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Rimsulfuron for Postemergence Weed Control in Corn in Humid Tropical Environments of Nigeria

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Cogongrass and guineagrass are serious perennial weeds in small-scale farms in lowland subhumid zones of West Africa. Field studies were conducted in 2002 and 2003 at two sites in Ibadan, Nigeria [Ijaye and the International Institute of Tropical Agriculture (IITA)], to evaluate the effect of rimsulfuron on weed communities dominated by cogongrass and guineagrass in corn. At both sites, treatments were rimsulfuron dosages of 0 (nontreated control), 10, 20, 30, 40, 50, 60, 70, and 80 g ai/ha. Rimsulfuron did not cause any visible phytotoxicity on the corn at any dosage at either site. There was a rapid increase in weed control as the dosage of rimsulfuron increased from 0 to 20 g/ha. Weed control was not improved at rates higher than 20 g/ha. Rimsulfuron was very effective against sedges, *Ipomoea involucrata*, Bengal dayflower, gulf leafflower, old-world diamond-flower, and wild jute providing more than 80% control at dosages between 10 and 20 g/ha at Ijaye. Rimsulfuron was less effective for cogongrass, with a maximum of only 38% control observed. At IITA, the herbicide was very effective against guineagrass, Bengal dayflower, nodeweed, coat buttons, redfruit passionflower, and waterleaf; all of which were controlled more than 70% with any rate of rimsulfuron. Regression analysis showed that the dosage of rimsulfuron required to reduce shoot dry biomass by 70% was 5 g/ha for guineagrass and 35 g/ha for cogongrass at 3 wk after treatment (WAT). At crop maturity, the dosage of rimsulfuron required to reduce shoot dry biomass by 70% was 43 g/ha for guineagrass and 200 g/ha for cogongrass. The dry biomass of cogongrass and guineagrass was higher at crop harvest than at 2 WAT regardless of herbicide dosage. Corn grain yield was 1.8 times higher at IITA than at Ijaye. At both sites, corn grain yield increased with increased herbicide dosage. Maximum corn grain yields were obtained at a rimsulfuron dosage of 20 g/ha.

Nomenclature: Rimsulfuron; coat buttons, *Tridax procumbens* L. TRQPR; cogongrass, *Imperata cylindrica* (L.) Beauv. IMPCY; old-world diamond-flower, *Oldenlandia corymbosa* L. OLDCO; guineagrass, *Panicum maximum* Jacq. PANMA; gulf leafflower, *Phyllanthus amarus* Schum. & Thonn. PYLAM; nodeweed, *Synedrella nodiflora* (L.) Gaertn SYDNO; redfruit passionflower, *Passiflora foetida* L. PAQFO; sedges, *Cyperus*, *Mariscus*, and *Kyllinga* spp.; Bengal dayflower, *Commelina benghalensis* L. COMBE; waterleaf, *Talinum triangulare* (Jacq.) Willd TALTR; wild jute, *Corchorus tridens* L. CRGTR; corn, *Zea mays* L. 'TZL Comp 4W'.

Key words: Rhizome, sulfonylurea, chemical control.

Corn is an important staple cereal for about 66% of the population of West and Central Africa (Pingali 2001). In addition to its use for human consumption, corn is also a major ingredient in livestock feed, beer, and starch production. In West Africa, corn production has increased from 2.7 billion kg/yr in the 1980s to 10.5 billion kg/yr in 2000 (Fakorede et al. 2003). This increase in total production is a result of an expansion of the cultivated area from 3 million ha in 1990 to 8 million ha in 2001. Corn yields obtained in researchers' fields (approximately 6,000 kg/ha) are much higher than yields from farmers' fields (1,000 to 2,000 kg/ha) (Badu–Apraku et al. 2003). This yield gap may be attributed to a multitude of biotic and abiotic stresses. Weeds are among the most serious biotic factors that limit crop productivity in small-scale farms in the humid and subhumid zones of West Africa (Oerke et al. 1994).

Cogongrass and guineagrass are two of the most significant invasive perennial weeds in corn in West Africa (Holm et al. 1977). Both weeds are widespread in cultivated fields, very competitive, difficult to control, and cause severe corn yield losses (Chikoye et al. 2002; Holm et al. 1977). Cogongrass is successful because it possesses underground rhizomes that resist most of the control options used by small-scale farmers. Guineagrass persists by profuse tiller and seed production, and it possesses a deep, dense, and fibrous root system that allows it to survive adverse conditions, such as long periods of drought or seasonal fires (Aganga and Tshwenyane 2004; Holm et al. 1977). Cogongrass has been reported to cause yield losses in corn that range from 50 to 90% in West Africa (Chikoye et al. 2002; Udensi et al. 1999). A weed community dominated by guineagrass has been reported to cause corn yield losses that range from 35 to 50% in Nigeria (Zuofa and Tariah 1992). Effective weed-management programs are, therefore, needed to reduce such losses and obtain optimum crop yields.

Previous studies have shown that chemical control is cheaper and more effective than hoe-weeding, the control option used by most small-holder farmers in West Africa (Akobundu 1980; Chikoye et al. 2002). Chemical control options in corn include mixtures of atrazine plus metolachlor, pendimethalin, or alachlor for PRE weed control (Anonymous 1994). These herbicides give acceptable control (greater than 70%) of annual weeds but not perennial weeds with vegetative structures such as rhizomes. POST chemical control is difficult because of a lack of effective herbicides that kill cogongrass but do not injure corn. For example, foliar application of glyphosate provides effective control of cogongrass (Chikoye et al. 2000; Chikoye et al. 2002; Udensi

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et al. 1999). However, because it is nonselective in most crops, except in glyphosate-ready corn or soybean [*Glycine max* (L.) Merr.], application has to occur before crop emergence. In West Africa, where herbicide-tolerant crops are not popular, additional weed-control tactics may be necessary to control weeds that emerge after glyphosate application. Alternatively, glyphosate may be directed at cogongrass with special application equipment, such as shields to avoid crop injury. POST control of perennial grass weeds in corn is now possible with the introduction of selective sulfonylurea herbicides, such as nicosulfuron, primisulfuron, and rimsulfuron (Camacho et al. 1991; Lum et al. 2004; Mitra and Bhowmik 1999). Rimsulfuron is highly effective against numerous annual and perennial weeds (Ackley 1996; Mitra and Bhowmik 1999). It has a short half life (less than 7 d) and short recrop intervals (2 to 6 wk) and, therefore, does not cause injury to many rotational crops (Onofri 1996). We are not aware of reports that rimsulfuron has been tested for perennial weed control in the tropics of West Africa. The objective of this study was to evaluate the suitability of rimsulfuron for POST weed management in corn.

Materials and Methods

Field experiments were conducted in 2002 and 2003 on a farmer's field at Ijaye, Nigeria, and at the International Institute of Tropical Agriculture (IITA) research farm, Ibadan, Oyo State, Nigeria. Both sites are located in the forest–savanna transition zone (7°35′N, 3°55′E). The soil at Ijaye was loamy sand (Oxic Paleustalf) with a pH of 6.5 and texture of 86% sand, 6% clay, and 8% silt. At IITA, the soil was sandy loam (Isohyperthermic Kanhaptic Haplustalfs) with a pH of 5.7 and texture of 69% sand, 18% clay, and 13% silt. At Ijaye, the dominant weed was cogongrass with a population of more than 200 shoots/m^2. Minor weed species with densities less than 5 plants/m^2 were *Ipomoea involucrata* P. Beauv., sedges, gulf leafflower, old-world diamond-flower, Bengal dayflower, and wild jute. The IITA site was heavily infested with guineagrass at a population of 100 to 150 shoots/m^2. Minor weed species that occurred at densities less than 10 plants/m^2 were Bengal dayflower, nodeweed, coat buttons, redfruit passionflower, and waterleaf.

At both sites, the land was plowed and harrowed with tractor-mounted implements. Corn 'TZL Comp 4W' was sown on May 28, 2002, and June 12, 2003, at Ijaye and on May 15, 2002, and June 5, 2003, at IITA. Corn was seeded 5 cm deep at approximately 53,000 seeds/ha. Two corn seeds were seeded per stand and thinned to one plant per stand 2 wk after planting (WAP). The experimental design was a randomized complete block with four replications. Treatments were rimsulfuron dosages of 0 (nontreated control), 10, 20, 30, 40, 50, 60, 70, and 80 g ai/ha and a hoe-weeded control. Plots were 8 m long and 3 m wide, with four rows of corn spaced at 0.75 m with an intrarow space of 0.25 m. Rimsulfuron was applied 2 WAP, when the corn was at the three- to four-leaf stage and weeds were at the two- to four-leaf stage of growth (about 20 to 30 cm tall). Rimsulfuron was applied with a hand-pumped CP3 knapsack sprayer[1] with a flood jet nozzle[1] calibrated to deliver 200 L/ha of water at a pressure of 200 kPa. All hoe-weeded plots were weeded at weekly intervals from 2 WAP until the corn canopy was closed (6 to 8 WAP). Both sites received basal fertilizer at a rate of N at 45 kg/ha, P at 60 kg/ha, and K at 45 kg/ha at 2 WAP. At 6 WAP, at both sites, urea was side-dressed to the corn with N at 45 kg/ha.

Corn injury was assessed visually, whereas weed control was visually assessed early in the season and as weighed cogongrass and guineagrass dry biomass at crop maturity. Corn injury and weed control were estimated visually using a scale of 0 to 100% with 0 = no effect, and 100 = complete kill. Assessment data were recorded at 2 and 4 wk after treatment (WAT) at Ijaye, and at 2 and 6 WAT at IITA. At Ijaye, cogongrass shoot dry biomass was recorded at 2 and 14 WAT (crop harvest) in 2002 and at 2 and 16 WAT (crop harvest) in 2003. Cogongrass shoot dry biomass was determined from four 0.25-m^2 quadrats in each plot at 2 WAT in both years. At crop harvest (14 to 16 WAT), cogongrass shoot and rhizome dry biomass were determined from four 0.25-m^2 quadrats in each plot in both years. Rhizomes were excavated from a depth of 30 cm. At IITA, guineagrass dry biomass was sampled at 2 and 16 WAT (crop harvest) in 2002 and 2003. Guineagrass dry biomass was determined from four 0.25 m^2 quadrats in each plot at each sampling time in both years. All weed samples were oven-dried at 100 C for 48 h. Corn was harvested manually on September 3, 2002, and October 14, 2003, at Ijaye and on September 28, 2002, and October 7, 2003, at IITA. Corn grain yield was measured from ears harvested from approximately 48 plants from two center rows of each plot, except the 1 m border (net harvest area = 9 m^2). Corn grain yields were adjusted to 12% moisture content with a moisture tester.[2]

Corn injury, weed-control data, cogongrass and guineagrass dry biomass, and corn grain yield at both sites were pooled across years because the year by treatment interactions were not significant ($P > 0.05$). Corn yield and weed dry biomass data were analyzed with regression procedures and fitted to exponential models (Blackshaw et al. 1998). Visual weed-control data were fitted to a nonlinear regression model:

$$Y = A\left(1 - \exp^{-BX}\right) \qquad [1]$$

where Y is the predicted percentage of weed control, A is the upper limit for weed control, B is the proportional increase in weed control as the herbicide dosage increases, and X is the herbicide dosage. The slope of each weed was first determined for each replicate. The slopes were subjected to ANOVA to determine whether they were similar.

Weed dry biomass data were fitted to the model:

$$Y = A\exp(-BX) \qquad [2]$$

where Y is the weed dry biomass, A is the dry biomass in the nontreated control, X is the herbicide dosage, and B is the proportional decrease in weed dry biomass as the herbicide dosage increases.

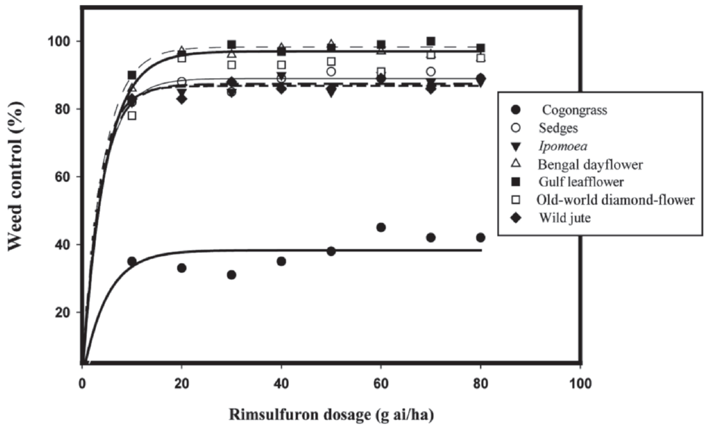

Figure 1. Weed control in response to rimsulfuron dosage at 2 and 4 wk after treatment at Ijaye, Nigeria. Regression equations for each weed were cogongrass, $Y = 38.3\ (1 - \exp^{-0.8139X})$, $R^2 = 0.87$; sedges, $Y = 88.9\ (1 - \exp^{-0.7766X})$, $R^2 = 0.79$; *Ipomoea involucrata*, $Y = 87.4\ (1 - \exp^{-0.7607X})$, $R^2 = 0.90$; Bengal dayflower, $Y = 86.8\ (1 - \exp^{-0.7374X})$, $R^2 = 0.92$; gulf leafflower, $Y = 98.3\ (1 - \exp^{-0.7833X})$, $R^2 = 0.99$; old-world diamond-flower, $Y = 94.1\ (1 - \exp^{-0.8331X})$, $R^2 = 0.82$; wild jute, $Y = 86.8\ (1 - \exp^{-0.7374X})$, $R^2 = 0.90$.

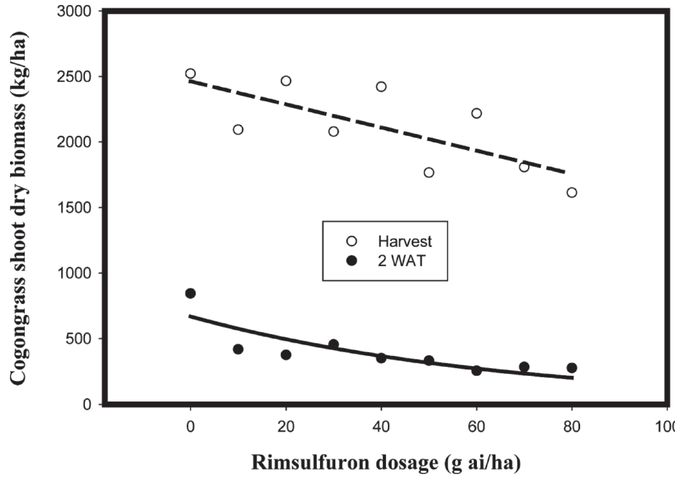

Figure 2. Shoot dry biomass response of cogongrass to rimsulfuron dosages at 2 wk after treatment (WAT) ($Y = 668.7\ \exp^{-0.015X}$), $R^2 = 0.78$, and at crop harvest ($Y = 2{,}462.9 - 8.8X$), $R^2 = 0.80$ at Ijaye, Nigeria.

The regression model for corn yield was as shown in Equation 3:

$$Y = A + B[1 - \exp(-CX)] \qquad [3]$$

where Y is the corn grain yield, A is the asymptotic corn grain yield, X is the herbicide dosage, and B and C are parameter estimates that depict the proportional change in corn grain yield with increases in herbicide dosage. All statistical analyses and curves were fitted with SAS (SAS 1990).

Results and Discussion

Visual Corn Injury and Weed-Control Rating at Ijaye. Rimsulfuron did not cause any visible phytotoxicity (stunting or chlorosis) on the corn at any dosages used in this study (data not shown). These results agree with previous research that showed that corn was tolerant to rimsulfuron (Eleftherohorinos and Kotoula-Syka 1995; Onofri 1996). The slopes of all weeds were not significantly different from each other ($P > 0.05$). There was a rapid increase in the control of most weeds as the rimsulfuron dosage increased from 0 to 20 g/ha. Regardless of weed species, there was no improvement in the level of weed control at dosages higher than 20 g/ha. Rimsulfuron was less effective on cogongrass at all dosages, providing a maximum control of 38% only (Figure 1). Rimsulfuron was highly effective on sedges, *Ipomoea involucrata*, Bengal dayflower, gulf leafflower, old-world diamond-flower, and wild jute, providing more than 80% control at dosages between 10 and 20 g/ha. Other researchers have shown that rimsulfuron was effective against a number of grass and broadleaf weeds (Ackley et al. 1996; Mitra and Bhowmik et al. 1999).

Cogongrass Dry Biomass at Ijaye. Cogongrass rhizome dry biomass was not affected by rimsulfuron at any dosage (data not shown). Cogongrass shoot dry biomass decreased with increase in rimsulfuron dosage (Figure 2). The relationship between shoot dry biomass and herbicide dosage was exponential at 2 WAT ($R^2 = 0.78$) and linear at crop harvest ($R^2 = 0.80$). Estimates from the fitted-regression equations showed that a 70% reduction in cogongrass shoot dry biomass would require application of 35 g/ha of rimsulfuron at 2 WAT and 200 g/ha at crop maturity (Figure 1). Cogongrass shoot dry biomass increased from 2 WAT until crop harvest regardless of herbicide treatment. The higher shoot dry biomass at crop harvest may be attributed to new shoot regrowth that occurred from rhizomes that were poorly controlled by rimsulfuron. Application of rimsulfuron may have broken apical dominance in the rhizome buds and stimulated growth of new shoots from auxiliary rhizome buds that are normally dormant (Willard et al. 1996). These results are consistent with those of Lum et al. (2004, 2005), who found that cogongrass shoot dry biomass increased between 2 WAT and crop harvest, after the initial population had been suppressed by nicosulfuron.

Visual Corn Injury and Weed-Control Rating at IITA. Rimsulfuron at all dosages used in this study did not visibly stunt or cause chlorosis to corn (data not shown). Weed control improved with increase in rimsulfuron dosage (Figure 3). There were no significant differences in the weed slopes. Rimsulfuron provided more than 80% control of all weeds except guineagrass and redfruit passionflower at rates of 10 to 30 g/ha. Rimsulfuron dosages greater than 20 g/ha did not improve control of coat buttons, Bengal dayflower, or redfruit passionflower. Rates higher than 40 g/ha did not improve control of guineagrass or redfruit passionflower.

Guineagrass Dry Biomass at IITA. Guineagrass dry biomass decreased with increases in rimsulfuron dosage (Figure 3). The nonlinear regression model fitted the data for guineagrass dry biomass well ($R^2 = 0.89$ at 2 WAT and $R^2 = 0.87$ at harvest) (Figure 4). From the fitted regression equations, it was estimated that the dosage of rimsulfuron required to

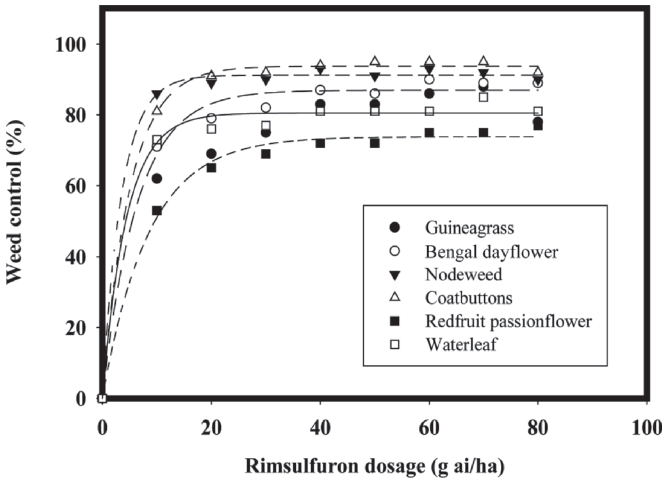

Figure 3. Weed control in response to rimsulfuron at 2 and 6 wk after treatment at the International Institute of Tropical Agriculture research farm, Ibadan, Oyo State, Nigeria. Regression equations for each weed were guineagrass, $Y = 82.4\ (1 - \exp^{-0.8878X})$, $R^2 = 0.97$; Bengal dayflower, $Y = 86.9\ (1 - \exp^{-0.3084X})$, $R^2 = 0.79$; nodeweed, $Y = 91.2\ (1 - \exp^{-0.7546X})$, $R^2 = 0.90$; coat buttons, $Y = 93.8\ (1 - \exp^{-0.8215X})$, $R^2 = 0.82$; redfruit passionflower, $Y = 73.81\ (1 - \exp^{-0.8894X})$, $R^2 = 0.99$; waterleaf, $Y = 80.5\ (1 - \exp^{-0.7979X})$, $R^2 = 0.92$.

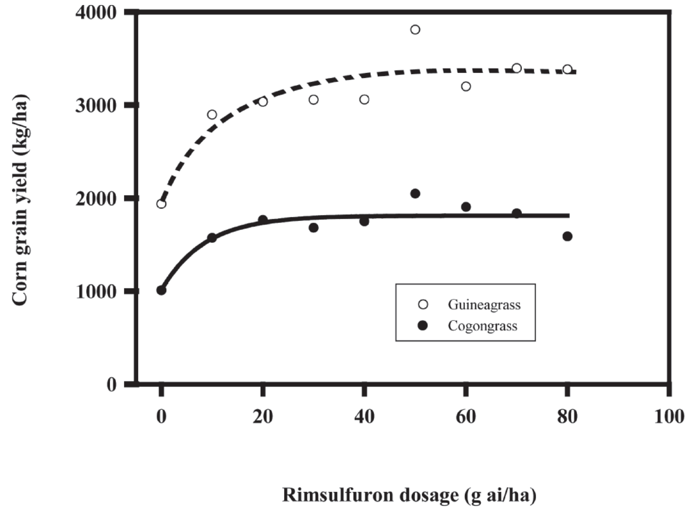

Figure 5. Corn grain yield response to rimsulfuron dosages applied to control cogongrass at Ijaye, Nigeria ($Y = 1{,}010.7 + 800.4\ \exp^{-0.8894X}$, $R^2 = 0.75$), and guineagrass at the International Institute of Tropical Agriculture research farm, Ibadan, Oyo State, Nigeria ($I = 1{,}982 + 1387.5\ \exp^{-0.9253X}$, $R^2 = 0.76$).

reduce guineagrass shoot dry biomass by 70% ranged from 5 g/ha at 2 WAT to 43 g/ha at crop harvest. Guineagrass shoot dry biomass was lower at 2 WAT than at crop harvest. Although rimsulfuron was highly effective on guineagrass initially (2 WAT), it is likely that seedlings that emerged later were not affected by the herbicide because of its short soil-residue period (Onofri 1994).

Corn Grain Yield at Ijaye and IITA. Averaged across all treatments, corn grain yield was 1.8 times higher at IITA (3,040 ± 159 kg/ha) than at Ijaye (1,680 ± 109 kg/ha) (Figure 5). Low grain yield at Ijaye may be partially attributed to cogongrass competition because the weed was not adequately controlled by rimsulfuron. Akobundu and Ekeleme (2000) have reported low grain yields in fields dominated by cogongrass, which they attributed to allelopathic effects of the rhizomes on corn growth. Regardless of experimental site, corn grain yield increased with increased herbicide dosage. The maximum corn grain yields were obtained at a dosage of 20 g/ha at both sites. Rimsulfuron dosages higher than 20 g/ha did not improve corn grain yields at either site. In studies conducted in a similar environment in West Africa, Lum et al. (2005) reported improved corn grain yields with cogongrass control using nicosulfuron.

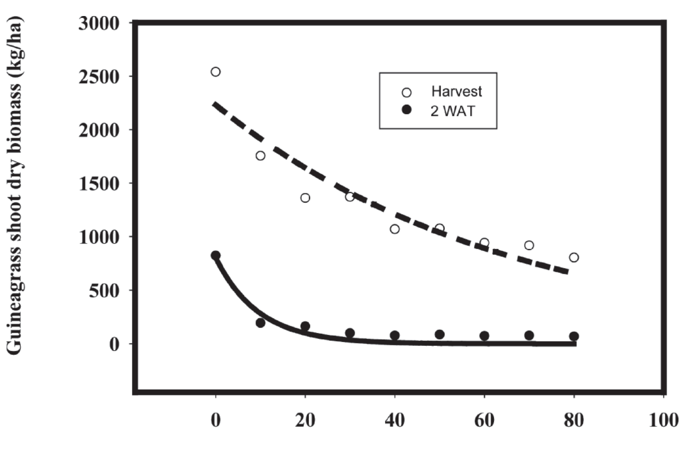

Figure 4. Shoot dry-biomass response of guineagrass to rimsulfuron dosages at 2 wk after treatment (WAT; $Y = 804.9\ \exp^{-0.1045X}$, $R^2 = 0.89$) and at crop harvest ($Y = 2{,}230.7\ \exp^{-0.0153X}$, $R^2 = 0.87$) at the International Institute of Tropical Agriculture research farm, Ibadan, Oyo State, Nigeria.

This study showed that rimsulfuron has great potential for selective POST control of annual and perennial weeds in corn. Based on visual evaluations, rimsulfuron dosages of 10 to 40 g/ha gave acceptable control (> 80%) of most weeds, even guineagrass, but not cogongrass, which required higher dosages. Regression analysis showed that 5 to 35 g/ha of rimsulfuron would be required to reduce the dry biomass of cogongrass and guineagrass by 70% early in the season, which agreed with visual evaluation data. Maximum corn yields were obtained at a dosage of 20 g/ha, which indicated improved corn yields because of good weed control. To develop effective management programs for cogongrass, the use of rimsulfuron may need to be integrated with other herbicides such as glyphosate or nicosulfuron that provide control of shoot regrowth from rhizomes (Chikoye et al. 2002; Lum et al. 2005). Further studies are also needed to assess the economic feasibility of using rimsulfuron in small-scale farms in Africa.

Sources of Materials

[1] Hand-pumped CP3 knapsack sprayer with a flood jet nozzle, Hardi International A/S, Helgeshøj Allé 38, DK 2630 Taastrup, Denmark.

[2] Moisture tester, model 14998, Dickey-John Corporation, 5200 Dickey John Rd., Auburn, IL 62615.

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