

TILLAGE EFFECTS ON ITCHGRASS SEEDLING EMERGENCE AND CHANGES IN THE SEED SOIL RESERVOIR

James L. Griffin*, Ronald P. Strahan, Donnie K. Miller, and Katherine R. LeJeune

School of Plant, Environmental, and Soil Sciences

Louisiana State University Agricultural Center, 104 Sturgis Hall, Baton Rouge, LA 70803

*Corresponding author: JGriffin@agcenter.lsu.edu

ABSTRACT

Tillage and glyphosate application (no-tillage) treatments were evaluated in fallowed fields to determine the effect on itchgrass (*Rottboellia cochinchinensis* (Lour.) W. Clayton) seedling emergence and subsequent changes in the itchgrass seed bank over time. Experimental areas were tilled to a depth of 7.5 cm in April and the tillage (7.5 cm depth) and no-tillage glyphosate treatments were initiated in mid-May and continued monthly through mid-October. Both tillage and glyphosate treatments were effective in controlling itchgrass, and seed were not produced. Total rainfall during the data collection period was 67.7 cm in 1991 and 39.4 cm in 1994. Itchgrass seed population in soil was determined from soil core samples collected at a 7.5 cm depth in May and at experiment termination in November for the tillage and no-tillage treatments and for a season long undisturbed control. During the six month period, itchgrass seed population in soil where itchgrass was allowed to naturally reseed in the undisturbed control increased 2 fold in 1991 and 3.8 fold in 1994. Itchgrass seedling emergence following tillage was greater compared with the no-tillage glyphosate treatment for the mid-September sampling date in 1991 and for the mid-June, mid-August, and mid-October sampling dates in 1994. For other sampling dates each year, seedling emergence was equal for the tillage and no-tillage glyphosate treatments. Total itchgrass seedling emergence from April through October was equal for the tillage and no-tillage glyphosate treatments in 1991 (around 1,200 seed/m²). In 1994, total seedling emergence was 36% greater for the tillage treatment compared with the no-tillage glyphosate treatment (488 vs. 358/m²). Itchgrass seed population in soil core samples collected in November each year for the tillage and no-tillage glyphosate treatments was equal and compared with seed population in soil in May, decreased an average of 90% in 1991 and 92% in 1994. Compared with the season long undisturbed control, seed population in November for the tillage and no-tillage glyphosate treatments averaged 94% less in 1991 and 99% less in 1994. Results show that frequent tillage and timely herbicide application, which prevent seed production, can be equally effective options for reducing the itchgrass soil seed reservoir over time in fallowed sugarcane fields. Although itchgrass seed population in soil was reduced at least 90% where reseeding did not occur, a significant quantity of itchgrass seed would still remain in the soil. It would be imperative that integrated weed management strategies be implemented in sugarcane in successive years to prevent seed production. Successful efforts in preventing itchgrass seed production over time would further reduce the seed reservoir and could eliminate the presence of itchgrass in fields.

INTRODUCTION

Itchgrass is detrimental to crop production in the Philippines, Africa, Australia, the Caribbean, and along the Gulf of Mexico (Holm et al. 1977). Currently itchgrass is a major weed problem in sugarcane (*Saccharum* spp. hybrids), corn (*Zea mays* L.), and soybean

(*Glycine max* (L.) Merr.) in Louisiana. Dissemination of itchgrass seed has been linked to birds (Aison et al. 1984), flood water, rodents, and contaminated farm machinery (Freshwater et al. 1986; Millhollon 1980). The spread of itchgrass in Louisiana has been attributed to movement of contaminated equipment and road matting materials used for oil exploration during the 1970's and 1980's (personal observation).

Itchgrass is characterized by prop roots that descend from the lower nodes and trichomes on the leaf sheath that can cause an itching sensation (Holm et al. 1977). The weed is very aggressive and may grow an average of 6.1 cm per day (Millhollon 1965) and reach a height of 3 m at maturity (Holm et al. 1977). Itchgrass is capable of producing over 200 million seed/ha (Thomas 1970). A single itchgrass plant can produce over 2,000 seed (Holm et al. 1977). Because of its tremendous reproductive capacity, itchgrass if left uncontrolled can reach populations that can prevent crop harvest within three years (Harger et al. 1982). Itchgrass seed can remain viable at depths in the soil of 45 cm (Bridgemohan and Brathwaite 1991) for up to four years (Thomas 1970). The longevity of buried seed represents a major survival mechanism for the weed by providing a continued source of weed seed in crop land (Bridgemohan and Brathwaite 1991). An effective long-term method of decreasing plant populations would be to reduce seed reservoirs in the soil (Freshwater et al. 1986). One method to reduce itchgrass infestation is deep plowing to stimulate seedling emergence followed by shallow cultivation ten to fifteen days later to destroy seedlings (Bridgemohan and Brathwaite 1989; Nester et al. 1984). More frequent cultivation has been shown to reduce the dormancy period of itchgrass seed thus increasing the rate of seed depletion in soil (Mercado 1978; Pamplona and Imlan 1977). Bridgemohan and Brathwaite (1991) reported that 32% of the soil seed reserve of itchgrass could be depleted with only tillage in a single year. In general, it is not economically feasible to completely prevent seed production, however, spot spraying isolated itchgrass infestations is recommended to reduce seed production and spread to other areas (Harger et al. 1982).

In Louisiana, itchgrass was first observed in 1927 growing along a train track near Ruth in St. Martin parish (Millhollon 1975). It quickly spread throughout much of the sugarcane growing area and is considered a major weed problem in sugarcane in Louisiana. In Louisiana, seedling emergence occurs from March through November. Control measures in sugarcane include use of trfluralin and pendimethalin preemergence and asulam and trifloxysulfuron postemergence (Anonymous 2009; Griffin and Lencse 1992; Lencse et al. 1992). Itchgrass does not grow well in shade but has the capacity for high growth rates when introduced to light (Patterson 1979). Consequently itchgrass would be most competitive with sugarcane early in the growing season. In Louisiana, itchgrass competition from March through June (early season) reduced sugarcane stalk population and sugar yield an average of 14 and 18%, respectively, compared with a season long weed free control (Lencse and Griffin 1991). Itchgrass can be effectively controlled during the fallow period with glyphosate and tillage (Anonymous 2009).

This study was conducted to evaluate itchgrass weed management programs in fallowed fields to include monthly tillage and no-tillage with monthly application of glyphosate to control emerged weeds. Soil seed counts and seedling emergence across the growing season were determined to assess the effectiveness of the itchgrass management programs.

MATERIALS AND METHODS

A field study was conducted in 1991 at the Central Research Station, Ben Hur Research Farm in Baton Rouge, LA, on a Mhoon silty clay loam soil and in 1994 near Henderson, LA, on a Sharkey clay soil with a natural itchgrass infestation. Sites had not been planted to crops and were allowed to naturally reseed for three years prior to study initiation. Three areas, each 6.1 by 15.2 m, were used to evaluate weed management programs which included: 1) weed removal by monthly tillage, 2) weed removal monthly with glyphosate (no-tillage), and 3) no weed removal (undisturbed control). Each treatment area was subdivided into 250 small plots measuring 0.6 by 0.6 m in size. Twenty of the plots were chosen at random within each treatment area to serve as replications. Data were collected from a different set of 20 sub-plots at each sampling date throughout the study.

To initiate the study the experimental areas both years were tilled to a 7.5 cm depth with a rotary tiller. In mid-May after a rain had settled the soil, bulb planters were used to take soil core samples 6.4 cm in diameter and 7.5 cm in depth from each of the designated sub-plots within the three treatment areas. Collected soil samples were chemically dispersed by the method described by Malone (1967) and the number of full itchgrass spikelets (solid and hard to the touch) was recorded. Itchgrass seed viability was not determined. The no weed removal (undisturbed control) treatment block was left undisturbed for the remainder of the season to allow for determination of seed production and contribution to the soil seed bank.

Also in mid-May, number of emerged seedlings per 0.6 by 0.6 subplot was determined for the tillage and no-tillage glyphosate treatments. Following data collection tillage treatments were tilled to a depth of 7.5 cm with a rotary tiller and the no-tillage chemical control treatment was sprayed with glyphosate at 1.7 kg ai/ha. Complete destruction of itchgrass seedlings occurred where both tillage and glyphosate were used. Seedling emergence was recorded monthly followed by imposition of tillage and no-tillage glyphosate treatments thereafter through mid-October. After the first frost in mid-November, soil core samples were again collected using bulb planters from the designated 20 sub-plots for all treatments including the undisturbed control. Soil samples were chemically dispersed and the number of full seeds was recorded as described previously. Because of differences in initial seed population in soil for the two years and differences in seasonal rainfall and subsequent variation in seedling emergence across the growing seasons, data for each year were subjected to analysis of variance (ANOVA) and differences in treatment means within each sampling date (seedling emergence and seed data) were determined based on ANOVA or Fisher's Protected LSD ($P \leq 0.05$) in SAS (2003).

RESULTS AND DISCUSSION

In mid-May, itchgrass seed population in soil core samples was equivalent for the tillage, no-tillage glyphosate, and undisturbed control treatments and averaged 6.5 seed/core in 1991 and 2.4 seed/core in 1994 (Table 1). Itchgrass seed were fairly uniformly distributed within the experimental areas for the two years and seed population in soil averaged 2.7 times greater in 1991 than in 1994. In mid-May when itchgrass seedling emergence data was first collected, the tillage and no-tillage glyphosate treatments had not been imposed. For both years in mid-May as expected, differences between the tillage and no-tillage glyphosate treatments were not observed

(Table 2), again indicating a consistency in weed population within the experimental areas. The higher initial soil seed population in 1991 (Table 1) was reflected in greater seedling emergence in mid-May (average of 659 seed/m² in 1991 vs. 149 seed/m² in 1994) (Table 2).

In 1991, the difference in itchgrass seedling emergence between the tillage and the no-tillage glyphosate treatments was detected only in mid-September (212/m² with tillage vs. 100/m² for no-tillage treatment) (Table 2). During the month prior to the mid-September sampling date in 1991, 14.0 cm of rainfall was received. However, the month prior to the mid-June and mid-July sampling dates rainfall was 23.1 and 22.1 cm, respectively, but differences between the tillage and no-tillage treatments in seedling emergence were not observed. Total itchgrass seedling emergence from mid-April through mid-October was also equal for the tillage and no-tillage treatments and averaged 1199/m².

In 1994, differences in itchgrass seedling emergence between tillage and no-tillage glyphosate treatments were observed in mid-June, mid-August, and mid-October (Table 2). In June, itchgrass emergence for the tillage treatment (109/m²) was 1.8 times that of the no-tillage glyphosate treatment. During the 30 day period prior to mid-June sampling date 10.8 cm of rainfall was received. However, in July when 11.4 cm of rainfall was received, itchgrass seedling emergence following tillage was equal to that of the no-tillage glyphosate treatment. Itchgrass seedling emergence for the tillage treatment in mid-August (31/m²) and in mid-October (65/m²) was 1.6 times that of the no-tillage chemical treatment. Precipitation between mid-July and mid-August in 1994 was only 3.2 cm, whereas 10.2 cm was received between mid-September and mid-October. Itchgrass emergence is often enhanced by successive periods of soil wetting and drying (Pamplona and Mercado 1974). Total seedling emergence from mid-April through mid-October in 1994 for plots receiving tillage was 488/m², which was 36% greater than for the no-tillage glyphosate treatment. It appears that in 1994, aeration of soil and repositioning of dormant seed with tillage stimulated seed germination more so than in 1991. Bridgemohan and Brathwaite (1991) reported that itchgrass seed can remain viable in soil at a 45 cm depth.

When itchgrass was allowed to grow undisturbed from May through November and produce seed, the number of seed per soil core increased 2 fold in 1991 and 3.8 fold in 1994 (Table 1). In November, seed population in the undisturbed control was 11.1 seed/core in 1991 and 12.6 seed/soil core in 1994. Seed in soil cores for the undisturbed control would represent both seed present in the soil at initiation of the experiment and seed produced during the growing season from the undisturbed plants. When itchgrass seedlings were removed by tillage or with glyphosate from May to November and seed production did not occur, the soil seed reservoir was reduced during that period an average of 90% in 1991 and 92% in 1994. Bridgemohan and Brathwaite (1991) reported that with tillage in a single year, the itchgrass seed reserve was reduced 32%. Compared with the undisturbed control in the present study, itchgrass seed population in November for the tillage and no-tillage glyphosate treatments was an average of 94% less in 1991 and 99% less in 1994. Although seedling emergence can account for much of the reduction in seed population for the tillage and no-tillage glyphosate treatments, seed loss was also likely due to seed rot. In a study where itchgrass seed was buried in soil at depths of 0 to 45 cm and left undisturbed for 60 to 360 days, 55% of the total buried seed was lost due to rotting (Bridgemohan and Brathwaite 1991).

Results show that frequent tillage and timely herbicide application, which prevent seed production, can be equally effective options for reducing the itchgrass soil seed reservoir over time in fallowed fields. The use of glyphosate would be especially effective when field conditions preclude tillage operations. In the present research conducted over two growing seasons with variable rainfall, monthly tillage or no-tillage where glyphosate was used to kill emerged weeds reduced the itchgrass seed reservoir 90 to 92%. Even so, there would still be a significant quantity of itchgrass seed remaining in the soil. Thomas (1970) reported that itchgrass seed can remain viable in soil for up to 4 years. In sugarcane, itchgrass should first be addressed during the fallow period with combinations of mechanical and chemical weed control that prevent seed production. Following a successful fallow program, in crop weed control should include mechanical tillage of row middles and use of effective soil and foliar applied herbicides (Anonymous 2009). Since a single itchgrass plant can produce over 2,000 seed (Holm et al. 1977), growers should not overlook spot spraying or hand removal of escapes. Over years, prevention of itchgrass seed production would further reduce the itchgrass seed reservoir. Anecdotally, some growers in Louisiana using the methods described have been successful in eliminating itchgrass as a major weed problem in sugarcane fields.

ACKNOWLEDGMENTS

Partial funding for this research was provided by the American Sugar Cane League.

REFERENCES CITED

- Aison, S., M.K. Johnson, and T.R. Harger. 1984. Role of birds in dispersal of itchgrass (*Rottboellia exaltata* (L.) L.f.) seeds in the southeastern U.S.A. *Prot. Ecol.* 6:307-313.
- Anonymous. 2009. Louisiana Suggested Chemical Weed Control Guide. Baton Rouge, LA: Louisiana State University AgCenter and Louisiana Cooperative Extension Service. Web page: <http://www.lsuagcenter.com/agsummary/index.aspx>. Accessed February 19, 2010.
- Bridgemohan, P., and R.A.I. Brathwaite. 1989. Weed management strategies for the control of *Rottboellia cochinchinensis* in maize in Trinidad. *Weed Res.* 29:433-440.
- Bridgemohan, P. and R.A.I. Brathwaite. 1991. Seed survival and patterns of seedling emergence studies of *Rottboellia cochinchinensis* (Lour.) W. Clayton in cultivated soils. *Weed Res.* 31:265-272.
- Freshwater, I.T., A.J. Benson, and T.F. Hall. 1986. Itchgrass *Rottboellia cochinchinensis*-Burdekin infestation and legislative control program. *Proc. Aust. Soc. of Sugar Cane Technol.* Pp. 155-160.
- Griffin, J.L. and R.J. Lencse. 1992. Preemergence control of itchgrass (*Rottboellia cochinchinensis*) in sugarcane. *J. Am. Soc. Sugarcane Technol.* 12:65-70.

- Harger, T.R., P.R. Vidrine, and P.R. Nester. 1982. Control and management of itchgrass. *La. Agric.* 25 (4):20-21, 24.
- Holm, L.G., D.L. Plucknett, J.V. Pancho, and J.P. Herberger. 1977. *The World's Worst Weeds, Distribution, and Biology*. Univ. Press of Hawaii Honolulu. 609 pp.
- Lencse, R.J. and J.L. Griffin. 1991. Itchgrass (*Rottboellia cochinchinensis*) interference in sugarcane (*Saccharum* sp.). *Weed Technol.* 5:396-399.
- Lencse, R.J., J.L. Griffin, and E.P. Richard, Jr. 1992. Itchgrass (*Rottboellia cochinchinensis*) control in sugarcane with postemergence herbicides. *J. Am. Soc. Sugarcane Technol.* 12:9-15.
- Malone, C.R. 1967. A rapid method for enumeration of viable seeds in soil. *Weeds.* 15:381-382.
- Mercado, B.L. 1978. Biology, problems, and control of *Rottboellia exaltata* L. f. A monograph. *Biotrop Bull.* No. 14.
- Millhollon, R.W. 1965. Growth characteristics and control of *Rottboellia exaltata* L.f., a new weed in sugarcane. *Sugar Bull.* 44(5):82-88.
- Millhollon, R.W. 1975. Weed watch. *Weeds Today* 6(4):20
- Millhollon, R.W. 1980. Itchgrass -- a weed of world-wide concern. *Sugar J.* 43:16.
- Nester, P.R., T.R. Harger, and J.P. Geaghan. 1984. Itchgrass (*Rottboellia exaltata*) response to control practices in soybean (*Glycine max*). *Weed Sci.* 27:77-82.
- Pamplona, P.P. and B.L. Mercado. 1974. Dormancy and germination of (*Rottboellia exaltata*) L. f. *Phil. J. Sci.* 103:191-197.
- Pamplona, P.P. and J.S. Imlan. 1977. Methods of controlling *Rottboellia exaltata* L. f. in corn. *Phil. Weed Sci.* 4:13-20.
- Patterson, D.T. 1979. The effects of shading on growth and photosynthetic capacity of itchgrass (*Rottboellia exaltata*). *Weed Sci.* 27:549-553.
- SAS Institute. 2003. *SAS User's Guide: Statistics. Version 9.1*. SAS Institute. Cary, NC.
- Thomas, P.E.L. 1970. A study of the biology of *Rottboellia exaltata* L. f. *Proceedings 10th British Weed Control Conference.* 669-676.

Table 1. Number of itchgrass seed in soil core samples at study initiation in May and at the end of the growing season in November 1991 and 1994 as influenced by tillage.¹

Weed management program ²	1991		1994	
	May	November	May	November
	— no. seed/core —		— no. seed/core —	
Undisturbed control	5.6	11.1	3.3	12.6
Tillage monthly (May-October)	7.9	0.7	2.2	0.1
No-tillage and glyphosate applied monthly (May-October)	5.9	0.7	1.8	0.2
LSD (0.05)	NS	2.4	NS	1.6

¹ The experimental areas at Baton Rouge and Henderson, LA were tilled to a 7.5 cm depth in April and soil core samples (6.4 cm in diameter and 7.5 cm in depth) were collected in mid-May and mid-November.

² For the undisturbed control, plants were allowed to reseed. From mid-May through mid-October tillage plots were tilled monthly to a 7.5 cm depth and no-tillage plots were treated monthly with glyphosate at 1.7 kg ai/ha to kill emerged itchgrass. For both tillage and no-tillage plots itchgrass did not reseed.

Table 2. Itchgrass seedling emergence as influenced by tillage and rainfall for the 1991 and 1994 growing seasons.¹

Month	1991			1994		
	Tillage	No-tillage	Rainfall ²	Tillage	No-tillage	Rainfall ²
	no./m ²	no./m ²	cm/month	no./m ²	no./m ²	m/month
May ³	573	745	-	167	131	-
June	291	226	23.1	109* ⁴	62	10.8
July	110	81	22.1	75	71	11.4
August	8	24	3.4	31*	20	3.2
September	212* ⁴	100	14.0	41	33	3.8
October	13	13	5.1	65*	41	10.2
Total	1208	1189	67.7	488*	358	39.4

¹ The experimental areas at Baton Rouge and Henderson, LA were tilled to a 7.5 cm depth in April. From mid-May through mid-October tillage plots were tilled monthly to a 7.5 cm depth and no-tillage plots were treated monthly with glyphosate at 1.7 kg ai/ha to kill emerged itchgrass. For both tillage and no-tillage plots destruction of itchgrass seedlings was complete.

² Rainfall represents amount received during the month prior to each sampling date.

³ Tillage treatments had not been imposed at the mid-May sampling date.

⁴ An asterisk indicates a significant difference ($P \leq 0.05$) in seedling emergence between the tillage and no-tillage treatments within each year.