96	61	90	100	89	100	74	100	100	9050
bispyribac Na + trichlopyr + kinetic	30 + 280 + 0.125% v/v	1-3 Til	6	50	70	50	100	100	36	63	58	100	100	8770
propanil + thiobencarb	4480 +4480	5 lsr	16	75	98	86	63	100	84	100	89	98	100	9040
propanil + thiobencarb fb.[5] propanil + C.O.C	4480 + 4480 fb. 6720 + 1.25% v/v	5 lsr fb. 1-3 Til	19	96	100	98	73	100	98	100	96	75	100	9120
propanil + carfentrazone + C.O.C.	4480 + 112 + 1.25% v/v	5 lsr	21	84	79	98	100	100	80	61	98	98	100	9300
propanil + trichlopyr + C.O.C.	6720 + 280 + 1.25% v/v	1-3 Til	9	65	80	89	100	100	66	83	88	98	100	9130
clomazone	337	0.5 lsr	15	75	100	0	0	0	100	100	0	0	0	6090
clomazone	673	0.5 lsr	58	100	100	0	3	0	98	100	0	0	0	3390
clomazone fb. propanil + C.O.C.	673 fb. 4480 + 1.25% v/v	0.5 lsr fb. 5 lsr	31	96	100	58	16	88	98	100	30	50	70	7410
clomazone fb. carfentrazone	673 fb. 112	0.5 lsr fb. 5 lsr	33	84	100	93	100	98	88	100	88	100	98	8660
clomazone fb. trichlopyr	673 fb. 280	0.5 lsr fb. 1-3 Til	33	88	100	0	68	100	86	100	0	93	100	5190
clomazone fb. bispyribac Na + kinetic	673 fb. 30 + 0.125% v/v	0.5 lsr fb. 1-3 Til	35	99	100	0	73	95	98	100	0	98	95	4980
cyhalofop + C.O.C.	210 + 1.25% v/v	5 lsr	1	53	100	10	25	18	53	93	19	98	55	8280
cyhalofop + propanil + C.O.C.	210 + 4480 + 1.25% v/v	5 lsr	5	78	100	35	0	31	93	100	33	88	50	8630
cyhalofop + propanil + C.O.C.	280 + 6720 + 1.25% v/v	1-3 Til	10	75	99	64	86	98	84	95	58	88	73	9000
cyhalofop + trichlopyr + C.O.C.	280 + 280 + 1.25% v/v	1-3 Til	5	53	100	28	100	100	40	100	24	100	100	8330
cyhalofop + carfentrazone + C.O.C.	210 + 112 + 1.25% v/v	5 lsr	21	90	100	100	93	98	94	96	95	100	99	9040
cyhalofop + trichlopyr + propanil + C.O.C.	210 + 280 + 4480 + 1.25% v/v	1-3 Til	6	83	98	81	98	100	90	100	81	98	98	9040
cyhalofop + C.O.C. fb. bispyribac Na + kinetic	210 + 1.25% v/v fb. 30 + 0.125% v/v	5 lsr fb. 1-3 Til	3	100	100	50	97	95	100	100	30	100	83	8640
molinate + bensulfuron	4480 + 70	1-2 lsr	24	89	100	88	19	100	90	95	78	25	100	8730
thiobencarb (15G) fb. trichlpyr	4480 + 280	1-2 lsr fb. 1-3 Til	6	48	103	98	3	100	48	103	101	0	99	8830
Untreated	--	--	0	5	5	14	19	8	6	5	16	16	8	8260
LSD														641

[1] ECHOR (Early Watergrass), LEFFA (Bearded Sprangletop), CYPDI (Smallflower Umbrellasedge), SAGMO (California Arrowhead), AMMAU (Red Stem).

[2] lsr (leaf stage rice), Til (Tillers of rice).

[3] Yiled adjusted to 14% moisture.

[4] Untreated weed control values represent % cover by respective weeds.

[5] fb. (followed by).

Table 4. Varietal tolerance to clomazone (Command) at the RES.

				Tolerance						
				Injury	Bleaching	Stand Reduction	Stunting	Stand Reduction	Stunting	
Variety	Treatment	Rate	Timing[1]	7 DAT	7 DAT	28 DAT	28 DAT	42 DAT	42 DAT	Yield[2]
		(g ai/ha)		%						(%)
A-201	clomazone	673	0.5 lsr	10	43	0	0	0	2	105
AKITA	clomazone	673	0.5 lsr	15	63	15	40	8	8	103
CALMOCHI 101	clomazone	673	0.5 lsr	8	38	0	5	0	2	91
CH-201	clomazone	673	0.5 lsr	13	68	0	13	0	3	92
CT-201	clomazone	673	0.5 lsr	10	43	0	2	0	7	104
KOSHIKARI	clomazone	673	0.5 lsr	17	65	2	15	0	12	102
L-204	clomazone	673	0.5 lsr	8	23	0	2	0	2	107
L-205	clomazone	673	0.5 lsr	7	22	0	3	0	7	104
M-104	clomazone	673	0.5 lsr	7	37	0	2	0	0	95
M-202	clomazone	673	0.5 lsr	7	37	0	5	0	7	99
M-205	clomazone	673	0.5 lsr	10	48	0	2	0	3	98
S-102	clomazone	673	0.5 lsr	12	45	0	3	7	7	95
A-201	clomazone	1346	0.5 lsr	17	65	0	2	0	3	108
AKITA	clomazone	1346	0.5 lsr	18	45	32	7	32	12	67
CALMOCHI 101	clomazone	1346	0.5 lsr	18	72	52	10	48	18	69
CH-201	clomazone	1346	0.5 lsr	17	77	23	15	28	15	81
CT-201	clomazone	1346	0.5 lsr	10	52	0	0	0	5	102
KOSHIKARI	clomazone	1346	0.5 lsr	17	45	7	5	8	8	114
L-204	clomazone	1346	0.5 lsr	12	48	0	0	0	8	114
L-205	clomazone	1346	0.5 lsr	8	27	0	2	0	5	91
M-104	clomazone	1346	0.5 lsr	20	80	27	13	28	10	85
M-202	clomazone	1346	0.5 lsr	15	67	53	15	52	22	57
M-205	clomazone	1346	0.5 lsr	12	45	32	8	32	10	71
S-102	clomazone	1346	1-2 lsr	22	73	50	13	63	22	54
A-201	molinate	4480	1-2 lsr	0	0	0	0	0	0	100
AKITA	molinate	4480	1-2 lsr	0	0	0	0	0	0	100
CALMOCHI 101	molinate	4480	1-2 lsr	0	0	0	0	0	0	100
CH-201	molinate	4480	1-2 lsr	0	0	0	0	0	0	100
CT-201	molinate	4480	1-2 lsr	0	0	0	0	0	0	100
KOSHIKARI	molinate	4480	1-2 lsr	0	0	0	0	0	0	100
L-204	molinate	4480	1-2 lsr	0	0	0	0	0	0	100
L-205	molinate	4480	1-2 lsr	0	0	0	0	0	0	100
M-104	molinate	4480	1-2 lsr	0	0	0	0	0	0	100
M-202	molinate	4480	1-2 lsr	0	0	0	0	0	0	100
M-205	molinate	4480	1-2 lsr	0	0	0	0	0	0	100
S-102	molinate	4480	1-2 lsr	0	0	0	0	0	0	100

[1] lsr (leaf stage rice).

[2] Yiled expressed as percent of the yield obtained under molinate application.

Table 5. Propanil and combination trial at the RES.

Treatment	Rate	Timing[2]	Injury	Weed Control[1]								
				ECHPH	LEFFA	SCPMU	CYPDI	ECHPH	LEFFA	SCPMU	CYPDI	
			7 DAT	28 DAT	28 DAT	28 DAT	28 DAT	42 DAT	42 DAT	42 DAT	42 DAT	Yield[3]
	(g ai/Ha)		%									(lb/A)
Untreated[4]	--	--	0	39	10	21	31	36	8	25	30	5410
propanil (EC) + C.O.C.	4480 + 1.25% v/v	4 lsr	8	79	8	100	100	61	0	98	96	7900
propanil (EDF) + C.O.C.	4480 + 1.25% v/v	4 lsr	5	91	49	100	100	86	54	98	100	8270
bensulfuron	70	4 lsr	6	50	9	100	100	46	0	100	95	7320
thiobencarb	4480	4 lsr	3	55	84	25	31	60	100	0	15	7330
cyhalofop + C.O.C.	210 + 1.25% v/v	4 lsr	1	91	99	0	0	90	100	9	23	5540
bispyribac Na + kinetic	25 + 0.125% v/v	4 lsr	14	88	0	99	60	73	0	100	50	7970
propanil (EC) + bensulfuron + C.O.C.	4480 + 70 + 1.25% v/v	4 lsr	6	86	33	100	100	79	0	100	98	8000
propanil (EC) + thiobencarb	4480 + 4480	4 lsr	11	96	90	93	100	90	90	80	76	8010
propanil (EC) + cyhalofop + C.O.C.	4480 + 210 + 1.25% v/v	4 lsr	10	84	13	93	98	78	0	83	98	7610
propanil (EC) + bispyribac Na + kinetic	4480 + 30 + 0.125% v/v	4 lsr	8	66	21	100	98	59	0	94	98	7920
propanil (EDF) + bensulfuron + C.O.C.	4480 + 70 + 1.25% v/v	4 lsr	8	76	25	100	100	70	0	100	100	8180
propanil (EDF) + thiobencarb	4480 + 4480	4 lsr	6	88	88	99	100	83	83	95	100	8790
propanil (EDF) + cyhalofop + C.O.C.	4480 + 210 + 1.25% v/v	4 lsr	5	98	100	98	100	95	100	94	100	8400
propanil (EDF) + bispyribac Na + kinetic	4480 + 30 + 0.125% v/v	4 lsr	6	90	29	100	100	85	13	100	78	7630
propanil (EC) + bispyribac Na + kinetic	3360 + 30 + 0.125% v/v	4 lsr	11	74	10	99	100	65	0	98	95	8060
propanil (EDF) + bispyribac Na + kinetic	3360 + 30 + 0.125% v/v	4 lsr	6	85	30	99	100	74	13	95	67	8430
Duet + C.O.C.	4480 + 1.25% v/v	4 lsr	5	86	45	95	100	75	31	100	100	8180
Duet + C.O.C.	6720 + 1.25% V/V	1-2 Til	5	79	38	93	100	71	25	93	100	7400
molinate + bensulfuron	4480 + 70	1-2 lsr	0	100	99	100	100	100	100	100	100	7970
LSD												1010

1 ECHPH (Late Watergrass), LEFFA (Bearded Sprangletop),SCPMU (Ricefield Bulrush), CYPDI (Smallflower Umbrellasedge), .

2 lsr (leaf stage rice), Til (Tillers of rice).

3 Yiled adjusted to 14% moisture.

4 Untreated weed control values represent % cover by respective weeds.

Table 6. Herbicide combination trial at the RES.

Treatment	Rate	Timing[2]	Injury	Weed Control[1] ECHPH	LEFFA	SCPMU	CYPDI	ECHPH	SCPMU	CYPDI	Yield[3]
	(g ai/Ha)		7 DAT	28 DAT	28 DAT	28 DAT	28 DAT	42 DAT	42 DAT	42 DAT	(lb/A)
				%							
Untreated[4]	--	--	0	40	5	8	5	48	13	5	2040
clomazone	673	0.5 lsr	58	97	100	0	0	97	0	0	1690
propanil + C.O.C.	6720 + 1.25% v/v	5-6 lsr	5	73	10	100	100	75	98	100	7030
cyhalofop + C.O.C.	210 + 1.25% v/v	5-6 lsr	5	72	100	0	0	75	20	0	5620
bispyribac Na + Kinetic	25 + 0.125% v/v	5-6 lsr	10	83	0	100	57	72	95	17	6380
thiobencarb	4480	5-6 lsr	5	20	93	0	33	23	30	33	2950
propanil + cyhalofop + C.O.C.	4480 + 210 + 1.25% v/v	5-6 lsr	7	85	97	100	100	82	100	93	7740
propanil + bisbyibac Na + Kinetic	4480 + 25 + 0.125% v/v	5-6 lsr	7	63	50	100	100	62	67	67	4680
propanil + thiobencarb	4480 + 4480	5-6 lsr	10	82	98	100	100	78	100	100	7550
bispyribac Na + thiobencarb	25 + 4480	5-6 lsr	7	80	63	100	57	80	100	58	7430
cyhalofop + C.O.C. fb.[5] bispyribac Na + kinetic	211 + 1.25% v/v fb. 30 + 0.125% v/v	5-6 lsr fb. 2-3 Til	0	98	100	100	23	100	97	88	7020
cyhalofop + C.O.C. fb. propanil +C.O.C.	210 + 1.25% v/v fb. 6720 + 1.25% v/v	5-6 lsr fb. 2-3 Til	0	100	100	100	100	100	100	100	7330
UC-2112 (thiobencarb + clomazone)	3360 + 338	1.0 lsr	17	100	100	17	92	100	17	67	6290
bensulfuron	70	5-6 lsr	3	28	33	100	100	32	100	100	4400
carfentrazone	112	5-6 lsr	5	0	0	100	100	0	100	100	1780
trichlopyr	280	5-6 lsr	2	17	17	100	100	18	100	100	2880
bensulfuron + propanil + C.O.C.	70 + 6720 + 1.25% v/v	5-6 lsr	7	82	82	77	100	85	100	100	7110
carfentrazone + propanil + C.O.C.	112 + 6720 + 1.25% v/v	5-6 lsr	12	63	63	57	100	62	100	100	7390
trichlopyr + propanil + C.O.C.	280 + 6720 + 1.25% v/v	5-6 lsr	13	77	77	65	100	72	67	67	7290
trichlopyr + bispyribac Na + kinetic	280 + 25 + 0.125% v/v	5-6 lsr	10	75	75	90	90	75	100	75	6960
carfentrazone + cyhalofop + C.O.C.	112 + 210 + 1.25% v/v	5-6 lsr	15	28	28	0	100	22	100	100	4650
propanil + trichlopyr + cyhalofop + C.O.C.	6720 + 280 + 210 + 1.25% v/v	5-6 lsr	8	83	83	100	100	80	100	100	7640
clomazone fb. bensulfuron + C.O.C.	673 fb. 70 + 1.25% v/v	0.5 lsr fb. 2-3 Til	53	95	95	100	92	93	97	62	4600
clomazone fb. carfentrazone	673 fb. 112	0.5 lsr fb. 2-3 Til	43	83	83	100	57	85	62	33	5590
clomazone fb. trichlopyr	673 fb. 280	0.5 lsr fb. 2-3 Til	37	88	88	100	33	95	0	0	4640
clomazone fb. propanil + C.O.C.	673 fb. 6720 + 1.25% v/v	0.5 lsr fb. 2-3 Til	57	98	98	100	57	100	0	0	5920
clomazone fb. bispyribac Na + kinetic	673 fb. 30 + 0.125% v/v	0.5 lsr fb. 2-3 Til	58	100	100	100	0	100	0	0	3140
command fb. thiobencarb (15G)	673 fb. 4480	0.5 lsr fb. 1-2 lsr	70	100	100	100	67	100	0	67	4980
molinate + bensulfuron	4480 + 70	1-2 lsr	7	100	100	100	100	100	100	100	7810
clomazone fb. molinate	449 fb. 3360	P.F.S. fb. 1-2 lsr	7	100	100	57	64	100	64	60	6330
LSD											2100

[1] ECHPH (Late Watergrass), LEFFA (Bearded Sprangletop), SCPMU (Ricefield Bulrush), CYPDI (Smallflower Umbrellasedge).

[2] lsr (leaf stage rice), Til (Tillers of rice), PFS (preflood surface).

[3] Yiled adjusted to 14% moisture.

[4] Untreated weed control values represent % cover by respective weeds.

[5] fb. (followed by).

Table 7. Regiment and Abolish trial at the RES.

				Weed Control[1]							
			Injury	ECHPH	LEFFA	SCPMU	CYPDI	ECHPH	SCPMU	CYPDI	
Treatment	Rate	Timing[2]	7 DAT	28 DAT	28 DAT	28 DAT	28 DAT	42 DAT	42 DAT	42 DAT	Yield[3]
	(g ai/ha)		%								(lb/A)
Untreated[4]	--	--	0	40	5	14	6	39	19	5	4510
thiobencarb	2240	5-6 lsr	3	6	38	6	0	33	3	6	6070
thiobencarb	3360	5-6 lsr	4	16	45	6	0	20	15	0	5220
thiobencarb	4480	5-6 lsr	5	9	88	6	0	21	3	0	5410
bispyribac Na	10	5-6 lsr	0	5	0	95	0	13	75	0	5350
bispyribac Na	15	5-6 lsr	1	3	0	98	0	6	94	0	5860
bispyribac Na	25	5-6 lsr	0	4	13	100	50	0	98	0	4210
bispyribac Na	30	5-6 lsr	0	10	0	100	25	0	100	25	5380
bispyribac Na + thiobencarb	10 + 2240	5-6 lsr	0	93	75	100	85	86	100	90	6770
bispyribac Na + thiobencarb	15 + 2240	5-6 lsr	4	100	49	100	89	93	100	75	7320
bispyribac Na + thiobencarb	25 + 2240	5-6 lsr	6	100	50	100	98	100	100	95	7460
bispyribac Na + thiobencarb	30 + 2240	5-6 lsr	11	100	43	100	94	98	100	96	7490
bispyribac Na + thiobencarb	15 + 3360	5-6 lsr	3	98	68	100	88	91	95	94	7400
bispyribac Na + thiobencarb	25 + 3360	5-6 lsr	4	100	94	100	95	98	98	91	7440
bispyribac Na + thiobencarb	30 + 3360	5-6 lsr	11	99	91	100	100	100	100	99	7030
bispyribac Na + thiobencarb	15 + 4480	5-6 lsr	4	95	66	100	93	88	98	91	7570
bispyribac Na + thiobencarb	25 + 4480	5-6 lsr	10	100	66	100	100	94	99	98	7270
bispyribac Na + thiobencarb	30 + 4480	5-6 lsr	11	94	86	100	99	93	98	96	7420
bispyibac Na + Kinetic	10 + 0.125% v/v	5-6 lsr	4	70	25	75	61	70	70	60	7190
bispyibac Na + Kinetic	15 + 0.125% v/v	5-6 lsr	7	93	18	100	91	85	93	85	7260
bispyibac Na + Kinetic	25 + 0.125% v/v	5-6 lsr	9	98	13	100	89	90	100	89	7010
bispyibac Na + Kinetic	30 + 0.125% v/v	5-6 lsr	9	94	23	100	95	88	100	91	7260
propanil + C.O.C.	6720 + 1.25% v/v	5-6 lsr	5	65	26	79	100	64	96	100	7680
Untreated	--	--	0	40	5	13	6	36	16	5	5370
LSD											1220

[1] ECHPH (Late Watergrass), LEFFA (Bearded Sprangletop), SCPMU (Ricefield Bulrush), CYPDI (Smallflower Umbrellasedge).

[2] lsr (leaf stage rice).

[3] Yiled adjusted to 14% moisture.

[4] Untreated weed control values represent % cover by respective weeds.

Table 8. UC Davis J-9 ACCase inhibitor study at the RES.

				Weed Control[1]				
			Injury	ECHPH	LEFFA	ECHPH	LEFFA	
Treatment	Rate	Timing[2]	7 DAT	28 DAT	28 DAT	42 DAT	42 DAT	Yiled[3]
	(g ai/ha)		%					(lb/A)
Untreated[4]	--	--	0	24	8	19	5	7700
cyhalofop + C.O.C.	140 + 1.25% v/v	3 lsr	0	63	78	68	86	8090
cyhalofop + C.O.C.	210 + 1.25% v/v	3 lsr	0	86	98	94	100	7960
BAS 625H + C.O.C.	100 + 1.25% v/v	3 lsr	3	75	90	78	93	8310
BAS 625H + C.O.C.	150 + 1.25% v/v	3 lsr	8	75	84	71	78	8830
fenoxaprop + safener	75	3 lsr	10	79	94	70	100	7420
fenoxaprop + safener	90	3 lsr	14	70	95	65	98	8290
cyhalofop + C.O.C.	210 + 1.25% v/v	1-2 Til	0	69	93	79	96	8240
cyhalofop + C.O.C.	280 + 1.25% v/v	1-2 Til	0	78	88	89	98	8340
BAS 625H + C.O.C.	100 + 1.25% v/v	1-2 Til	3	48	79	46	98	7720
BAS 625H + C.O.C.	150 + 1.25% v/v	1-2 Til	0	56	63	65	85	7430
fenoxaprop	90	1-2 Til	3	83	95	83	95	8090
fenoxaprop + safener	90	1-2 Til	0	48	83	54	98	6590
fenoxaprop + safener	120	1-2 Til	3	81	93	81	100	8460
fenoxaprop	90	Mid-Til	3	80	95	79	100	7630
fenoxaprop + safener	120	Mid-Til	5	93	98	86	99	7870
cyhalofop + C.O.C.	280 + 1.25% v/v	Mid-Til	5	93	98	90	100	8040
fenoxaprop	90	Full-Til	1	95	100	91	100	6740
fenoxaprop + safener	120	Full-Til	5	73	89	70	100	8020
cyhalofop + C.O.C.	560	Full-Til	5	63	98	60	100	8400
LSD								1480

[1] ECHPH (Late Watergrass), LEFFA (Bearded Sprangletop).

[2] lsr (leaf stage rice), Til (Tillers of rice).

[3] Yiled adjusted to 14% moisture.

[4] Untreated weed control values represent % cover by respective weeds.

Table 9. UC Davis Hamilton road ACCase inhibitor study.

				Weed Control[1]				
			Injury	ECHPH	LEFFA	ECHPH	LEFFA	
Treatment	Rate	Timing[2]	7 DAT	28 DAT	28 DAT	42 DAT	42 DAT	Yield[3]
	(g ai/ha)		----------	----------	%	----------	----------	(lb/A)
Untreated[4]	--	--	0	30	10	37	30	6390
BAS625H + C.O.C.	100 + 1.25% v/v	4 lsr	2	50	62	60	58	7720
BAS625H + C.O.C.	150 + 1.25% v/v	4 lsr	8	78	95	70	92	7420
fenoxaprop + safener	75	4 lsr	8	65	98	57	100	6560
fenoxaprop + safener	90	4 lsr	8	72	100	73	100	7500
cyhalofop + C.O.C.	210 + 1.25% v/v	4 lsr	2	95	100	92	100	7470
BAS625H + C.O.C.	100 + 1.25% v/v	1-2 Til	5	27	50	33	85	6630
BAS625H + C.O.C.	150 + 1.25% v/v	1-2 Til	3	37	63	47	83	6780
fenoxaprop + safener	90	1-2 Til	5	47	100	47	100	6710
cyhalofop + C.O.C.	280 + 1.25% v/v	1-2 Til	2	82	90	78	62	7850
LSD								1570

[1] ECHPH (Late Watergrass), LEFFA (Bearded Sprangletop).

[2] lsr (leaf stage rice), Til (Tillers of rice).

[3] Yiled adjusted to 14% moisture.

[4] Untreated weed control values represent % cover by respective weeds.

Table 10. Shark (carfentrazone) into the water study at the RES.

Treatment	Method[2]	Rate	Timing[3]	Injury	Weed Control[1]						Yield[4]
					SCPMU	MOOVA	CYPDI	SCPMU	MOOVA	CYPDI	
				7 DAT	28 DAT	28 DAT	28 DAT	42 DAT	42 DAT	42 DAT	
		(g ai/ha)		%							(lb/A)
Untreated[5]	--	--	--	0	19	9	5	19	8	5	4990
carfentrazone	D.D.A.	112	2-3	0	68	93	94	56	100	63	6490
carfentrazone	D.D.A.	168	2-3	0	76	100	98	68	100	85	6420
carfentrazone	D.D.A.	224	2-3	0	88	100	99	80	98	100	6970
carfentrazone	D.S.A.	112	2-3	0	86	93	90	79	98	83	6670
carfentrazone	D.S.A.	168	2-3	1	93	100	100	88	100	98	6970
carfentrazone	D.S.A.	224	2-3	1	98	100	100	95	100	99	7330
carfentrazone + bensulfuron	D.D.A.	112 + 53	2-3	4	96	100	100	90	100	100	7270
carfentrazone + bensulfuron	D.S.A.	112 + 53	2-3	11	100	100	100	100	100	98	8100
bensulfuron	D.D.A.	53	2-3	4	100	100	99	100	100	95	7870
LSD											1070

[1] SCPMU (Ricefield Bulrush), MOOVA (Monochoria), CYPDI (Smallflower Umbrellasedge).

[2] D.D.A. (Direct-Dry Application), D.S.A. (Direct-Spray Application).

[3] lsr (leaf stage rice), Til (Tillers of rice).

[4] Yiled adjusted to 14% moisture.

[5] Untreated weed control values represent % cover by respective weeds.

Table 11. IR-5878 trial at the RES.

Treatment	Rate	Timing[2]	Injury	Weed Control[1]							Yield[3]
				ECHPH	LEFFA	CYPDI	ECHPH	LEFFA	CYPDI	SCPMU	
			7 DAT	28 DAT	28 DAT	28 DAT	42 DAT	42 DAT	42 DAT	42 DAT	
	(g ai/ha)		%								(lb/A)
Untreated[4]	--	--	0	11	5	9	8	5	9	5	6520
IR-5878 + Trend	60 + 0.3% v/v	3 lsr	16	84	75	100	76	43	100	0	6950
IR-5878 + Trend	75 + 0.3% v/v	3 lsr	18	64	43	73	48	23	99	28	6540
IR-5878 + Trend	120 + 0.3% v/v	3 lsr	19	81	69	93	80	40	100	21	6780
azimsulfuron + Trend	20 + 0.3% v/v	3 lsr	10	93	73	90	88	13	100	0	7110
propanil + C.O.C.	3360 + 1.25% v/v	3 lsr	11	98	80	100	91	43	95	100	7190
IR-5878 + propanil +Trend	60 + 3360 + 0.3% v/v	3 lsr	15	91	44	98	73	43	95	94	7350
azimsulfuron + propanil +Trend	20 + 3360 + 0.3% v/v	3 lsr	11	98	93	100	93	85	100	100	6930
LSD											680

[1] ECHPH (Late Watergrass), LEFFA (Bearded Sprangletop), CYPDI (Smallflower Umbrellasedge), SCPMU (Ricefield Bulrush).

[2] lsr (leaf stage rice).

[3] Yiled adjusted to 14% moisture.

[4] Untreated weed control values represent % cover by respective weeds.

Table 12. Sempra (halosulfuron) foliar trial at the RES.

Treatment	Rate	Timing[2]	Injury	Weed Control[1] ECHPH	LEFFA	CYPDI	AMMAU	ECHPH	LEFFA	CYPDI	AMMAU	Yiled[3]
			7 DAT	28 DAT	28 DAT	28 DAT	28 DAT	42 DAT	42 DAT	42 DAT	42 DAT	
	(g ai/ha)		%									(lb/A)
Untreated[4]	--	--	0	13	15	13	5	18	11	13	5	2440
halosulfuron + C.O.C.	36 + 1.25% v/v	3 lsr	1	45	17	57	0	58	10	38	0	2290
halosulfuron + C.O.C.	53 + 1.25% v/v	3 lsr	4	52	43	70	0	58	23	39	33	2150
halosulfuron + C.O.C.	70 + 1.25% v/v	3 lsr	6	43	17	67	0	66	13	38	19	2490
bensulfuron + C.O.C.	70 + 1.25% v/v	3 lsr	8	57	8	57	0	45	14	40	0	2330
propanil + halosulfuron + C.O.C.	3360 + 36 + 1.25% v/v	3 lsr	9	75	17	82	0	74	14	49	38	2380
propanil + halosulfuron + C.O.C.	3360 + 53 + 1.25% v/v	3 lsr	8	68	13	73	0	71	13	34	39	2610
propanil + halosulfuron + C.O.C.	3360 + 70 + 1.25% v/v	3 lsr	8	55	20	55	0	56	11	48	13	2380
propanil + bensulfuron + C.O.C.	3360 + 70 + 1.25% v/v	3 lsr	5	85	33	77	45	84	30	54	39	2760
cyhalofop + C.O.C. fb.[5] halosulfuron + C.O.C.	210 + 1.25% v/v fb. 36 + 1.25% v/v	3 lsr fb. 1-2 Til	0	97	97	58	30	100	99	14	1	2460
cyhalofop + C.O.C. fb. halosulfuron + C.O.C.	210 + 1.25% v/v fb. 53 + 1.25% v/v	3 lsr fb. 1-2 Til	0	100	100	62	17	100	100	30	0	2230
cyhalofop + C.O.C. fb. halosulfuron + C.O.C.	210 + 1.25% v/v fb. 70 + 1.25% v/v	3 lsr fb. 1-2 Til	0	100	100	70	28	100	100	34	0	2290
cyhalofop + C.O.C. fb. bensulfuron + C.O.C.	210 + 1.25% v/v fb. 70 + 1.25% v/v	3 lsr fb. 1-2 Til	0	100	100	67	90	100	100	10	25	2520
propanil + halosulfuron + C.O.C.	6720 + 36 + 1.25% v/v	1-2 Til	4	72	40	98	97	84	17	95	100	2670
propanil + halosulfuron + C.O.C.	6720 + 53 + 1.25% v/v	1-2 Til	4	83	47	100	100	85	38	98	100	3130
propanil + halosulfuron + C.O.C.	6720 + 70 + 1.25% v/v	1-2 Til	5	85	40	100	100	86	41	98	99	2590
propanil + bensulfuron + C.O.C.	6720 + 70 + 1.25% v/v	1-2 Til	3	53	33	100	100	85	25	100	100	2380
LSD												640

[1] ECHPH (Late Watergrass), LEFFA (Bearded Sprangletop), CYPDI (Smallflower Umbrellasedge), AMMAU (Red Stem).

[2] lsr (leaf stage rice), Til (Tillers of rice).

[3] Yiled adjusted to 14% moisture.

[4] Untreated weed control values represent % cover by respective weeds.

[5] fb. (followed by)

Table 13. Sempra (halosulfuron) into the water study at the RES.

				Weed Control[1]					
			Injury	ECHPH	SCPMU	MOOVA	ECHPH	SCPMU	
Treatment	Rate	Timing[2]	7 DAT	28 DAT	28 DAT	28 DAT	42 DAT	42 DAT	Yield[3]
	(g ai/ha)		%						(lb/A)
Untreated[4]	--	--	0	39	13	6	43	14	3280
halosulfuron	36	1-2 lsr	6	64	100	100	60	100	7700
halosulfuron	53	1-2 lsr	8	76	100	100	73	100	8010
halosulfuron	70	1-2 lsr	13	81	100	100	75	100	7570
bensulfuron	70	1-2 lsr	8	71	100	100	69	100	7170
halosulfuron + molinate	36 + 4480	1-2 lsr	5	100	100	100	100	100	8350
halosulfuron + molinate	53 + 4480	1-2 lsr	5	100	100	100	100	99	7760
halosulfuron + molinate	70 + 4480	1-2 lsr	13	99	100	100	100	100	8270
halosulfuron + thiobencarb	36 + 4480	1-2 lsr	9	95	100	100	86	100	8070
halosulfuron + thiobencarb	53 + 4480	1-2 lsr	11	96	100	100	88	100	7060
halosulfuron + thiobencarb	70 + 4480	1-2 lsr	14	99	100	100	88	100	7710
bensulfuron + thiobencarb	70 + 4480	1-2 lsr	10	90	100	100	88	100	8110
halosulfuron	53	2-3 lsr	1	68	100	100	61	100	7520
halosulfuron	70	2-3 lsr	6	51	100	100	60	100	6760
bensulfuron	70	2-3 lsr	3	61	100	100	59	93	6530
LSD									640

[1] ECHPH (Late Watergrass), SCPMU (Ricefield Bulrush), MOOVA (Monochoria).

[2] lsr (leaf stage rice).

[3] Yiled adjusted to 14% moisture.

[4] Untreated weed control values represent % cover by respective weeds.

Table 14. Clearfield rice trial at the RES.

Treatment	Rate	Timing[2]	Injury 7 DAT	Weed Control[1] ECHPH 28 DAT	LEFFA 28 DAT	CYPDI 28 DAT	AMMAU 28 DAT	ECHPH 42 DAT	LEFFA 42 DAT	CYPDI 42 DAT	AMMAU 42 DAT	SCPMU 42 DAT	Yield[3]
	(g ai/ha)		%										(lb/A)
Untreated[4]	--	--	0	13	8	11	5	21	5	11	6	8	3180
imazethapyr + C.O.C. + UN-32	70 + 0.25% v/v + 4.67 L/ha	3 lsr	9	90	78	93	48	75	90	46	9	100	3620
imazethapyr + C.O.C. + UN-32	140 + 0.25% v/v + 4.67 L/ha	3 lsr	14	100	100	96	98	90	100	66	45	98	3540
imazethapox + C.O.C. + UN-32	53 + 0.25% v/v + 4.67 L/ha	3 lsr	6	91	91	91	41	89	95	53	38	98	3720
bensulfuron + C.O.C.	70 + 1.25% v/v	3 lsr	3	30	30	89	3	53	25	20	13	78	3460
propanil + C.O.C.	3360 + 1.25% v/v	3 lsr	20	93	93	100	100	90	33	100	100	98	3700
bispyrabac Na + Kinetic	30 + 0.125% v/v	1-2 Til	5	80	80	95	100	79	4	68	20	98	3760
LSD													350

[1] ECHPH (Late Watergrass), LEFFA (Bearded Sprangletop), CYPDI (Smallflower Umbrellasedge), AMMAU (Red-Stem), SCPMU (Ricefield Bulrush).

[2] lsr (leaf stage rice), Til (Tillers of rice).

[3] Yiled adjusted to 14% moisture.

[4] Untreated weed control values represent % cover by respective weeds.

Table 15. Tolerance of weed-free rice to herbicides at the RES.

			Rice Tolerance					
			Injury	Tiller Reduction	Stunting	Tiller Reduction	Plant Height	
Treatment	Rate	Timing[2]	7 DAT	28 DAT	28 DAT	42 DAT	42 DAT	Yield[3]
	(g ai/Ha)		----------	----------	%	----------	(cm)	(lb/A)
Weed Free	--	--	0	0	0	0	75	6950
thiobencarb (15G)	4480	1-2 lsr	9	6	4	21	73	6900
thiobencarb (15G)	9660	1-2 lsr	35	24	10	14	72	6830
clomazone	673	0.5 lsr	28	6	5	18	75	7110
clomazone	1346	0.5 lsr	75	84	33	50	66	4200
molinate	4480	1-2 lsr	4	4	0	6	77	7400
bispyribac Na + Kinetic	30 + 0.125% v/v	1-2 Til	6	5	3	1	77	6880
bispyribac Na + Kinetic	60 + 0.125% v/v	1-2 Til	28	18	6	14	77	6650
carfentrazone	224	1-2 Til	10	14	4	6	76	6180
carfentrazone	448	1-2 Til	18	8	1	4	77	6780
fenoxaprop-P-ethyl	90	1-2 Til	14	5	4	1	74	7170
fenoxaprop-P-ethyl	180	1-2 Til	83	58	28	23	69	6100
trichlopyr	420	1-2 Til	6	6	6	4	77	7120
trichlopyr	840	1-2 Til	10	3	6	5	74	7120
propanil + C.O.C.	6720 + 1.25% v/v	1-2 Til	28	1	0	1	79	6450
propanil + C.O.C.	13440 + 1.25% v/v	1-2 Til	16	3	0	3	79	7400
cyhalofop + C.O.C.	280 + 1.25% v/v	1-2 Til	1	3	0	3	75	6850
cyhalofop + C.O.C.	560 + 1.25% v/v	1-2 Til	5	10	1	10	75	6780
bensulfuron + C.O.C.	70 + 1.25% v/v	1-2 Til	1	4	4	1	77	6950
bensulfuron + C.O.C.	140 + 1.25% v/v	1-2 Til	13	1	0	0	80	7790
LSD (0.05)								1430

[1] lsr (leaf stage rice), Til (Tillers of rice).

[2] Yiled adjusted to 14% moisture.

Appendix A

Trade Names, Common Names, and Manufacturer of Herbicides.

Trade Name	Common Name	Manufacturer
Abolish	thiobencarb	United Agri Products
Aura	BAS 625H	BASF
Bolero	thiobencarb	Valent
Clincher	cyhalofop	Dow AgroSciences
Command	clomazone	FMC
Duet	propanil + bensulfuron	RiceCo
Grandstand	trichlopyr	Dow AgroSciences
IR-5878	IR-5878	Isagro
Liberty	glufosinate	Aventis
Londax	bensulfuron	DuPont
Ordram	molinate	Zeneca
Prowl	pendimethalin	American Cyanimid
RC-999	propanil + bensulfuron	RiceCo
Regiment	bispyribac-sodium	Valent
Round-Up Ultra	glyphosate	Monsanto
Sempra	halosulfuron	Monsanto
Shark	carfentrazone	FMC
Stam	propanil	Rohm and Haas
Super Wham	propanil	RiceCo
Whip	fenoxaprop	Aventis

Appendix B

Additives used with Herbicides

Trade Name	Type	Manufacture
Agri-Dex	crop oil concentrate	Dow AgroSciences
Herbimax	crop oil concentrate	Loveland
Kinetic	organo silicone surfactant	Helena
Silwet	organo silicone surfactant	Loveland
Trend	non-ionic surfactant	Isagro
X-77	non-ionic surfactant	Valent