SEED BIOLOGY AND CHEMICAL CONTROL OF GIANT AND SMALL SMUTGRASS

By

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To Maggie

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Chair: Jason Ferrell
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Smutgrass *(Sporobolus indicus)* is a perennial weed that affects improved pastures in Florida. Smutgrass is a bunch-type grass that is believed to have originated in tropical Southeast Asia. There are two species of smutgrass currently in Florida: small smutgrass *(Sporobolus indicus)* and giant smutgrass *(Sporobolus indicus var pyramidalis)*. Small smutgrass was first observed in Florida in the 1950s and by the 1970s, it was estimated that it infested greater than 70% of the improved pastures of central Florida. Giant smutgrass was first detected in south Florida in the early 1990s and rapidly displaced small smutgrass in central and south Florida. Regardless of variety, smutgrass is problematic in grazed pastures due to its low palatably and rapid spread. Hexazinone is currently the only herbicide labeled for control of both smutgrass varieties. However, giant smutgrass is clearly more aggressive than small and it is unknown if a higher hexazinone rate is required for control. Smutgrass research has been conducted in Florida since the 1950s, but since giant smutgrass has only recently arrived in Florida there less known about the plant. This research was conducted to explore the differences between small and giant smutgrass. The first section compared seed germination characteristics of both varieties. Significant differences were found in temperature, pH, light, and depth of burial between giant and small smutgrass. The second section was a rate titration experiment to determine if separate

recommendations were needed for small and giant smutgrass. There were no significant differences found in the optimum hexazinone rate needed to control both smutgrass varieties. The third section examined whether spray adjuvants could be used to improve the efficacy of hexazinone on giant smutgrass. Two experiments were conducted. The first experiment tested varying amounts of the commercial adjuvant 'Optima™'. The second experiment tested Optima™ along with different types of adjuvants. It was observed in both experiments that the addition of spray adjuvants did not statistically improve smutgrass control relative to hexazinone applied alone.

CHAPTER 1
INTRODUCTION

Small smutgrass *(Sporobolus indicus)* was first discovered as a pasture weed in Florida in the early 1950s. By the 1970s, it had become the dominant and most serious pasture weed in central Florida. In the early 1990s, giant smutgrass *(Sporobolus indicus var pyramidalis)* was detected in south Florida. By the end of the decade, giant smutgrass had displaced small smutgrass as the dominant variety in central and south Florida. Previous research has concentrated on small smutgrass biology, especially seed germination characteristics, in the past. However, there has been limited research on seed germination for giant smutgrass. This thesis will, in part, describe results from studies testing factors required for germination of both small and giant smutgrass. This research will provide a better understanding of these weeds thus allowing for better management recommendations.

The second section of the thesis addresses the role of adjuvants in improving hexazinone efficacy, which is the only herbicide labeled for selective smutgrass control in pastures. Experiments were conducted on varying rates of different types of adjuvants for hexazinone efficacy.

The final part of the thesis is a rate titration study to determine the minimum hexazinone rate in (kg/ha) to achieve consistent 90% control for small or giant smutgrass.

CHAPTER 2
LITERATURE REVIEW

The total cost of weed control can be staggering. It is estimated that the total accumulated cost of non-native species (animals, plants, and microbes) control in the United States is $7 billion per year (Pimentel et al. 2000). In the United States, more than 700,000 hectares are invaded each year to non-native plant species (Pimentel et al. 2000). In Florida, more than 25,000 plant species have been introduced for ornamental use (Pimentel et al. 2000). Of these 25,000 species, approximately 900 have escaped and naturalized into various ecosystems (Pimentel et al. 2000).

In pastures, where approximately $10 billion of the U.S. forage crops are grown annually (USDA 1998), 45% of the weeds are non-native (Pimentel et al. 2000). The annual forage loss due to non-native weeds in the U.S. totals nearly $1 billion on average and in 1998, ranchers spent $5 billion in pasture weed control (Pimentel et al. 2001). Pasture weeds can cause problems for ranchers including, but not limited to; competition with desirable forages for light and other nutrients, displacement of desirable forages, reduction in stocking rate, animal discomfort; and animal toxicity.

Due to its low palatability and ability to out-compete desirable grasses such as bahiagrass and bermudagrass for light and nutrients, smutgrass (*Sporobolus indicus)* is considered one of the worst pasture weeds in Florida (Crawford 2003). Smutgrass *(Sporobolus* sp.), also known in Australia as giant paramatta grass, is a serious perennial weed in improved pastures on the sandy soils of Florida (McCaleb and Hodges 1971). It is found in 23 states around the southeast, Midwest, eastern seaboard, as well as the Pacific coast (McCaleb and Hodges 1971). It is also found throughout the world in Japan and the Philippines. Smutgrass, a member of the Poaceae family, is a bunch-type grass with a long single stalk inflorescence that is often infected with a

dark colored fungus (*Bipolaris* spp.) from which the weed is named (Mislevy et al. 2002). Smutgrass is believed to have originated in tropical Southeast Asia (Mears et al. 1996).

Smutgrass is a problem in pastures due to its low palatability and ability to displace desirable forages in improved pastures. Since cattle will not preferentially graze smutgrass, interspecific competition is reduced and smutgrass spread increases (Mears et al. 1996). In Australia, Mears et al. (1996) found that giant Parramatta grass digestibility was 47% with a nitrogen concentration of only 0.68%. This compares to 57.6% digestibility and 9-11% nitrogen concentration in bahiagrass. However, smutgrass regrowth following an intensive grazing program has similar forage quality to bahiagrass (Mullahey 2000).

In the 1970s, it was estimated that 75% of improved pastures in central Florida were infested with small smutgrass *(Sporobolus indicus)* (Mislevy and Martin 1985). It was not until the 1990s that giant smutgrass *(Sporobolus indicus var. pyramidalis)* was first detected in south Florida (Adjei et al. 2003). Since that time it has continued to spread and is now the dominant smutgrass species in central and south Florida (Adjei et al. 2003).

Smutgrass has proven to be a difficult weed to control. In the past, mowing, fertility management, intensive rotational grazing, and use of the herbicide dalapon (2, 2-Dichloropropionic acid) were the only viable control options. Dalapon was the most effective herbicide option. It was found that mowing 5 weeks after dalapon treatment greatly improved control and increased bahiagrass ground cover (Mislevy and Currey 1980; Mislevy et al. 1980). However, the rate of dalapon required to achieve greater than 80% smutgrass control also reduced bahiagrass stand density by 50% (Mislevy and Currey 1980). Dalapon is no longer registered for use in pastures (Mislevy et al. 1999), but hexazinone (Velpar™) provides good control of small smutgrass with less bahiagrass toxicity compared to dalapon (Brecke 1981;

Meyer and Baur 1979). Research has shown that hexazinone is also effective in controlling giant smutgrass; however, bahiagrass injury remains a concern (Mislevy et al. 1999).

Smutgrass reduces the quality of a pasture for cow-calf production. However, it can take several years before smutgrass is present in sufficient densities to reduce forage production (Currey et al. 1972). The colonizing plants are, at first, inconspicuous and cause little concern. However, if not properly controlled, smutgrass will quickly become the dominant species in the pasture (Currey et al. 1972). Cattle avoid mature smutgrass, but young stands may be grazed (Simon and Jacobs 1999). Mullahey (2000) found that when giant smutgrass is managed intensively, cattle readily consume the tender shoots. However, intensive grazing management may not be suitable for all cattle operations, due to the short 2 week window of smutgrass palatability after burning and high cost of rotational grazing.

Smutgrass Biology

Small smutgrass is described as a dark green, tufted erect plant; leaves smooth, usually folded, seedhead usually elongated and spike-like, and is often infected with a black smut fungus (Elmore 2006). It is a perennial grass that grows up to 1.1 m tall in 20-25 cm clumps. The leaf blades are 15-48 cm long by 1-5 mm wide, with a smooth sheath. The leaves are usually folded but can be either flat or rolled with a small (<0.1 mm) membranous ligule. Seed production is continuous with flowering to shattering of mature seed occurring simultaneously on the same plant and on the same inflorescence (Currey et al. 1972). Seed production takes place from April to December (Currey et al. 1972). The 40 cm long panicle is spike-like, but interrupted. It is also branched, appressed, or ascending with shining spikelets about 2 cm long. Glumes are obtuse, unequal and about half as long as the spikelet. The lemma is pointed and is slightly longer than the blunt palea (Currey et al.1972). Giant smutgrass is similar in appearance to small

smutgrass, however, is it 1.2-1.5 m tall, with clump diameter of 30-46 cm in diameter. Its seed head is also more open and branching compared to small smutgrass.

Mature seeds are red and free of the smut fungus. Each plant produces around 30 seed heads per plant and each mature panicle can produce up to 1,400 seeds (Currey et al. 1972). The amount of time the seeds stay on the panicle before shattering depends on weather conditions or mechanical forces (Currey et al. 1972). Field germination studies indicated that small smutgrass germination ranges from 1 to 9%, but scarification increased germination between 94 and 98% (Currey et al. 1972). The seeds have been shown to be viable for two or more years by (Currey et al. 1972).

Smutgrass Dispersal

Smutgrass seeds are able to quickly disperse due to their viability after ingestion and excretion by livestock (Andrews 1995). Research by Andrews (1995) revealed that it takes an average of 3 and 7 days for 50 and 100%, respectively, of smutgrass seeds to pass through a cow's digestive system. On average, only about 19% of the seeds fed to the cattle were viable after passing through the digestive process. The highest number of viable smutgrass seeds was collected in cattle manure on day two and three, with approximately 300 and 150 viable seeds per heifer, respectively. Since smutgrass seed heads are unpalatable to cattle, Andrews (1995) suggested the following possible indirect ingestion mechanisms: 1) smutgrass seeds stick to other palatable species growing in their proximity, 2) and/or seeds are spread by cattle licking their hair and that of other cattle. This is further supported by the fact that mature grains of smutgrass have a loose pericarp and become mucilaginous and sticky when wet. Andrews (1995) also found that after seven months no smutgrass seedlings were found manure exposed to natural conditions and that all remaining seeds in manure were nonviable. Other species of grass seedlings and other viable seeds were found in the manure, which suggests that smutgrass seeds

are possibly unable to remain viable in manure for extended periods. Andrews (1995) concluded that smutgrass dispersion by seed ingestion is not likely unless the manure is dispersed right after excretion. Dispersion could be accomplished by heavy rain or by hosing out of cattle trailers. Andrews (1995) believes that it is much more probable that the seeds stick to the hair of the cattle and are brushed off in adjacent pastures. This could be a major problem in Florida since direct or indirect ingestion would take place in the rainy season. This would allow smutgrass to easily spread into new pastures.

Smutgrass in Forages

Smutgrass can be a serious weed in forages, especially bahiagrass *(Paspalum notatum)*. There are currently two varieties of smutgrass affecting the pastures of Florida, small smutgrass and giant smutgrass. Hexazinone (Velpar™) has been shown to be effective in control of both smutgrass varieties. One of the most serious problems with smutgrass is that it reduces the stocking rate of a pasture. The stocking rate directly corresponds to the number of cow-calf pairs that a pasture can support.

It has been shown that smutgrass is detrimental to cattle production in Florida. As smutgrass density in a pasture increases, at the expense of bahiagrass or other desirable forage, the stocking rate of a pasture will decrease unless it is supplemented by purchased feeds due to smutgrass' low palatability and nutrition (Ferrell et al. 2006). If additional forage is unavailable, the end result will be a lower calving percentage and/or decreased calf weaning weight (Ferrell et al. 2006).

Bahiagrass yield is influenced by smutgrass infestations. Ferrell et al. (2006) found that bahiagrass yield in pastures with a low density of smutgrass (<20%) was 1164 kg/ha*mo. As the smutgrass groundcover increased to medium density (20-70%), bahiagrass yield was reduced to 590 kg/ha*mo, a reduction of 51% compared to low density infested bahiagrass. At a high

smutgrass density (>70%), bahiagrass yield decreased to 154 kg/ha*mo, a reduction of 87% from low densities (Ferrell et al. 2006).

Hexazinone is known to cause phytotoxicity in bahiagrass. In 1999, Mislevy et al. observed that chlorosis in bahiagrass can persist up to 20 days after hexazinone treatment, but no data on yield reduction was taken. Ferrell et al. (2006) found that hexazinone application resulted in at least a 25% reduction in bahiagrass yield compared to non-treated bahiagrass when infested with <20% smutgrass. Bahiagrass yield was reduced by 13% following hexazinone application compared to non-treated bahiagrass when infested with 20-70% smutgrass. It was concluded that the reduction in yield from hexazinone treatment is more pronounced than yield reduction from smutgrass competition at low and medium densities (Ferrell et al. 2006). It was not until the high smutgrass densities (greater than 80% smutgrass) that the reduction in yield from smutgrass competition was greater than the reduction from hexazinone treatment. One year after hexazinone treatment in the medium levels of smutgrass infestation, the bahiagrass biomass increased by 31%. In the high smutgrass densities, the bahiagrass biomass increased by 45% (Ferrell et al. 2006). There was not a significant difference between the low smutgrass densities and the untreated check. In light of this data, it was concluded that any attempts to control smutgrass with hexazinone at less than 20% groundcover will result in a net loss of bahiagrass forage production (Ferrell et al. 2006).

The cost of weed control should be less than the cost of infestation. Stocking rates of pastures with medium and high levels of smutgrass infestations are significantly lower than smutgrass free pastures and treatment of smutgrass is often economically justified (Ferrell et al. 2006). However, there was no difference in stocking rate between low smutgrass-densities and

no-smutgrass pastures. Therefore, treating a pasture with a low level of smutgrass infestation will result in a net economic loss (Ferrell et al. 2006).

It is important for a rancher to realize when smutgrass infestations should be controlled in order to maximize bahiagrass forage production. Ferrell et al. (2006) determined that the break-even smutgrass density when hexazinone should be applied is approximately 35%. When smutgrass density is less than 35%, the cost of control would be greater than the net return based upon bahiagrass yield. It is also important to mention that many variables must be taken into account for the break-even analysis. The cost of infestation will increase with higher calf prices, animal performance levels and bahiagrass productivity. For example, if the market calf price fell to $1.10 per kg, a rancher would lose money by spraying hexazinone, regardless of density. However, if the price increased to $2.65 per kg it would be economical to control low densities of giant smutgrass. Overall, the most important variable in determining a break-even point is bahiagrass productivity. As bahiagrass production increases, so will the monetary gain from controlling giant smutgrass. In addition, as the bahiagrass biomass increases the stocking rate of the pasture will also increase, decreasing the cost of giant smutgrass control.

Hexazinone Application and Mode of Action

Hexazinone is a member of the s-triazine family. It is sold under the trade names Velpar™ and Pronone™ and is registered for the edible crops pineapple and sugarcane. The only other crops it is registered for are dormant or semi-dormant alfalfa, before bud break in first year Christmas trees, site prep for conifer reforestation, bermudagrass and bahiagrass pastures (Vencill 2002). In non-cropland sites, hexazinone is registered for industrial sites, railroads, right-of-ways, and storage areas. Hexazinone is effective against many annual and perennial broadleaf weeds and brush species.

Hexazinone is soil active and xylem mobile (Vencill 2002). The primary mode of absorption for hexazinone is through the roots. However, some limited foliar absorption occurs despite the fact that it undergoes little translocation due to its lack of phloem mobility. Once hexazinone enters the plant, it inhibits photosynthesis. Its mechanism of action is the following: It binds to the Qb binding site on the D1 protein in photosystem II, blocking electron flow from Qa to Qb (Vencill 2002). This blocks the formation of NADPH and ATP, which are needed in the dark reactions of photosynthesis. However, these reactions do not lead to plant death. Since hexazinone blocks electron flow, the buildup of electrons is passed to the chlorophyll molecule forming triplet state chlorophyll (Vencill 2002). Triplet state chlorophyll reacts with the oxygen in the cell to form radical oxygen. These collectively attack lipid membranes causing a free radical chain reaction, causing cell membrane disruption (Vencill 2002). Cell organelles leak and are destroyed. Plants treated with hexazinone typically display foliar chlorosis followed by necrosis.

Adjuvants and Their Use

Adjuvants are a critical component of chemical weed control. The use of adjuvants worldwide accounted for over 1 billion dollars annually (Underwood 2000). In the year 2000, the US adjuvant market alone was worth 400 million dollars or around 40% of the worldwide adjuvant market (Underwood 2000). They have been used as far back as 1889 for increasing arsenical herbicide efficacy (Hazen 2000). According to the American Society for Testing and Materials (ASTM) an adjuvant is any material added to a tank mix to aid or modify the action of an agrichemical, or the physical characteristics of the mixture. Adjuvants typically consist of the following: surfactants, oils, solvents, polymers, salts, diluents, humectants, and water (Hazen 2000). However, adjuvants are grouped into just two categories: 1), those that modify the physical characteristics of the spray mixture, and 2), those that enhance the biological efficacy of

the crop production chemical (Hazen 2000). The second group of adjuvants is known as activator adjuvants. There are four types of activator adjuvants: wetter-spreader adjuvants, sticker adjuvants, humectants, and penetration agents.

Wetter-spreader adjuvants are the most common type of adjuvant. They are comprised of surface active agents (surfactants) that lower the free energy of the substrate being wetted (Hazen 2000). This causes the herbicide droplet to flatten and spread out, hence the name spreader. Wetter-spreader adjuvants also lower the surface tension of the spray solution, causing the spray solution to spread. In addition, this allows the spray solution to lie as a thin film on a waxy surface such as a leaf cuticle (Hazen 2000).

Sticker adjuvants are commonly used in wettable powder and granular suspensions spray mixes to aid in keeping the solid herbicide material on the leaf surface after drying (Hazen 2000). The longer the herbicide can remain on the leaf, the greater the herbicide uptake. Rain, wind, and physical contact can remove the herbicide deposits on a leaf surface. Sticker adjuvants are not water-soluble and aid in rainfastness.

Humectants are a variation of sticker adjuvants. Humectants increase the drying time of individual droplets (Hazen 2000). This allows the herbicide to remain in liquid form longer. As the spray solution begins to dry, the herbicide in the droplet begins to crystallize, thus reducing the herbicide's bioavailability (Hazen 2000). Some humectants behave like salt and wick moisture from the surrounding air, maintaining high humidity around the spray droplet (Hazen 2000).

Penetration agents assist in moving the herbicide from the leaf surface, through the plant's natural barriers, and into the susceptible plant tissue (Hazen 2000). This is accomplished in variety of ways. First is by dissolving, softening, or plasticizing the leaf's waxy cuticle. The

second method is by infiltrating the plant's stomata (Hazen 2000). The goal of both methods is to allow the herbicide to penetrate to the more hydrophilic tissues beneath the leaf surface (Hazen 2000).

Summary and Research Objectives

Chapter 3 addresses research conducted on the efficacy of adjuvants on giant smutgrass control using hexazinone. Some ranchers have even reported improved control using adjuvants such as Optima™[1] and Dyne-Amic™[2]. However, many of these adjuvants are expensive, adding 3-4 dollars per acre in spray costs. Many ranchers have asked IFAS Extension to research the efficacy of these adjuvants on smutgrass control.

The objective of chapter 4 is to determine if there are differences in the two smutgrass varieties that could provide giant smutgrass a competitive advantage over small smutgrass. All previous seed germination studies were conducted on small smutgrass only due to its prevalence in Florida prior to the 1990s. Currently, there is no information available concerning giant smutgrass germination including factors such as pH, temperature, depth of emergence, light, and osmotic potential.

The objective of chapter 5 is to establish whether small and giant smutgrass require separate hexazinone rate recommendations to achieve 90% control.

[1] Helena Chemical Company

[2] Helena Chemical Company

CHAPTER 3
THE INFLUENCE OF ADJUVANTS ON THE CONTROL OF GIANT SMUTGRASS WITH HEXAZINONE HERBICIDE

Introduction

An adjuvant is any material added to a tank mix to aid or modify the action of an agrichemical, or the physical characteristics of the mixture (Penner 2000). Adjuvants usually consist of at least one of the following: surfactants, oils, solvents, polymers, salts, diluents, humectants, and water (Hazen 2000) and are generally grouped into two categories: utility adjuvants or activator adjuvants.

Utility adjuvants do not directly affect herbicide efficacy. They work by minimizing or reducing the negative effects of herbicides during application or mixing (McMullan 2000). There are five primary types of utility adjuvants: compatibility agent, defoaming agent, drift control agent, deposition agent, water conditioning agent. The goal of utility adjuvants is to mitigate any external factor that could lower the efficacy of the herbicide.

Activator adjuvants enhance the biological efficacy of the crop protection chemical being applied (Hazen 2000). There are four types of activator adjuvants: wetter-spreader adjuvants, sticker adjuvants, humectants, and penetration agents. The goal of activator adjuvants is to increase the herbicide uptake.

Adjuvants are a critical component to postemergence weed management by generally increasing pesticide absorption. Some herbicides require the use of adjuvants to achieve acceptable levels of weed control. Jordan et al. (1996) found that a crop oil adjuvant was needed when using clethodim for consistent control of barnyardgrass, broadleaf signalgrass, and johnsongrass. Jordan et al. (1996) also found that applying clethodim at a rate of 70 g/ha in conjunction with methylated seed oil adjuvants provided equivalent or better control than 140 g/ha of clethodim with any other adjuvant.

Hexazinone is currently the only herbicide labeled for selective smutgrass control in pastures. Hexazinone is a s-triazine, and therefore, xylem mobile (McNeil et al. 1984). Hexazinone is absorbed by leaf tissue, but it is poorly translocated throughout the plant due to lack of phloem mobility (Vencill 2002). Since leaf absorption does not allow sufficient hexazinone translocation for effective smutgrass control, there must be an alternative absorption route. The primary absorption route for hexazinone is through the plants roots (Vencill 2002).

Since hexazinone is the only available herbicide for smutgrass control, ranchers have expressed a great deal of interest in the use of adjuvants to increase smutgrass control, or as a way to reduce hexazinone use rates. Ranchers specifically requested that research be conducted on the adjuvant Optima™ to determine its effect on giant smutgrass control. Optima™ is a combination adjuvant made up of various proprietary surfactants and buffering agents. Some ranchers have claimed increased control of giant smutgrass when using Optima™. In addition, there has been limited research into the effects of other adjuvant types for giant smutgrass control with hexazinone. Although it is known that leaf absorption plays a minimal role in hexazinone activity, adjuvants such as crop oils have been used with s-triazine herbicides to improve herbicide efficacy (LeBaron et al. 2008). This research will investigate if there are any benefits to applying hexazinone with adjuvants.

Materials and Methods

Experiment One

Experiments examining the impact of the adjuvant Optima™ on hexazinone efficacy were conducted at two different locations over two years. Experiments were conducted in Clewiston, Florida in 2005 and in Ona, Florida in 2006. Giant smutgrass *(Sporobolus indicus var pyramidalis)* was the only species of smutgrass present at both locations. Experiments were initiated on June 28 and August 2 in 2005 and 2006, respectively. The soil type present in

Clewiston was Oldsmar sand (sandy, siliceous, hyperthermic Alfic Arenic Alaquods). The soil type in Ona was Pomona sand (sandy, siliceous, hyperthermic ultic Alaquods). Hexazinone was applied at 0.81 and 1.13 kg/ha alone and with Optima™ at rates of 0.13, 0.25, 0.5, 0.75, and 1.0% v/v. Smutgrass control was visually evaluated 1 and 12 months after treatment (MAT). Visual estimates of smutgrass control was based on a scale of 0 to 100, where 0 equals no smutgrass control and 100 equals complete smutgrass control.

Experiment Two

Various surfactants from different classes were evaluated to determine the influence on hexazinone efficacy. Experiments were initiated near Ona, Florida on July 31, 2006 and July 28, 2007. The soil type at both experimental sites was a Pomona sand. Hexazinone was applied at 1.12 kg/ha alone or with methylated seed oil (MSO) at 1.17 L/ha, Optima™ at 0.5% v/v, Kinetic™[1] at 0.1% v/v, Dyne-Amic™ at 0.5% v/v, or Induce™[2] at 0.25% v/v. Smutgrass control was visually estimated at 1, 3, 6, and 12 months, after herbicide application. Visual estimates of smutgrass control was based on a scale of 0 to 100, where 0 equals no smutgrass control and 100 equals complete smutgrass control.

Experimental Design and Analysis

All experiments were established with plots measuring 3 m wide by 15 m long. A 3 m untreated strip was included between all treated plots to aid in visual estimations of smutgrass control. Herbicides were applied using flat fan nozzles calibrated to deliver 280 L/ha. The first experiment was a 2 X 6 factorial with four replications. The second experiment was arranged in a randomized complete block design with four replications. All data were subjected to ANOVA and treatment means were separated using Fisher's LSD (0.05). Data were combined over years

[1] Helena Chemical Company

[2] Helena Chemical Company

and locations when no significant year by treatment interaction was present and data were homogeneous.

Results and Discussion

Experiment One

There was no treatment by location observed and data were pooled across years. There were no significant differences (P=0.23) in giant smutgrass control between the 0.84 kg/ha hexazinone rate and 1.12 kg/ha hexazinone rate at both 1 and 12 months after treatment (MAT) (Fig. 3-1). There were also no significant differences in giant smutgrass control between the different rates of Optima™ at 1 and 12 MAT (Fig. 3-2). All treatments including the control without adjuvant provided at least 90% control of giant smutgrass. Therefore, the addition of Optima™ does not improve control of giant smutgrass at either the 0.84 kg/ha or the 1.12 kg/ha hexazinone rate.

Experiment Two

There was no treatment by location interaction so data from both locations were pooled. There were no significant differences (P= 0.505) between any of the treatments 1 MAT (data not shown). All treatments, including the control with no adjuvant, provided at least 90% control of giant smutgrass (Fig. 3-3). The results revealed a similar trend 12 MAT (P=0.408). Therefore, it can be concluded that the use of adjuvants does not increase giant smutgrass control with hexazinone.

The data from both experiments show that the addition of adjuvants do not increase hexazinone efficacy compared to hexazinone alone. This is because hexazinone, a s-triazine herbicide is mobile only in the xylem tissue of the plant. Foliar application of s-triazine herbicides undergo little to no translocation within the plant, therefore acting like a contact herbicide. Since hexazinone is mobile only with the xylem, the primary absorption route of the

herbicide is through the roots, not the leaves. Thus, the addition of adjuvants that increase foliar absorption would have little effect on hexazinone efficacy. This corresponds with data from Chachalis et al. (2001), in which the addition of adjuvants did not always improve redvine and trumpet creeper control with glyphosate. Additionally, O'Sullivan and Bouw (1997) found that the addition of adjuvants to metolachlor and cyanazine at a ¼X rate did not improve weed control.

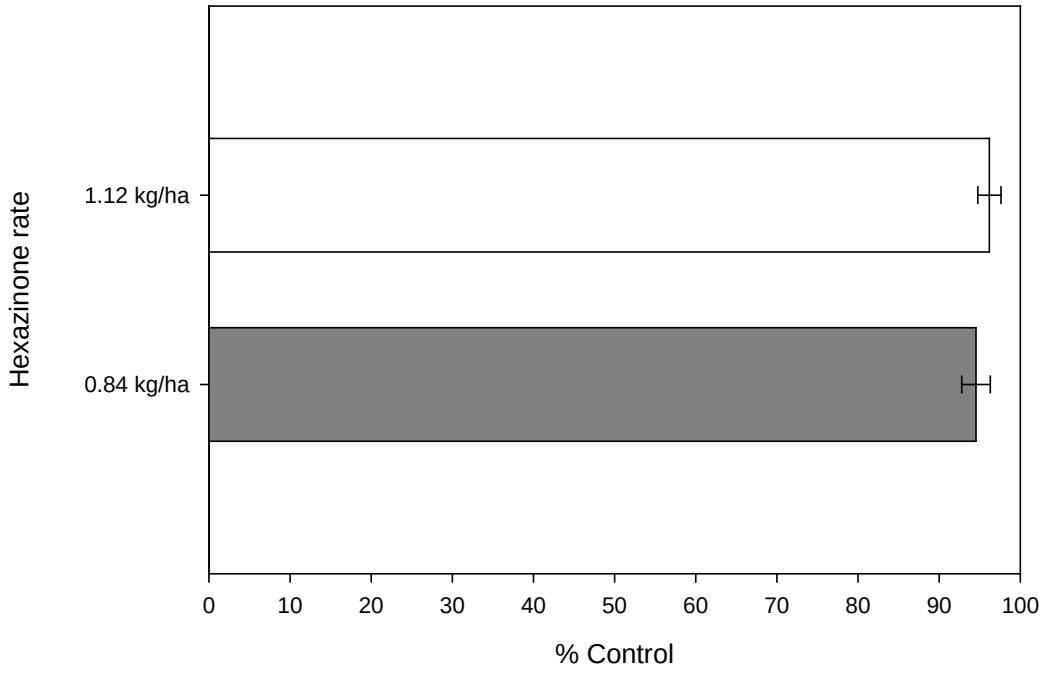

Figure 3-1. Giant smutgrass control with hexazinone and Optima™. Values represented with 95% confidence intervals.

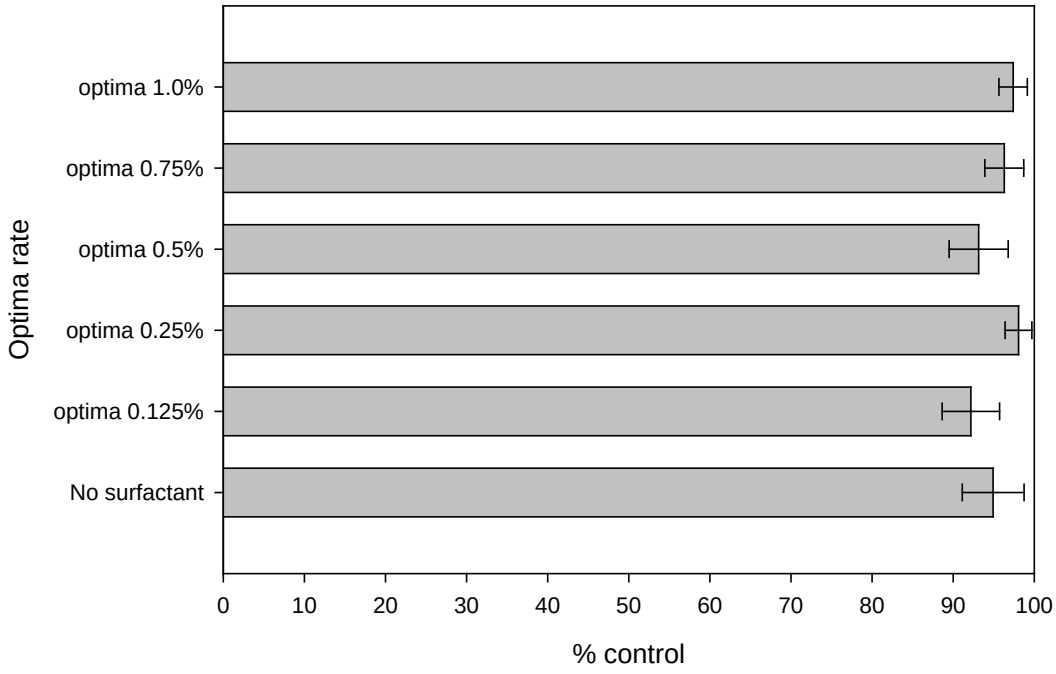

Figure 3-2. Optima™ control rates 12 months after treatment. Values represented with 95% confidence intervals.

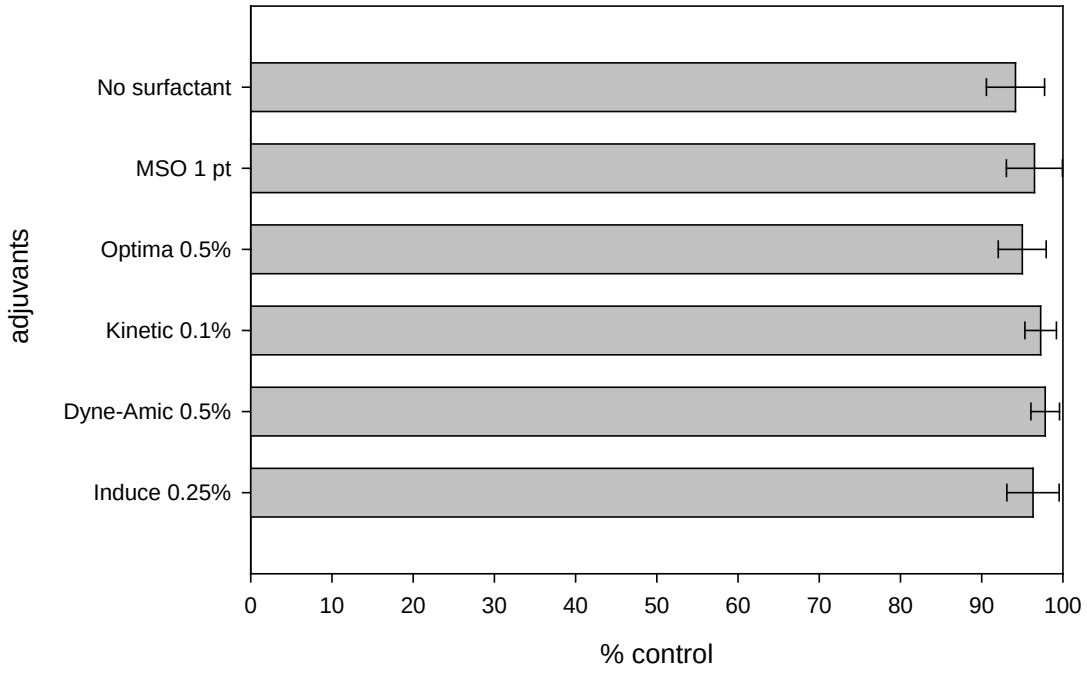

Figure 3-3. Various adjuvants with 1.12 kg/ha hexazinone. 12 months after treatment. Values represented with 95% confidence intervals.

CHAPTER 4
FACTORS AFFECTING SEED GERMINATION OF SMALL AND GIANT SMUTGRASS

Introduction

There are two varieties of smutgrass currently found in Florida: small smutgrass *(Sporobolus indicus)* and giant smutgrass *(Sporobolus indicus var pyramidalis)*. Both are believed to have originated in tropical Southeast Asia. Giant smutgrass is also known as West Indian dropseed (Mislevy 2002). Small smutgrass is a noxious invasive weed throughout the southern U.S., while giant smutgrass is limited to Florida and Puerto Rico (USDA 2009).

Small smutgrass was first detected in Florida in the 1950s and progressed across the state's pastures over the next 25 years. In 1972, seed germination tests were conducted on small smutgrass (Currey et al. 1972). It was observed that seed germination was very low, ranging between 1 and 9%. Currey et al. (1972) also found that, on average, each small smutgrass plant will produce 45,824 seeds with mature and immature seeds on the same panicle simultaneously.

It was not until the early 1990s that giant smutgrass was first detected in south Florida. However, in the past 10 years giant smutgrass has displaced small smutgrass as the dominant species in central and south Florida while continuing to spread north. It is unknown why giant smutgrass was able to displace small smutgrass and why it is spreading at such an accelerated rate. It is hypothesized that the scarification requirements of small smutgrass seeds inhibit their ability to spread (Currey 1972), while giant smutgrass seed do not have these same requirements. This could, in turn, provide a competitive advantage to giant smutgrass. However, the germination profiles of giant smutgrass are currently unknown. The objective of this experiment is to determine if differences in seed germination exist between the small and giant smutgrass varieties. The response of both varieties of smutgrass to differing light, temperature, pH, osmotic potential, and depth of burial will be observed. Since giant smutgrass has spread at a

much more robust pace than small smutgrass, these tests will serve as an important tool to test for any differences that might give giant smutgrass a competitive advantage over small smutgrass. It is the goal of this research to provide a better understanding of the seed biology of both smutgrass varieties in order to develop a more integrated approach for control of these weeds.

Materials and Methods

Seed Source

Small smutgrass seeds were collected at the Beef Research Unit north of Gainesville, Florida while giant smutgrass seeds were collected from various pastures near Ona and Plant City, Florida. The seedheads were dried at room temperature for 3 days. Seeds were rubbed free from the dried seedheads and cleaned using differential airflow. All seeds were stored at room temperature for the duration of the experiment.

Germination Protocol

A husk covers the seed of both varieties of smutgrass. Since earlier seed germination tests documented poor germination with the seed husk still intact (Currey et al. 1972), husks were removed using a seed blower. Germination tests were conducted in Petri dishes containing blotter paper moistened with 5 ml of deionized water and sealed with parafilm. Unless otherwise stated the seeds were placed in a growth chamber operating at 30 C with 16 h of light and 20 C for 8 h of darkness. The seeds were incubated for two weeks in a growth chamber. Seeds were considered germinated when the radical and cotyledon emerged from the seed coat.

Base Line Germination

Prior seed germination research conducted by Currey et al. (1972) revealed a germination rate of only 9% for small smutgrass, which indicated a high probability of seed dormancy. To test for base line germination, both species of smutgrass seeds were grown in growth chamber.

After two weeks, seeds that had not germinated were tested with 0.25 % tetrazolium solution as described in the Handbook on Tetrazolium Testing (Moore, 1985). Seeds were immersed in tetrazolium solution for 3 hours under dark conditions. The seeds were then dissected at 20X magnification, the presence of a red pigment indicated that seeds were viable.

Temperature

The seeds of both species were tested at the following constant temperatures: 10, 15, 20, 25, 30, 35, and 40 C. All tests were conducted in the growth chambers at constant light.

Light

To test if light is a requirement for germination, Petri dishes were prepared as described above. Seeds were placed in the dish in presence of the green light only. The dishes were then fully wrapped with two layers of aluminum foil to shield all incoming light. The control dishes remained unwrapped.

pH

To test the effects of pH on smutgrass germination, the seeds were germinated in various buffer solutions. Blotting paper was moistened with 5 ml of buffer solution. Buffer solutions were prepared using 100mM Citric Acid-NaOH (pH 4), 25mM MES (potassium hydrogen phthalate, 2[4-morpholino] ethanesulfonic acid) (pH 6), 50mM HEPES (N-2(2-hydroxyethyl)-piperazine-N'-2-ethanesulfonic acid) (pH 8), and 100mM Glycine-NaOH (pH 10).

Osmotic Potential

To test the effects of osmotic potential on smutgrass germination, the seeds were germinated in various osmotic potentials. Seed blotting paper was moistened using 5 ml of pre-measured concentrations of polyethylene glycol solutions. The following osmotic potentials, as measured with a vapor pressure osmometer were tested: 0.0, -0.2, -0.4, -0.6, -0.8, -1.0 MPa.

Depth of Burial

In order to test the effects of burial depth, the seeds were placed in 3.5 cm by 18 cm cone containers. The seeds were buried at depths of 0, 3, 6, 9, 12, and 15 cm, with each planting depth in a different container. Eight seeds were planted in each container. The growth chamber was set in 16-hour day, 8-hour night diurnal mode running at 30 C and 20 C respectively. The containers were visually checked for seed emergence after 2 weeks. The containers were watered as needed to keep soil moist.

Experimental Design and Statistical Analysis

All experiments were conducted as completely randomized design with four replications. All experiments were conducted twice. Data were evaluated using analysis of variance via PROC GLM and means separated using 95% confidence intervals. Simple regression analysis was used to determine the effect of temperature, planting depth, and pH on germination of each variety.

Results and Discussion

Baseline Germination

Previous research conducted by Currey et al. (1972) resulted in a germination rate of only 9%. However, in Currey's germination test, the smutgrass seeds were still in the seed husk. It was theorized that removal of the seed husks by a seed blower would increase germination. For the baseline germination tests, the average germination rate for both varieties was 88% and no statistical differences were observed (Fig. 4-1). The germination rate of giant smutgrass seeds was more variable, with a standard deviation of 11% compared to 7% for small smutgrass. Tetrazolium tests of the non-germinating seeds found them all to be non-viable. Therefore, seed dormancy was not observed with either smutgrass variety and it can be concluded that smutgrass seed is readily viable and able to germinate under optimum environmental conditions. These

data also infer that the seeds selected for these experiments are consistent and of sufficient quality for the following experiments.

Temperature

For the temperature germination test, there was no trial by treatment interaction and the data were pooled across experimental runs. However, significant differences between the two smutgrass varieties were detected. Unlike the other germination tests, each temperature in this experiment was held constant. This caused some unusual germination data, especially for small smutgrass. The small smutgrass followed a common hyperbolic response to temperature with 0% germination at 10 and 40 C with maximum germination of 55% occurring at 30 C (Fig. 4-2). This hyperbolic response is commonly observed among several plant species, but even tropical species such as tropical signalgrass, tropical soda apple and dogfennel show maximum germination between 64 and 70% with nearly 0% at 40 C (MacDonald et al. 1992; Akanda et al. 1996). Conversely, giant smutgrass germination followed a near linear trend with respect to temperature (Fig. 4-3). Giant smutgrass had maximum germination at 35 C with 85% germination, but still maintained 69% germination at 40 C. The lowest temperature at which either variety germinated was 15 C and neither had any germination at 10 C. Small smutgrass seeds that germinated at the 30:20 C had an average germination of 88%. Conversely, giant smutgrass seeds when subjected to constant 30 C had a germination rate of only 35%, compared to 88% germination when subjected to the diurnal temperature flux.

These results are similar to results found on giant paramatta grass (GPG) (*Sporobolus indicus* var *major*) in Australia (Andrews et al. 1997). Andrews et al. (1997) found that maximum GPG germination took place under 30/15 C temperature combinations while seed germination was depressed under constant temperature (Andrews et al. 1997). It is unknown

why giant smutgrass germination increased dramatically from 37% to 85% at 30 and 35 C. However, these data indicate that giant smutgrass is capable to enduring high temperatures more effectively than small smutgrass. The fact that giant smutgrass has a higher maximum germination temperature than small smutgrass may explain why it is displacing the small smutgrass in south and central Florida.

Light

There was a significant difference between the giant and small smutgrass in light germination experiment (Fig. 4-4). The seeds were grown under a 30:20 C day:night regiment. The germination rate of giant smutgrass seeds that were grown under dark conditions had an average germination rate of 53%. The small smutgrass grown under dark conditions had an average germination rate of 27%. The control had 88% germination for both varieties. The germination percentage for both giant and small smutgrass decreased in the dark. However, light is not a requirement for germination for both giant and small smutgrass as both varieties did germinate in the absence of light. Research conducted by Andrews et al. (1997) also found that light did not have an effect on GPG germination.

pH

There was a significant difference between the two smutgrass varieties. The highest germination for both species occurred at pH 6. At this pH, small and giant smutgrass had germination rates of 87 and 68%, respectively. As the pH decreased to 4, the small and giant smutgrass had germination rate of 55% and 53% respectively. At pH 8 small and giant smutgrass germination was reduced by 3% and 1% respectively. However, at pH 10 germination was only 4% for both varieties. These results are similar to results by Teuton et al. (2004) on tropical signalgrass (*Urochola subquadripara*) another perennial invasive grass. Teuton et al. (2004) found that tropical signalgrass had reduced germination at pH less than 5 and no

germination at pH 10. Both giant and small smutgrass seeds germinate over a wide pH range indicating that soil pH is unlikely to be a limiting factor in germination.

Osmotic Potential

For the osmotic potential germination test (data not shown) there was no trial by treatment interaction and data were pooled over experimental runs. A significant difference was detected between varieties at -0.2 MPa. At -0.2 MPa the small and giant smutgrass seeds had germination rates of 91 and 86%, respectively (data not shown). However, no germination was observed for either variety at water potentials greater than -0.2 MPa. Teuton et al. (2004) found similar results for tropical signalgrass. Tropical signalgrass germination was highest at 0 and -0.2 MPa. Tropical signalgrass germination was reduced to 5% or less at osmotic potentials greater than -0.2 MPa. From this data, it can be concluded that both giant and small smutgrass are not tolerant of drought stress and require sufficient soil moisture to germinate. Data collected from the Florida Automated Weather Network (FAWN), shows that the months of February through May are typically the driest time of the year. Therefore, giant and small smutgrass are unlikely to germinate until early to mid-June, typically when summer rains begin.

Depth of Burial

There was no trial by treatment interaction and the data were pooled across experimental runs. Both giant smutgrass and small smutgrass had the highest germination when placed on the soil surface. Surprisingly, no germination was observed in small smutgrass when seeds were placed at any depth below the surface level. Conversely, giant smutgrass emerged from 3 cm, though at a greatly reduced rate. The giant smutgrass seeds did not germinate at any depth greater than 3 cm. Benvenuti et al. (2001) examined the depth of germination for 20 weed species. They found that none of the weed species they tested would germinate at depths greater than 12 cm. Their research also showed that all species tested had a slight decrease at 2cm burial

and an exponential decrease as burial depth increased. Since small smutgrass only germinated at the soil surface and giant smutgrass did not germinate at any depth below 3 cm, deep tillage may be and effective pasture renovation technique. However, tillage would have its limitations. Care must be taken to ensure that the seeds remain adequately covered for this control strategy to work as future disking or tillage could resurface the seeds and allow them to germinate.

Data collected by Currey et al. (1972) documented that germination of small smutgrass seeds were approximately 9%, unless scarification techniques were employed. From these data it was hypothesized that giant smutgrass produces highly viable seeds and has overtaken the small variety due to inherently poor seed germination in small smutgrass. However, it was found that small smutgrass does not have inherently low germination since diurnal temperature fluctuation results in 88% germination. Additionally, data presented here indicate that few differences in germination exist between the small and giant variety. Of the varietal differences that do exist, the magnitude of these differences is not likely to be sufficient to explain why giant smutgrass has displaced small smutgrass in south and central Florida.

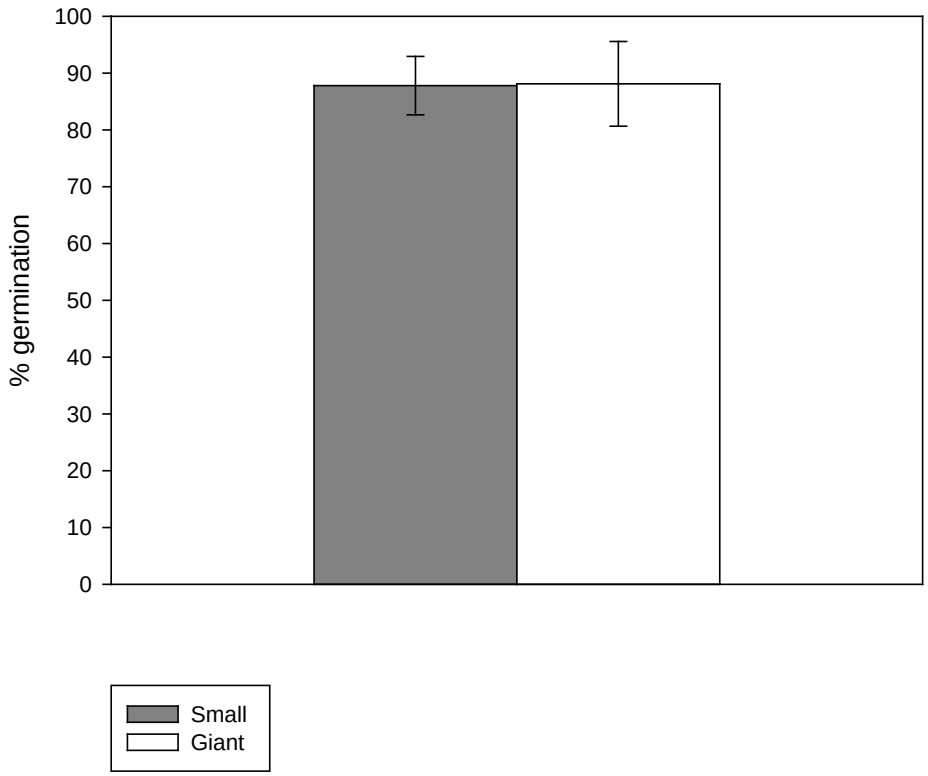

Figure 4-1. Baseline germination of two smutgrass varieties. Values represented with 95% confidence intervals.

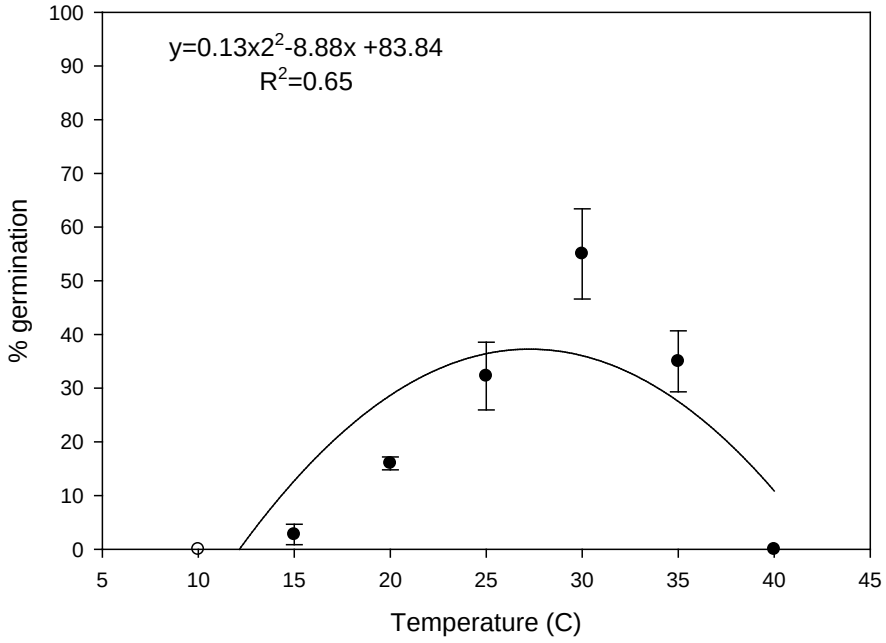

Figure 4-2. The effect of temperature on small smutgrass germination. Values represented with 95% confidence intervals.

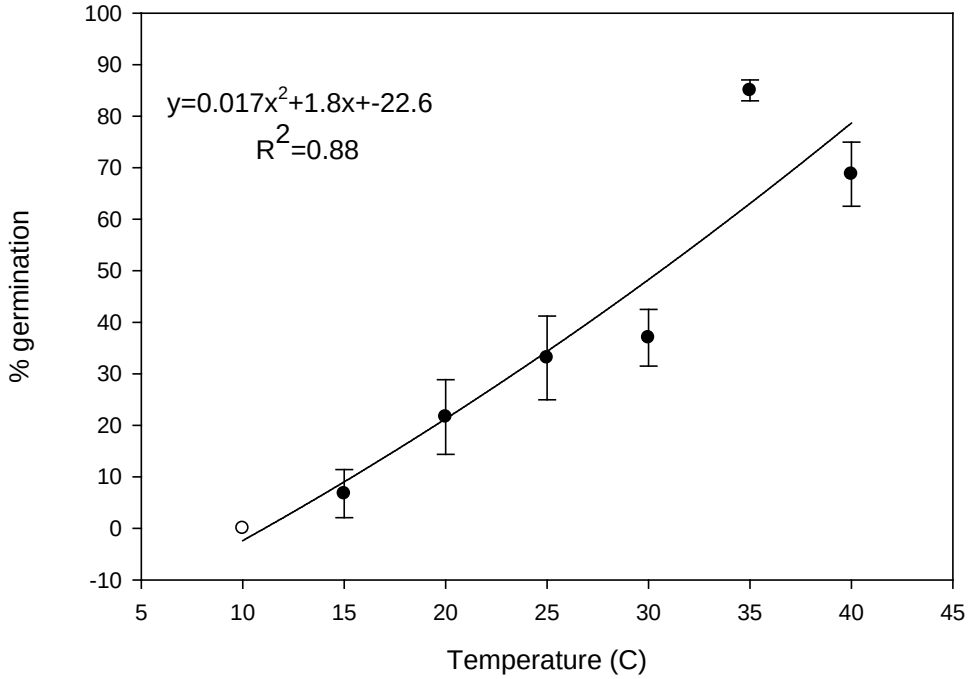

Figure 4-3. The effect of temperature on Giant smutgrass germination. Values represented with 95% confidence intervals.

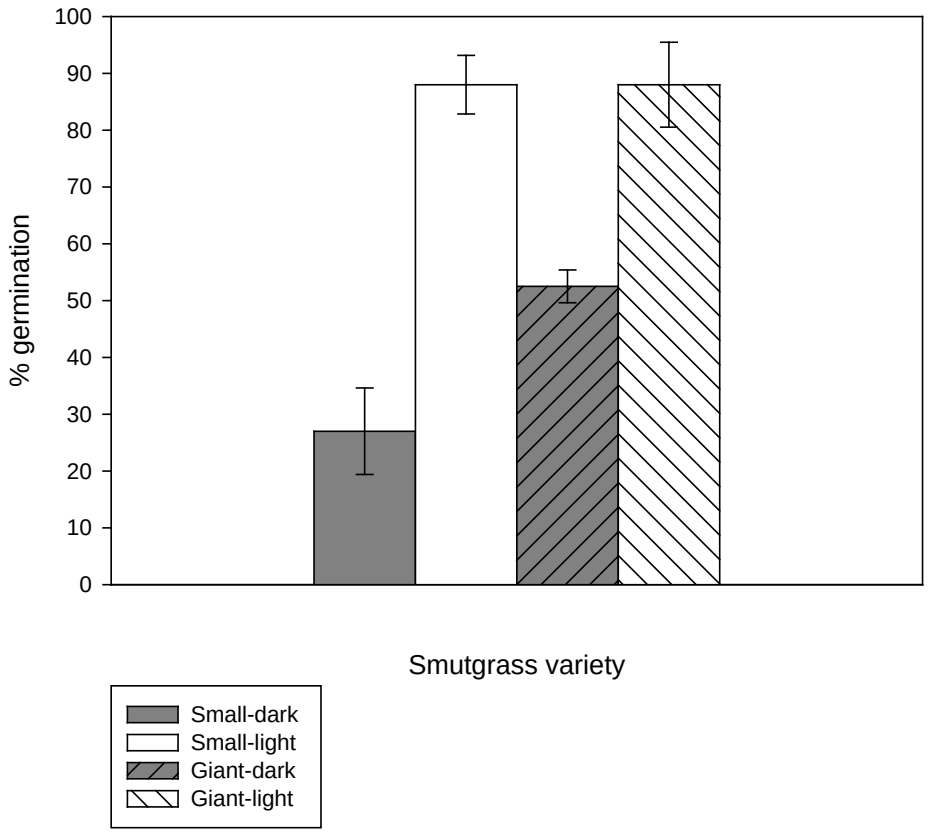

Figure 4-4. The effect of light on small and giant smutgrass germination. Values represented with 95% confidence intervals.

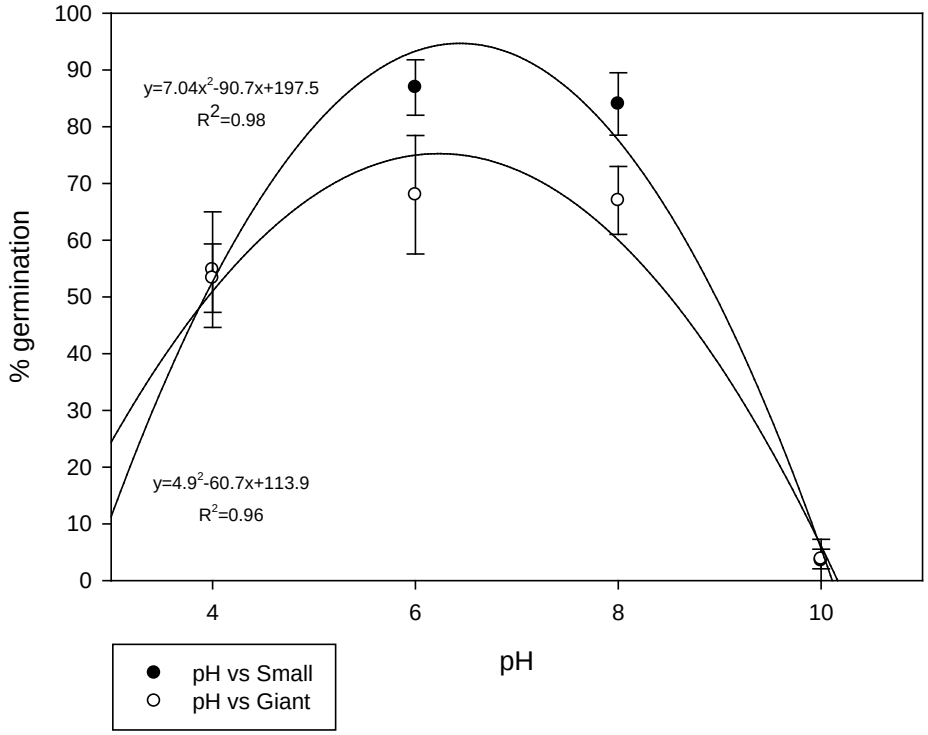

Figure 4-5. The effect of pH on small and giant smutgrass germination. Values represented with 95% confidence intervals.

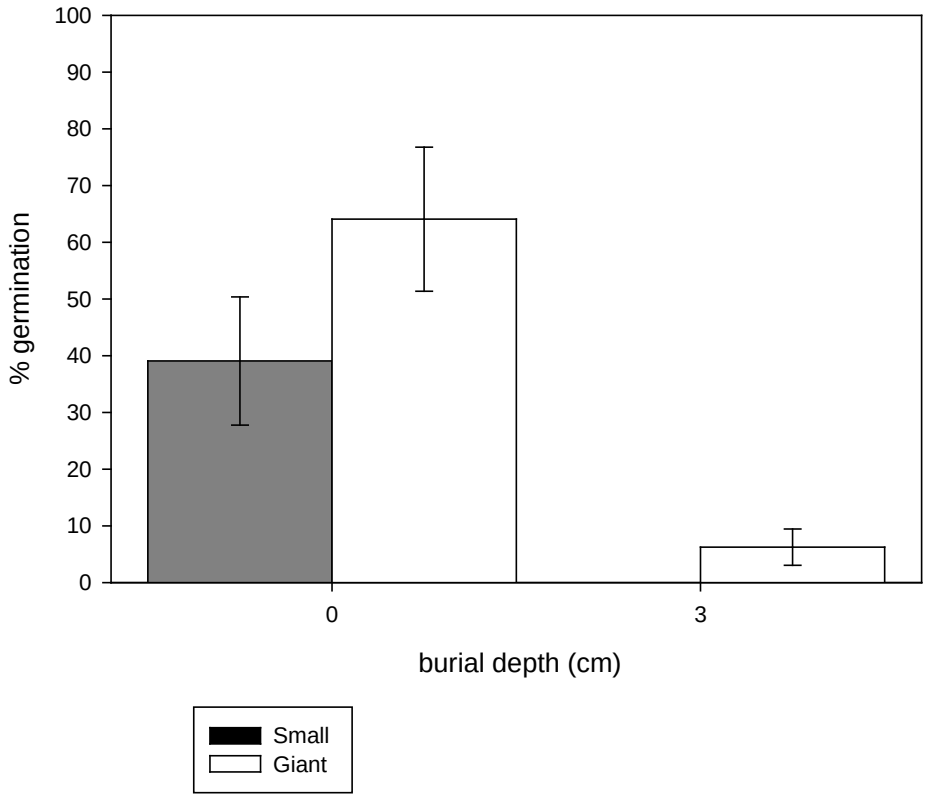

Figure 4-6. The effect of seed burial depth on small and giant smutgrass germination. Bars represent standard error.

CHAPTER 5
HEXAZINONE HERBICIDE RATE TITRATION FOR GIANT AND AND SMALL SMUTGRASS

Introduction

There are two varieties of smutgrass in Florida: small smutgrass *(Sporobolus indicus)* and giant smutgrass *(Sporobolus indicus var pyramidalis)*. Small smutgrass was first documented as invasive in the 1950s and by the mid 1970s had spread throughout central and south Florida (McCaleb and Hodges 1971). Giant smutgrass was first detected in south Florida in the early 1990s and by the end of the decade had become the dominant species of smutgrass in central and south Florida. Small smutgrass is now observed mostly in northern Florida, but is occasionally found in central and south Florida.

Smutgrass control methods have been investigated since it was first identified as a significant pest in improved grass pastures. Some of the earliest work with smutgrass management investigated the effects of mowing. Regardless of the time or mowing, height of mowing, or the number of mowing operations, mowing had no significant impact on smutgrass control (McCaleb and Hodges 1971). Mowing resulted in a decrease in the diameter of smutgrass clumps, but the number of total plants increased; suggesting that mowing aids smutgrass seed dispersal (McCaleb and Hodges 1971). Other cultural methods, such as tillage, resulted in inconsistent results, and complete pasture renovation was deemed too expensive (McCaleb and Hodges 1971). Therefore, potential herbicide treatments were investigated.

One of the first herbicides to be investigated for small smutgrass control was dalapon. McCaleb and Hodges (1971) reported that 6.7 kg/ha dalapon applied at any time of the growing season resulted in acceptable small smutgrass control. However, sequential applications were needed for complete eradication and this high rate of dalapon resulted in significant bahiagrass injury. Mislevy et al. (1980) determined that 3.3 kg/ha dalapon provided >85% control of small

smutgrass in pastures, but bahiagrass injury remained a concern. Further research determined that mowing the pasture 2 wk and fertilizing with 112-25-93 kg/ha N-P-K 6 weeks after an application of 3.3 kg/ha dalapon resulted in increased small smutgrass control and decreased bahiagrass injury (Mislevy et al. 1980).

Other herbicides, including atrazine, bromacil, MSMA, tebuthiruon and hexazinone, have been investigated for small smutgrass control. Exceedingly high rates of atrazine (4.4 kg/ha) were needed to obtain excellent control of small smutgrass (Smith et al. 1974; Johnson 1975). Sequential applications of 1.1 kg/ha or single applications of 2.2 kg/ha bromacil provided good to excellent control of small smutgrass (Smith et al. 1974; Johnson 1975). The herbicide MSMA alone at 2.2 and 4.5 kg/ha provided fair control of small smutgrass (Smith et al. 1974; Johnson 1975; Nishimoto and Murdoch 1994). However, the addition of atrazine at 2.2 kg/ha to either 2.2 or 4.5 kg/ha MSMA resulted in excellent small smutgrass control (Nishimoto and Murdoch 1994). High rates of tebuthiuron (3.4 kg/ha) were needed to obtain adequate control of small smutgrass (Brecke 1981). However, all herbicides mentioned thus far, with the exception of hexazinone and tebuthiuron are not, or are no longer, labeled for pasture use.

Currently, hexazinone is the only herbicide that is labeled for pastures that provides good to excellent smutgrass control. Brecke (1981) reported that spring application of hexazinone resulted in poor to good control of small smutgrass with 0.8 and 1.7 kg/ha, respectively. Delaying applications of hexazinone to the fall, increased the control of small smutgrass with 0.8 kg/ha to at least 79% in north Florida (Brecke 1981). Mislevy et al. (1999) determined that 0.56 kg/ha hexazinone was necessary to control small smutgrass when applied in the summer or the fall, but 0.84 kg/ha was needed if hexazinone was to be applied in the spring. Ferrell and Mullahey (2006) found that 1.1 kg/ha hexazinone was needed to consistently provide good to

excellent control of giant smutgrass in south Florida. Unlike with dalapon, mowing had no impact on small and giant smutgrass control in conjunction with hexazinone applications (Mislevy et al. 1999; Ferrell and Mullahey 2006).

Currently, hexazinone is the only herbicide labeled for selective control of both smutgrass varieties in pastures. However, hexazinone is an expensive herbicide that costs around $16 per liter. Hexazinone costs approximately $64/ha (Ferrell and Mullahey 2006). The estimated recommendation for giant smutgrass control is hexazinone at 1.1 kg/ha. This increases the cost to approximately $73/ha. There have not been any experiments conducted to determine if separate control recommendations are needed for giant and small smutgrass. The current theory is that giant smutgrass, the larger of the two varieties, would require a higher hexazinone rate for optimum control. There are two objectives for this experiment. First, is to determine if separate recommendations are needed for the two smutgrass varieties. Second, is to determine the lowest hexazinone rate that provides 90% control of giant and small smutgrass.

Materials and Methods

Experiments were conducted over 2 years in bahiagrass pastures containing dense infestations of giant or small smutgrass. The small smutgrass experiments were conducted in two locations at the University of Florida Beef Research Unit and near Alachua, Florida. The soil type present in the Alachua site was Arredondo fine sand (loamy, siliceous, semiactive, hyperthermic Grossarenic Paleudults). Experiments were initiated on 25 July and 2 July in 2006 and 2007, respectively. Giant smutgrass experiments were conducted at 3 locations near Ona, Florida; one location was utilized in 2006 (Location 1) and two in 2007 (Locations 2 and 3). Experiments were initiated on 30 July and 28 July in 2006 and 2007, respectively. The soil type present at all three locations near Ona was Pomona sand (sandy, siliceous, hyperthermic ultic Alaquods).

Hexazinone was applied to small and giant smutgrass at 0, 0.28, 0.56, 0.81, 1.12, 1.4 and 1.68 kg/ha. All treatments were applied using flat-fan nozzles calibrated to deliver 280 L/ha. Plot sizes were 7 by 18m and 3 by 15m for small and giant smutgrass, respectively. The experimental design was a randomized complete block with 4 replications. Smutgrass control and bahiagrass injury was visually estimated at 1, 3, and 12 months after herbicide application. Visual estimates of weed control were based on a scale of 0 to 100, where 0 equals no smutgrass control 100 equals complete smutgrass control. All data were subjected to ANOVA and means were separated using Fisher's LSD (P= 0.05). Regression analysis was used to determine the effective concentration (EC) of hexazinone needed to obtain consistent 90% control of small and giant smutgrass.

Results and Discussion

Data from the small smutgrass locations were pooled as a location by treatment interaction was not detected. No treatment provided greater than 80% control one month after treatment (MAT) (Fig. 5-1). At 3 MAT, 1.4 and 1.68 kg/ha hexazinone provided the highest level of control, but was less than 90% (Fig. 5-2). The only evaluation timing where at least 90% control was recorded was at 12 MAT (Fig. 5-3) with 1.12 and 1.68 kg/ha hexazinone. Through regression analysis, the EC_{90} of hexazinone for small smutgrass control was 1.13 kg/ha. These results differ from that of previous studies. Brecke (1981) found that small smutgrass control with 0.8 kg/ha hexazinone was 90% in one location, but was significantly lower (79%) at a separate location. Similarly, Mislevy et al. (1999) found that 0.56 kg/ha hexazinone resulted in at least 89% control of small smutgrass when applied in mid-summer and early fall. The reason for the differences among studies may be due to the drought conditions that were prevalent in Florida from 2006 – 2007. According to climatological reports from the Range Cattle Research and Education Centers in Ona, FL the year 2006 received 35.86 inches of rain which was 33.5%

less that the 65 year average (Sellers 2007). The year 2007 received 41.66 inches of rain which was 22.6% less 66 year average (Sellers 2008). Less rainfall would result in less available hexazinone in the soil solution for root uptake by smutgrass plants. Therefore, a higher application rate would be necessary to obtain satisfactory control.

There was a significant location by treatment interaction for the giant smutgrass data. Therefore, data from each location will be discussed separately. The only rate of hexazinone that resulted in greater than 90% control 1 MAT at Location 1 in 2006 was 1.68 kg/ha (Fig. 5-4). At 3 MAT, no treatments provided greater than 90% control (Fig. 5-5). Only hexazinone at 1.12 and 1.68 kg/ha provided greater than 90% control 12 MAT; EC_{90} of hexazinone for giant smutgrass control at this location was determined to be 1.11 kg/ha (Fig. 5-6).

Hexazinone at 1.68 kg/ha was the only treatment that provided greater than 90% control of giant smutgrass 1 MAT at Location 2 (Fig. 5-7). At least 0.84 kg/ha was required to provide greater than 90% control of giant smutgrass 3 and 12 MAT (Figs. 5-8 and 5-9). At this location, the EC_{90} of hexazinone for giant smutgrass control was 0.95 kg/ha.

At Location 3, 1 MAT at least 1.12 kg/ha hexazinone was required to obtain at least 90% control of hexazinone (Fig. 5-10). At 3 and 12 MAT, at least 0.84 kg/ha hexazinone was required to obtain 90% control of giant smutgrass (Figs. 5-11 and 5-12). The EC_{90} of hexazinone for giant smutgrass control at this location was 0.73 kg/ha.

The EC_{90} for giant smutgrass control varied among locations. Ferrell and Mullahey (2006) also demonstrated this variability in hexazinone efficacy on giant smutgrass. They conducted a similar experiment on giant smutgrass control resulting in an EC_{90} of 0.83 and 1.38 kg/ha over two years. Ferrell and Mullahey (2006) suggested that the higher EC_{90} value was due to hexazinone leaching caused by excessive rainfall during that year. Although a drought existed in

2006 and 2007 in Florida, there was sufficient rainfall following hexazinone applications for uptake by giant smutgrass plants. Therefore, rainfall may not be the only limiting factor causing variability among experiments on smutgrass control.

Hexazinone is an expensive herbicide and many producers often try to lower the application rate in order to reduce costs. However, environmental factors cannot be controlled and the amount of variability observed among the three giant smutgrass locations with regards to the EC_{90} is disconcerting. Furthermore, results reported in the literature on small smutgrass control suggests that control of small smutgrass can be quite variable among locations (Brecke 1981; Mislevy et al. 1999). To decrease the likelihood of hexazinone failure, it may be logical to recommend hexazinone at no less than 1.12 kg/ha for consistent smutgrass control. The results from these experiments indicate that a separate recommendation for the two smutgrass varieties is not warranted and that 1.1 kg/ha hexazinone will provide consistent control of both smutgrass species. Although the two varieties vary greatly in size, the amount of hexazinone required to obtain consistent control over various environments should be no less than 1.12 kg/ha.

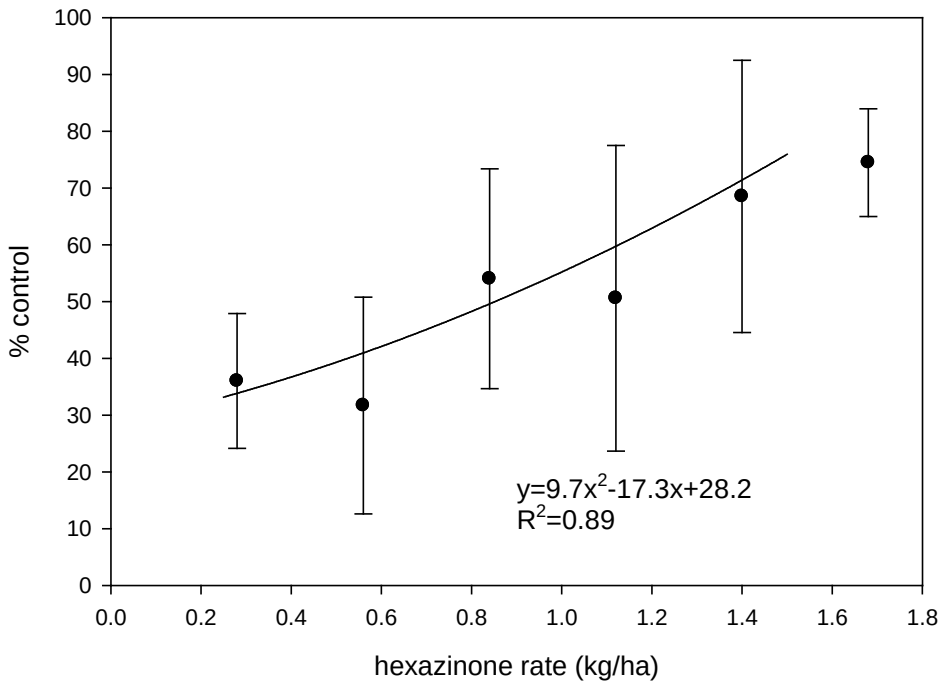

Figure 5-1. The effect of hexazinone rate on small smutgrass control 1 month after treatment. Means of 10 replications. Values represented with 95% confidence intervals.

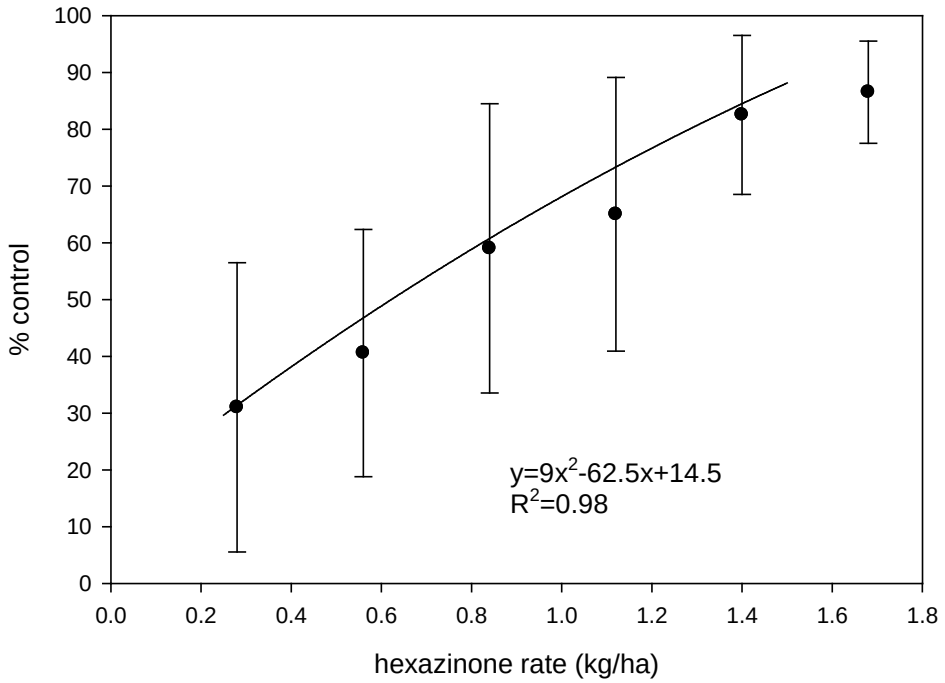

Figure 5-2. The effect of hexazinone rate on small smutgrass control 3 months after treatment. Means of 10 replications. Values represented with 95% confidence intervals.

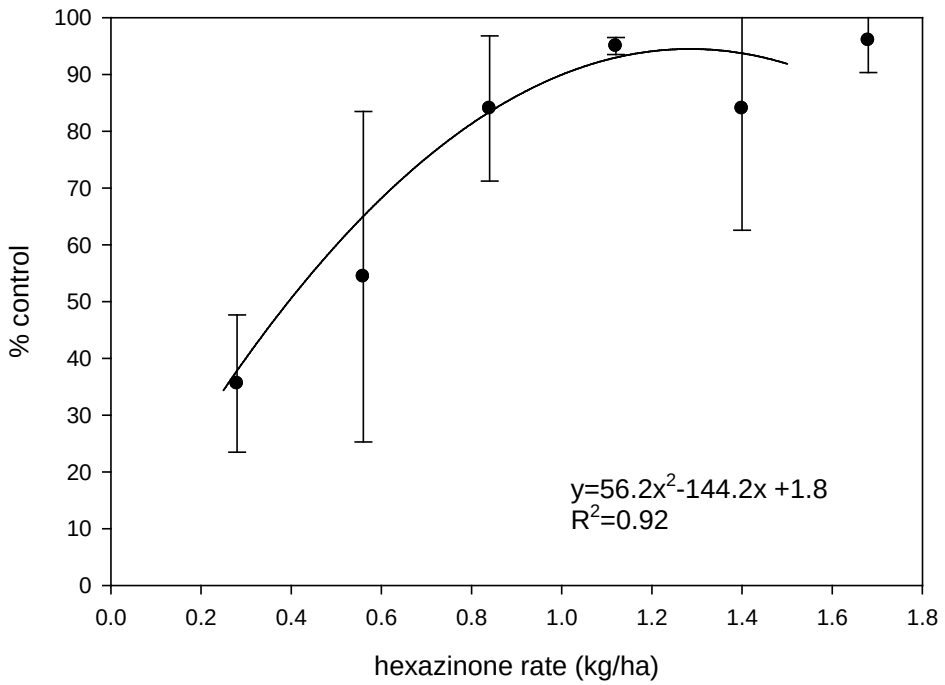

Figure 5-3. The effect of hexazinone rate on small smutgrass control 12 months after treatment. Means of 10 replications. Values represented with 95% confidence intervals.

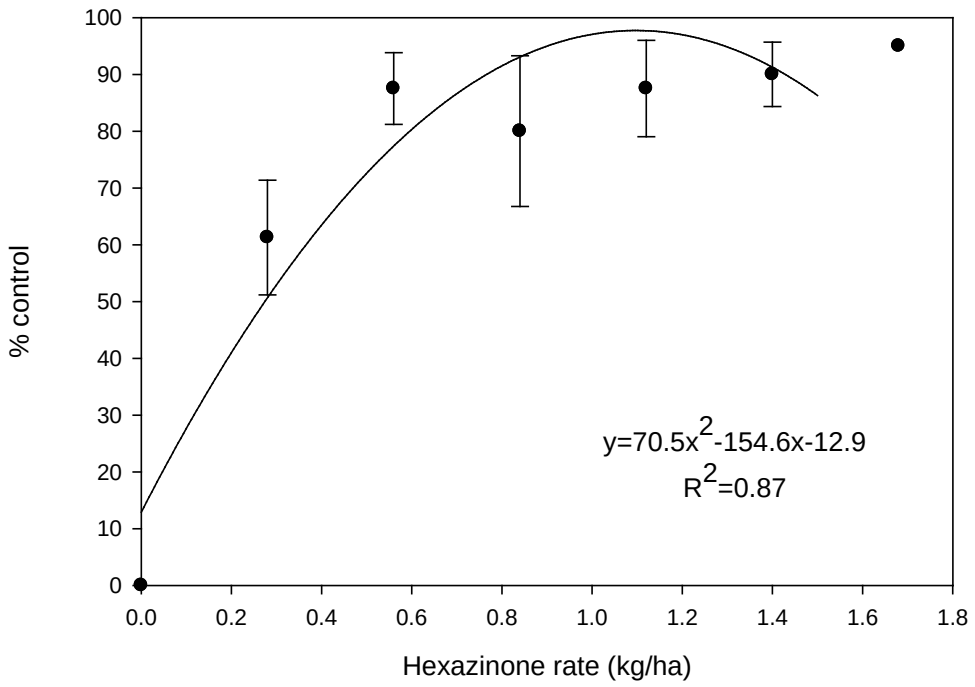

Figure 5-4. The effect of hexazinone rate on location 1 giant smutgrass control 1 month after treatment. Means of 12 replications. Values represented with 95% confidence intervals.

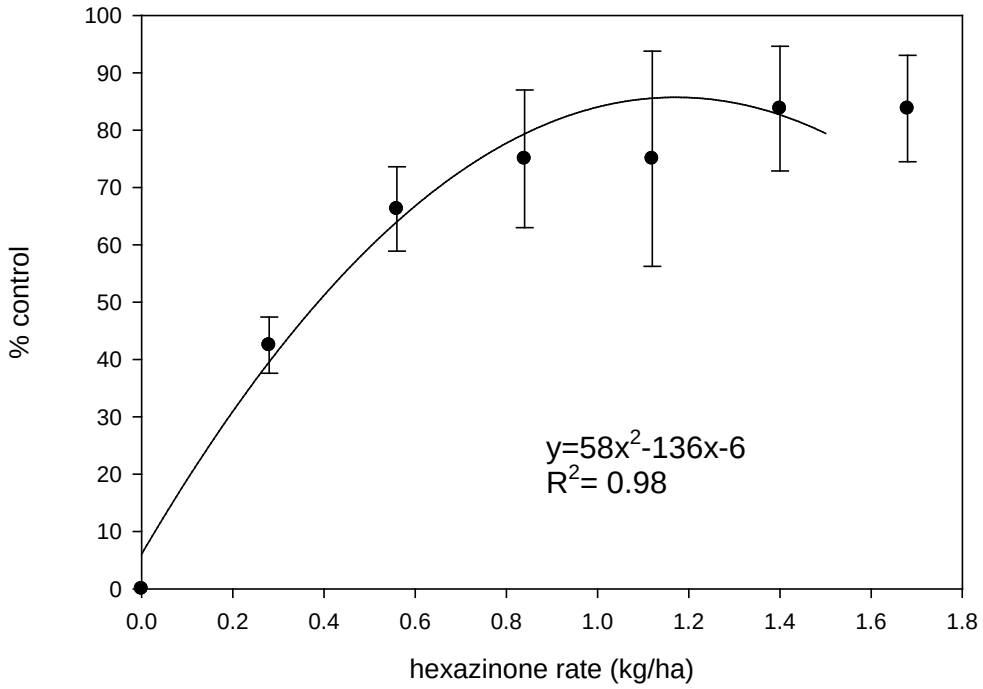

Figure 5-5. The effect of hexazinone rate on location 1 giant smutgrass control 3 months after treatment. Means of 12 replications. Values represented with 95% confidence intervals.

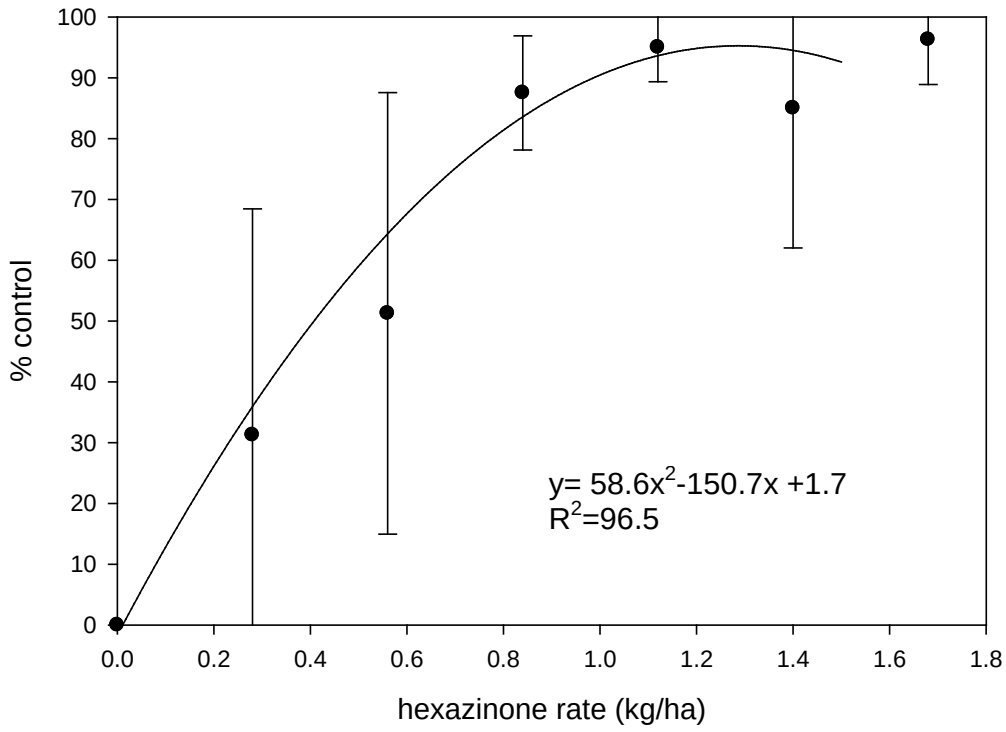

Figure 5-6. The effect of hexazinone rate on location 1 giant smutgrass control 12 months after treatment. Means of 12 replications. Values represented with 95% confidence intervals.

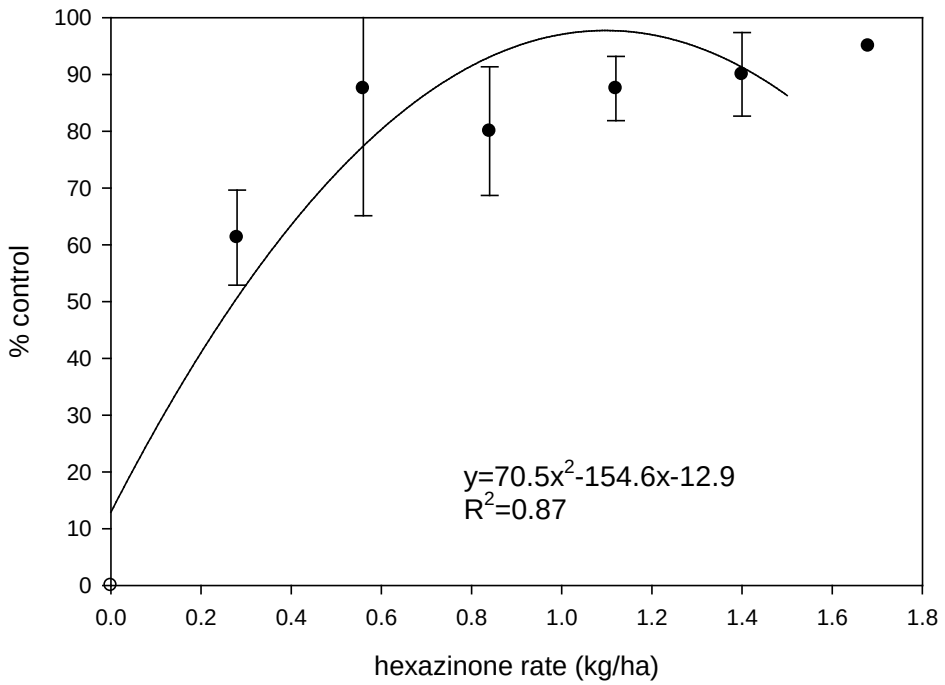

Figure 5-7. The effect of hexazinone rate on location 2 giant smutgrass control 1 month after treatment. Means of 12 replications. Values represented with 95% confidence intervals.

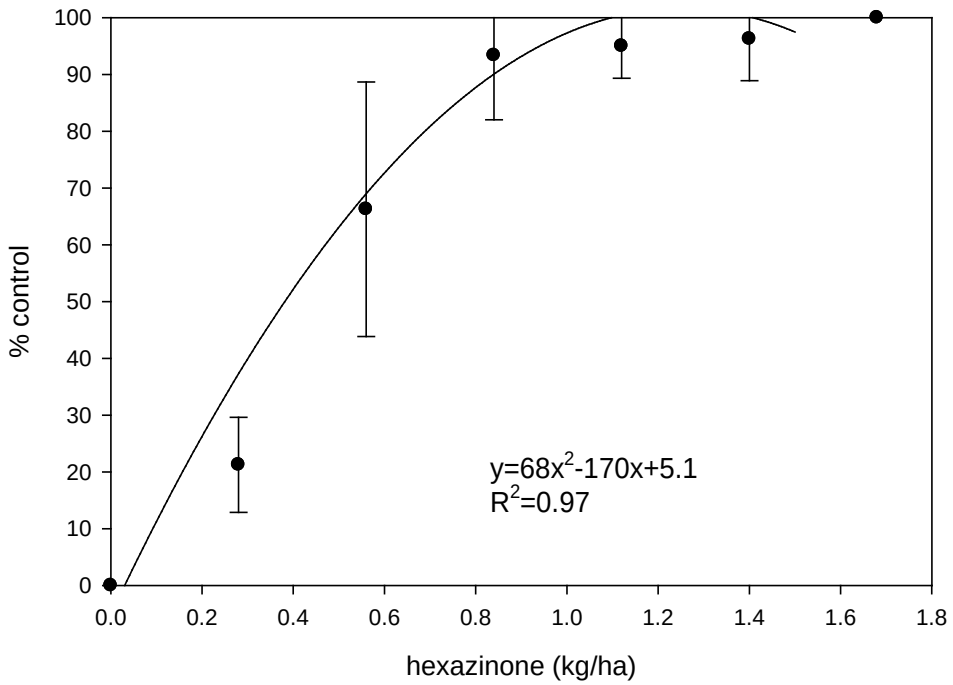

Figure 5-8. The effect of hexazinone rate on location 2 giant smutgrass control 3 months after treatment. Means of 12 replications. Values represented with 95% confidence intervals.

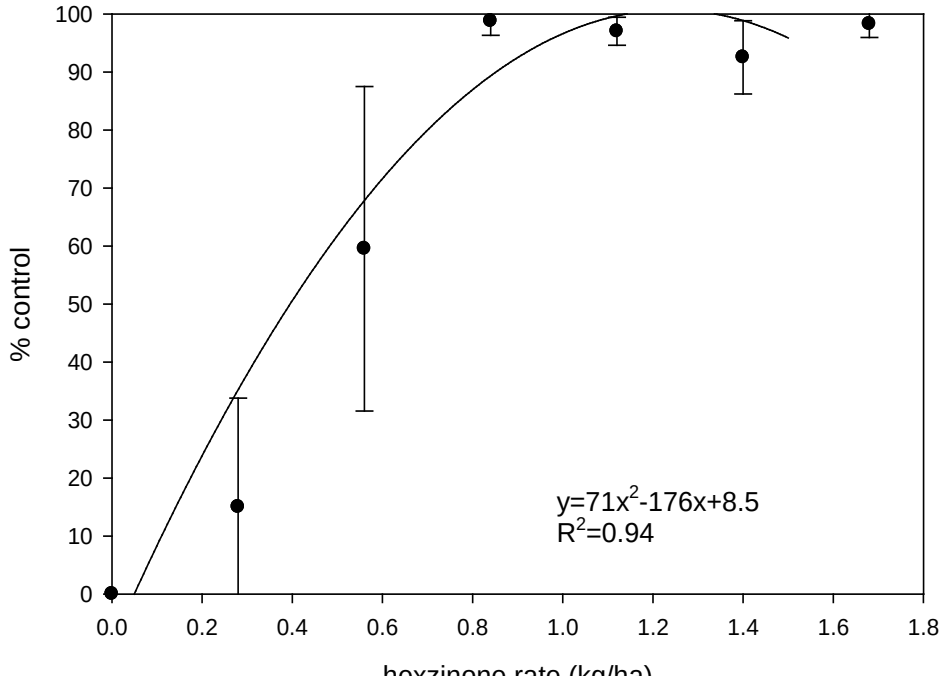

Figure 5-9. The effect of hexazinone rate on location 2 giant smutgrass control 12 months after treatment. Means of 12 replications. Values represented with 95% confidence intervals.

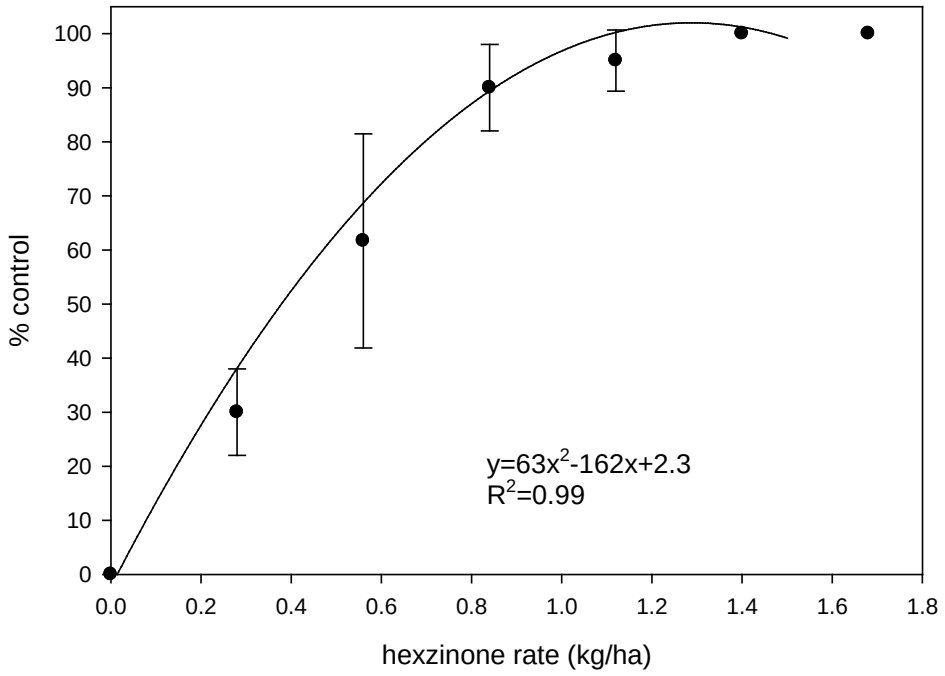

Figure 5-10. The effect of hexazinone rate on location 3 giant smutgrass control 1 month after treatment. Means of 12 replications. Values represented with 95% confidence intervals.

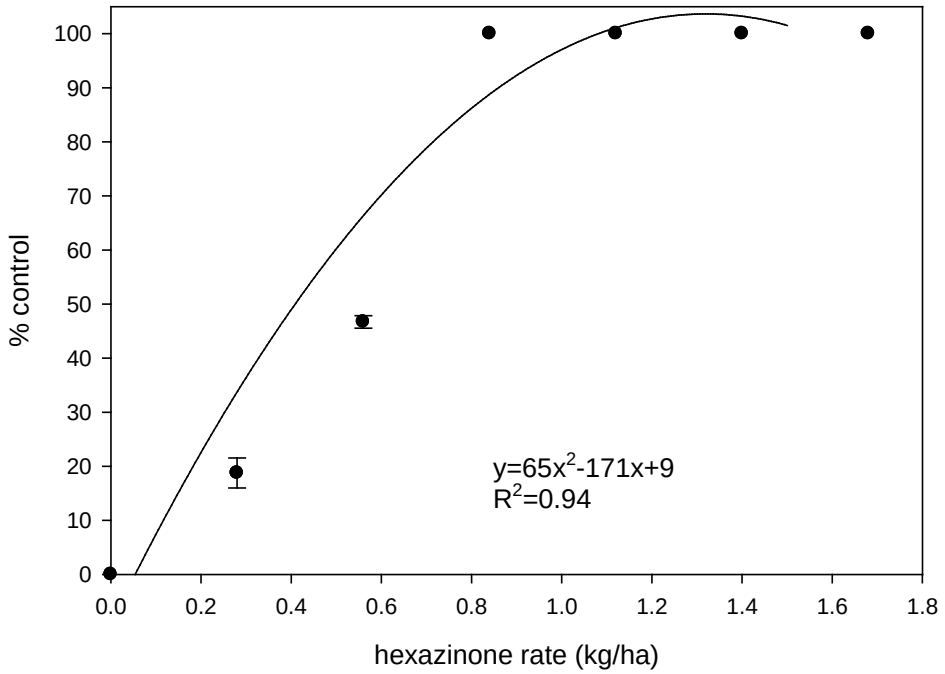

Figure 5-11. The effect of hexazinone rate on location 3 giant smutgrass control 3 months after treatment. Means of 12 replications. Values represented with 95% confidence intervals.

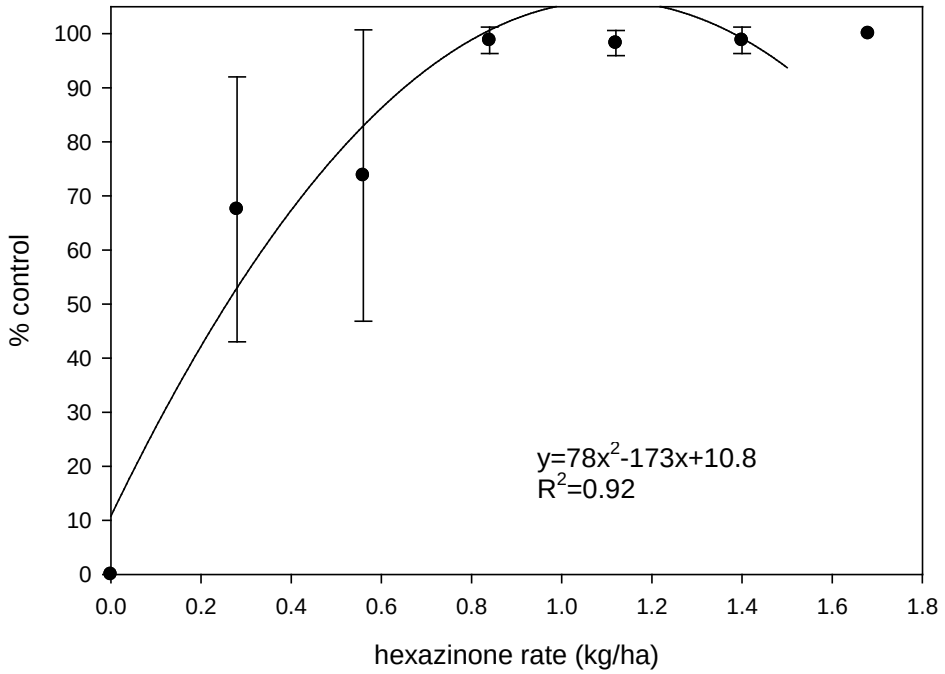

Figure 5-12. The effect of hexazinone rate on location 3 giant smutgrass control 12 months after treatment. Means of 12 replications. Values represented with 95% confidence intervals.

CHAPTER 6
CONCLUSION

Both varieties of smutgrass did not show any dormancy, with an average germination rate of 88%. Small smutgrass had its highest germination at 30 C while giant smutgrass had maximum germination at 35 C. Both small and giant smutgrass had their maximum germination at a pH of 6. However, small smutgrass had higher germination percentages across all pH values. Neither of the varieties requires light for germination, as both species germinated under dark conditions, though at a reduced rate. Both species also require very moist soil for germination. Neither variety germinated at water potentials greater than -0.2 MPa. Finally, there were some differences in depth of emergence for the two varieties. Tests showed that small smutgrass germinates only on the soil surface. Giant smutgrass germinates on the soil surface and to a maximum depth of 3cm.

The data from the Optima™ adjuvant study revealed no significant increase in hexazinone efficacy at both the 0.84 and 1.12 kg/ha rates. The data from the various adjuvants experiment resulted in no significant increase in hexazinone efficacy as well. This data, in conjunction with the fact that hexazinone uptake is primarily through the smutgrass roots, suggests that the use of adjuvants to increase hexazinone efficacy in giant smutgrass is not warranted.

For the rate titration experiment, the initial theory was that giant smutgrass, being the larger of the two varieties, would require a higher hexazinone rate for control compared to small smutgrass. That theory proved to be incorrect. The data from the small smutgrass and the data from the 3 giant smutgrass locations are not significantly different at the 0.56, 0.84, 1.12, 1.4, 1.68 kg/ha treatments. Only at the 0.28 kg/ha treatment are the two varieties significantly different from one another. However, that rate is well below the recommended control rate.

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BIOGRAPHICAL SKETCH

Barton James Wilder grew up in Plant City, Florida on a small farm. Barton is the son of two educators. He graduated high school in May 2001 and enrolled in the University of Florida that fall.

Barton received a Bachelor of Science degree in agricultural operations management in December 2005. As a student at the University of Florida, Barton was active in AOM Club, a member of Alpha Zeta Honor Fraternity, Gamma Sigma Delta, and Alpha Gamma Rho fraternity.

Barton began the Master of Science program in the Fall of 2006. He is currently the Agriculture and Natural Resources Extension Agent for Alachua County.