# WEED SCIENCE SOCIETY OF NORTH CAROLINA

**Weed Science in a Changing Environment**
**Proceedings of the WSSNC Seventeenth Annual Meeting**
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3. 3rd Place: COGONGRASS (*Imperata cylindrica*). Scott B. Clewis, North Carolina State University.

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**IMPLICATIONS OF THE FOOD QUALITY PROTECTION ACT ON PESTICIDE USAGE.** Dr. Allen Jennings, North Carolina Department of Agriculture.

**ABSTRACT**

*The Role of USDA in Implementing the Food Quality Protection Act*
The Food Quality Protection Act of 1996 (FQPA) charged the Department of Agriculture with the responsibility for creating a minor use program and gathering basic data used in pesticide exposure analysis. These data are fundamental components of EPA's risk assessments and include pesticide use surveys, pesticide residue analyses, and food consumption surveys.

The Vice President's April 8, 1998 memo to Secretary Dan Glickman and Administrator Carol Browner significantly expands the role of USDA to that of a partnership with EPA in FQPA implementation.

USDA's commitment to this charge is demonstrated by the Deputy Secretary's role as co-chair of the Tolerance Reassessment Advisory Committee (TRAC) and the establishment of a senior level EPA-USDA working group. USDA is committed to a long-term close working relationship with the EPA to help ensure that FQPA implementation is based on sound science, transparent processes, ongoing stake-holder involvement, and when necessary, orderly and predictable transitions in pest management strategies for agricultural producers.

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**ADVENTITIOUS BUDDING AS A SURVIVAL MECHANISM OF TROPICAL SODA APPLE (*Solanum viarum* Dunal)**. N. M. Call, S. D. Askew, H. D. Coble, and C. Arellano, North Carolina State University, Raleigh.

**ABSTRACT**

Lack of tropical soda apple control has often occurred due to regrowth of plants following management inputs. Repeated mowing controlled tropical soda apple only 60 to 70% in Florida. Plant age affected control by herbicides in North Carolina greenhouse trials. The exact mechanism by which tropical soda apple survives these management inputs is unknown. In addition, information is lacking on the effect of plant age on regrowth of tropical soda apple. Therefore, studies were conducted to determine the physiological mechanism of vegetative regrowth and the age at which tropical soda apple attains perennial characteristics.

Two independent studies were conducted for perennial age determination. Plants were grown from seed in the greenhouse to ages from 14 to 55 days old in the first experiment and 1 to 25 days old in the second experiment. At each day within the above age ranges, plants were cut 3 to 4 mm below the cotyledons and observed for regrowth. Data included height from soil line to apical meristem, diameter of hypocotyl, and leaf number. Data were analyzed using logistic regression. Chi-square tests with a 0.05 level of probability were used to test for significance and odds ratios were calculated for regrowth using age, height, leaf number, and stem diameter as dependent variables.

An observational study utilized transmission electron microscopy to determine the mechanism of tropical soda apple regrowth. Plants were cut at 1, 10, and 20 days after emergence and 16 plants were randomly selected and placed in a fixative solution each day for 30 days after cutting. Eight

plants were reserved for light microscopy examination and eight plants were used for electron microscopy examination. A rotary microtome was used to section plants for light microscopy.

Regrowth occurred when plants were cut 1 to 25 days after emergence regardless of age, stem diameter, and height. Unexpectedly, regrowth occurred on at least 50% of plants cut at the cotyledon stage, suggesting the ability of tropical soda apple to survive damage just after emergence. Over both trials, only 8% of plants failed to regrow and 75% of plants cut one day after emergence survived and regrew normally.

Microscopy studies revealed that adventitious buds originate shallowly in epidermal tissue where dedifferentiation occurred. Cell division was prolific near adventitious buds. By nine days after cutting, meristematic tissue and buds protrude through the callused tissue left from the cut scar. Leaf primordia and stem apical meristems were present 15 days after cutting regardless of plant age at cutting. From 12 to 24 buds formed per plant. Plants cut at 20 days after emergence produced more buds due to more area at the cut surface. This would indicate that even though plant age does not affect the occurrence of regrowth as shown by the age determination studies, older plants would regrow more vigorously than young plants.

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**VELVETLEAF (*Abutilon theophrasti*) INTERFERENCE AND SEED-RAIN DYNAMICS IN COTTON.** W. A. Bailey, J. W. Wilcut, and S. D. Askew, Crop Science Department, North Carolina State University, Raleigh, NC 27695-7620.

## ABSTRACT

Velvetleaf (*Abutilon theophrasti* Medicus) is a member of the family *Malvaceae* and is an intense competitor in several agronomic crops. Most research has been conducted on the interference characteristics of velvetleaf in corn and soybeans while little has been conducted with velvetleaf in cotton. Velvetleaf success is due to a combination of factors including seed dormancy, ability to germinate from deep within the soil, prolific seed production, and limited control measures. Past research (1977) has reported cotton yield reductions of 2.7% per velvetleaf plant in 10.1 m of row. Yield and harvesting efficiency reductions can be attributed to velvetleaf in cotton as well as a number of other economically important crops. Seed production of economic and sub-economic threshold populations is a concern and there is little or no published data on this area.

Field experiments were conducted at Clayton, NC in 1997 and 1998 to evaluate velvetleaf for competition and interference characteristics and to determine seed production and seed-rain dynamics when planted at different densities in conventional tillage cotton. Commercial cotton varieties used were 'Stoneville BXN 47' in 1997 and 'Deltapine 51' in 1998. Plot size was 3.7 X 9.1 m (4 rows per plot). Velvetleaf seedlings at the cotyledon to 2-leaf stage were planted into the center two rows of each plot at densities of 0, 1, 2, 4, 8, 12, 16, and 32 plants per row. All plots were kept weed-free except for velvetleaf for the entire season in both years of the study. All velvetleaf seed were harvested as pods matured. One velvetleaf plant from each plot was mapped throughout the season to determine the node placement for each mature pod. Height measurements for cotton and velvetleaf were taken weekly until 5 weeks after planting and bi-weekly for the remainder of the season.

Results determined that there was no effect on cotton height by any velvetleaf density up to 4 weeks after planting (WAP) in 1997 or 1998. Velvetleaf height was affected by density at all measurement times in 1997, but was not affected until 9 WAP in 1998. In 1998, velvetleaf and cotton achieved maximum height later than in 1997. However, velvetleaf seed production and cotton lint yield was higher in 1998. Differences in velvetleaf fresh weights and stem diameters were not significant in 1997, but decreased significantly as velvetleaf density increased in 1998. Bulk seed production in 1998 was nearly twice the bulk seed production in 1997. The majority of seed were produced higher on the plant in 1997 than in 1998. In both years, the higher plant densities of 8, 12, 16, and 32 plants per row resulted in seed being produced higher on the velvetleaf plants. In 1997, most seed were produced between nodes 6 and 20 while in 1998, most

seed were produced between nodes 1 and 10. In both years, cotton lint yield decreased linearly as density increased. Velvetleaf densities required to cause a 3% yield loss were approximately 6 plants per 9.1 m of row (6795 plants/ha) in 1997 and approximately 1 plant per 9.1 m of row (1133 plants/ha) in 1998. Rainfall amounts and heat units produced throughout the growing season were collected for both years. Rainfall amounts were 4.2, 8.6, and 12.9 cm in 1997 and 10.1, 3.8, and 18.1 cm in 1998 for the months of May, June, and July, respectively. Total rainfall for the entire growing season was 50.4 cm in 1997 and 60.4 cm in 1998. Heat units measured in cumulative degree-days were 245, 458, and 743 in 1997 and 364, 690, and 787 in 1998 for the months of May, June, and July, respectively. Total heat units produced for the entire growing season were 2530 in 1997 and 3202 in 1998. Differences in all parameters over years can most likely be attributed to differences in moisture and heat units produced early in the growing season as well as minor differences in the agronomic characteristics of BXN 47 and Deltapine 51. Additionally, velvetleaf appears to be sensitive to changes in the environment of the growing season. This is verified by the adaptive ability and competitive nature of velvetleaf as it has previously been more common and troublesome in the Midwest than in most southern states.

Velvetleaf canopied over cotton at 4 weeks after planting in 1997 and 2 weeks after planting in 1998. Highest lint yield in 1998 was 714 kg/ha with the control density of 0 velvetleaf plants per 9.1 m of row. A 3% yield loss with this yield would cost $35.34/ha (with cotton price estimated at $1.65/kg). This level of yield loss would justify the use of Roundup (approximately $18.50/ha) or Buctril (approximately $27.00/ha) systems for control of velvetleaf at densities as low as 1 plant per 9.1 m of row (1133 plants/ha).

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**JIMSONWEED (*DATURA STRAMONIUM*) INTERFERENCE AND SEEDRAIN DYNAMICS IN COTTON.** G.H. Scott, J.W. Wilcut, S.D. Askew, Crop Science Department, North Carolina State University, Raleigh, NC 27695-7620.

**ABSTRACT**

There have been numerous reports of jimsonweed being a problem weed throughout the Midwest. However, only recently has jimsonweed begun emerging as a problem weed in the Mississippi Delta and Southeastern United States. Jimsonweed is a large plant relative to cotton and competes with the crop extremely well for light while also reducing harvest efficiency. Especially since growth regulators keep cotton at a 36" to 48" maximum height, and jimsonweed frequently reaches heights of 5 ft. or greater. Under optimum conditions one jimsonweed plant can produce over 28,000 seed. Therefore, we feel it is important to determine the seed production of jimsonweed in North Carolina. This allows us to assess the effect of subeconomic jimsonweed populations on seedbank population dynamics. In cotton, yield reductions of 2.4% and 15.1% were reported for 3 plants per 30 row feet. The objectives of the study were as follows: 1) evaluate jimsonweed for competition and interference characteristics in conventional tillage cotton grown in North Carolina, and 2) determine the seed production and seed-rain dynamics of jimsonweed when planted at different densities with cotton.

A field study was conducted in 1998 at Clayton, NC to evaluate interference characteristics and seed-rain dynamics of jimsonweed in Deltapine 51 cotton. A randomized complete block design with 3 replications was used. Jimsonweed seedlings at the cotyledon to 2-leaf stage were planted into plots immediately after cotton planting at the following densities: 0, 1, 2, 4, 8, 16, and 32 plants per 30 foot of row. Jimsonweed seedlings were planted on the right side of each of the center two rows of each plot with the outer two rows left as untreated checks for each plot. All plots were kept weed free except for jimsonweed. All jimsonweed seed were harvested as they matured. Height measurements for cotton and jimsonweed were taken weekly until six weeks after planting and bi-weekly for the remainder of the season. Cotton was harvested and lint yields were determined. Data was subjected to ANOVA and regression analysis was performed where appropriate.

Jimsonweed seed rain increased with increasing jimsonweed densities. Seed production at 4 jimsonweed plants per 30 row feet was found to equivalent to approximately 89 million seed/A. This amount of seed production would obviously be a concern for growers, agricultural chemical dealers, and farm managers. Cotton lint yield decreased as jimsonweed density increased. Cotton lint yield was reduced 67.5% with the addition of 4 jimsonweed plants per 30 row feet. The relationship of cotton lint loss to jimsonweed density can be explained by the exponential equation [$y=923.02e^{0.0812x}$] ($r^2=0.87$). The stem diameters of jimsonweed decreased linearly [$y=-0.0125x+1.2125$] ($r^2=0.78$) as jimsonweed densities increased. The dry weights of jimsonweed plants also decreased as jimsonweed densities increased. This can be explained by the exponential equation [$y=1.2824e^{-0.0467x}$] ($r^2=0.92$). This is an indication that intraspecific competition was occurring at high densities. It was also found that it would take only 1.9 jimsonweed plants per 30 row feet to cause a 25% reduction in cotton yield. There was a definite inverse relationship between cotton heights and jimsonweed density This can be explained through the exponential equation [$y=24.749e^{0.0214x}$] ($r^2=0.87$).

This data indicates jimsonweed is more competitive with cotton in North Carolina than has previously been reported. The data also indicates jimsonweed is also more competitive with cotton in North Carolina than in more southern geographic locations. As a result, the economic thresholds for jimsonweed may need to be reevaluated in North Carolina. The data also shows very prolific seed-rain of jimsonweed in North Carolina. Therefore, the action threshold must be determined to prevent the buildup of jimsonweed seed throughout the soil seedbank. Future research efforts will include repeating the current study for a year to test the results in different environmental conditions, evaluation of the percent germination of jimsonweed as affected by parent density, and to determine the long-range viability of jimsonweed seed within the seedbank.

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**WEED IDENTIFICATION AND MANAGEMENT IN SOUTHEASTERN COTTON.** S. D. Askew and J. W. Wilcut, North Carolina State University, Raleigh.

**ABSTRACT**

The most common weeds of cotton grown in North Carolina, South Carolina, Georgia, and Alabama include crabgrass (*Digitaria* spp.), pigweed (*Amaranthus* spp.), goosegrass (*Eleusine indica*), morningglory (*Ipomoea* spp.), prickly sida (*Sida spinosa*), common lambsquarters (*Chenopodium album*), nutsedge (*Cyperus* spp.), sicklepod (*Senna obtusifolia*), broadleaf signalgrass (*Brachiaria platyphylla*), johnsongrass (*Sorghum halepense*), and common cocklebur (*Xanthium strumarium*). Proper identification is the first step to any weed management program.

Entireleaf morningglory versus tall morningglory, sicklepod versus coffee senna, and yellow nutsedge versus purple nutsedge are three examples of weeds that vary in response to herbicides and are difficult to differentiate. Subtle characteristics such as the suture along the hypocotyl of tall morningglory being shorter than that of entireleaf morningglory can help identify these species conclusively. Yellow nutsedge, when compared to purple nutsedge, can be identified by a camphor odor, edible nutlets, and tapering leaf tips. Coffee senna can easily be distinguished from sicklepod by the presence of pilose hairs on the hypocotyl which sicklepod plants lack.

A number of management options are available in cotton for control of troublesome weeds. Proper identification and timing of management inputs are critical. Recent registrations of glyphosate, bromoxynil, and pyrithiobac have expanded cotton producer's options for over-the-top herbicidal weed control. In some cases, cultivation may be a better option in lieu of chemical weed management.

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**THE NEUSE AGRICULTURAL RULE. (currently unavailable).**

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**CYANAMID AND ZENECA CO-PROMOTION.** Tom Hunt. American Cyanamid, 8504 Burnside Drive, Apex, NC 27502.

**ABSTRACT**

American Cyanamid Company and Zeneca Ag Products are pleased to announce a 1999 co-promotion agreement where each organization will support consistent agronomic recommendations in specific soybean geographies. This agrrangement offers growers simple, superior weed control solutions in a rapidly changing marketplace.
Together, Cyanamid and Zeneca will promote and service planned herbicide application programs utilizing leading brands from both companies on conventional (i.e. nonglyphosate-tolerant) soybeans. In the Northern Cornbelt, Cyanamid's Pursuit and Pursuit Plus herbicides and Zeneca's Flexstar and Fusion herbicides will be included in the co-promotion recommendations. Recommendations in the Delta will consist of Cyanamid's Squadron and Scepter herbicides and Zeneca's Flexstar, Fusion, and Typhoon herbicides. Zeneca's Touchdown 5 herbicide will be recommended when a burndown is needed.

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**INDUSTRY UPDATE: BASF.** Tom McKemie. BASF Corporation, PO Box 13528, Research Triangle Park, NC 27709.
(currently unavailable)

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**Undergraduate Student Essay Contest Winners**

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**AN OVERVIEW OF VARIOUS RESEARCH PROJECTS ASSOCIATED WITH COMMON RAGWEED (*Ambrosia artemisiifolia*).** Allen J. McNally, North Carolina State University.

Common ragweed (*Ambrosia artemisiifolia*) is not only a health concern to millions of Americans, but is also a major weed which affects many different crops. Until recently, I would have only been able to tell you that ragweed is a nuisance which caused me to have watery, itchy eyes, and a runny nose towards the end of every summer. Nearing completion of my first weeds course and upon researching common ragweed for this paper, I have come to appreciate the importance of common ragweed in agriculture. The many research papers I found while conducting my search showed that common ragweed is a problem in com, soybeans, potato, grain sorghum, white beans, and many other crops. Common ragweed is also an altemative host for the pathogen which causes Sclerotinia rot in cabbage. The objective of this paper is to share with you some of the findings of the research being done on common ragweed not only from the crop perspective, but also from the human health and plant pathology arenas. Common ragweed is a taprooted summer annual with branched stems(Murphy et al.). There are green separate male and female flowers. When looking at common ragweed you will see deeply twice dissected, hairy leaves. Common ragweed reproduces by seed and can often be found along roadsides, in fields, pastures, and waste places. Common ragweed is a weed which is native to the United States and can be found in the southeastem and northwestem United States as well as in Canada and North and South America.

Common ragweed is a member of the Helianthae (sunflower) family. Members of this family are wind pollinated and cause some of the most severe allergic reactions in people. Common ragweed is responsible for more cases of allergic rhinitis and other related diseases (hay fever, allergic asthma, and eczema), than all other plants combined (Bagarozzi, et al., 1998). The pollen of ragweed is very small and can be wind carried over long distances. It was previously documented that ragweed pollen only caused mast cell degranulation but possessed no enzymatic activity. The study (Bagarozzi, et al., 1998) which will now be discussed was designed to evaluate the proteins released from the pollen grains to determine if they had any enzymatic effects on the human respiratory system. The results of the study showed that common ragweed pollen contained not only proteolytic enzymes, but also two peptidases. They showed that one of these enzymes could worsen the effects of the pollen by causing bronchoconstriction due to the hydrolysis of lung neuropeptides. The other enzyme interfered with the balance of two respiratory systems resulting in allergic rhinitis and allergic asthma. With continued research such as this, it may someday be possible to prevent or lessen the effects of ragweed pollen. Another interesting non-crop research focused on the association of Sclerotinia rot of cabbage with common ragweed

(Dillard et al., 1986). The spores of the Sclerotinia sclerotium need a food supply to be able to invade healthy green tissues of plants. The aforementioned study showed that common ragweed served as source of nutrients for the S. sclerotium allowing cabbage which contacted the infected male ragweed flowers, fruits, or whole plants became infected. In infestations of S. sclerotium, the male flower part of ragweed seemed to be the source of the infectious agents. In their study, ragweed leaves inoculated with S. sclerotium did not lead to development of the disease in cabbage plants and pollen infected with the pathogen caused disease only 2/3 of the time. They speculated that better weed control, i.e. control of the common ragweed would lead to the reduction of Sclerotinia rot in cabbage.

This brings us to the focus of the remainder of this paper which will be to examine research which has been conducted on the effects of common ragweed on crops and the effects of different management practices on the reduction of common ragweed populations.

One such study set out to determine the effects density and time of emergence of common ragweed on white bean (Phaseolus vulgaris). This study was undertaken because common ragweed is a major problem in white bean productions in Ontario, Canada (Chikoye et al., 1995). Due to strict herbicide use and registration laws in Canada, this research was important to help develop an integrated weed management strategy for white beans. As you would expect, ragweed which emerged at the same time as white bean emergence had a greater impact on yields than did the ragweed which emerged at the trifoliate stage. Statistically the ragweed present at emergence of the white bean resulted in yield losses which were 6 to 13% higher than those in the plots where ragweed presence was not noted until the trifoliate stage. This is in accordance with weed-free requirements and maximum periods of weed competition (Wilcut, 1998). As far as density is concerned, the ragweed which emerged at the trifoliate stage did not affect the leaf area index or the number of pods which could be harvested. Only the ragweed which emerged at the same time of bean emergence had a negative effect on the leaf area of the beans. The earlier emerging ragweed plants also produced more seeds in amounts 4 to 6 times greater than those which appeared at the three leaf stage. One finding peculiar to me was that with increasing density of ragweed plants, there was a decrease in the number of seeds produced. This finding was not really discussed in detail in the paper. Their final recommendation was that pre-emergent or early season control of common ragweed in white bean is necessary to keep crop yields at their highest levels. Before we get into the effects of herbicides on common ragweed, I would like to share some research done on the effects of other management practices on ragweed in grain sorghum and in corn. The first study focused on the influence of four weed management systems (zero, low, medium, and high) on weed population and species dynamics in conventional-tillage and no-tillage grain sorghum production (Vencill, et al. 1994). The management systems varied by the timing and types of herbicides applied. The no-till plots showed that ragweed seed density was greater than in the conventional-tillage plots in four of the five years studied. This would seem to indicate that tillage has an effect on ragweed in grain sorghum. In comparing the different levels of weed management, their goal was only to show the effects on the weed seed bank over a five year period. The weed seed populations were relatively stable over the entire five year study indicating that management level did not affect the amount of weed seed in the field from year to year. One other finding of importance was that yield of grain sorghum was lower in the no and low management systems. This would seem to indicate that although the seed population is unaffected, treating ragweed with herbicides helps to reduce the negative effects of the ragweed on the sorghum.

In corn, the effects of using narrow row spacing, herbicides, and cultivation techniques were studied. The main goal of the study was to investigate the potential for reduced herbicide amount(either through below-label rate and/or banded applications) using narrow crop row spacing and timely cultivation(Johnson et al., 1998). Increases in com yield had been previously reported using narrow row spacing. The narrow rows were thought to reduce weed interference by shading the weeds. The results of this study showed that corn row spacing whether alone or with cultivation and/or herbicides did not affect the density of common ragweed. Cultivation appeared to be the best method for weed reduction when reduced herbicide rates were used.

Cultivation also improved the visual inspection of the plots where only acetochlor (which is a grass herbicide and only partially controls ragweed). These weed management strategies also had very little effect on weed height or biomass. Cultivation affected corn height apparently because of the reduced densities of ragweed. Yield of corn grain was more affected by cultivation and herbicide interactions. The final conclusions made in this study were that narrow row spacing had no affect on either grain yield or weed biomass or density.

One study looked to determine the effectiveness of combinations of nonselective herbicides for difficult to control weeds in no-till corn and soybeans(Wilson, et al. 1988). Ragweed was only studied in soybeans in this study. This study looked to determine whether the addition of 2,4-D to glyphosate and paraquat, alachlor + metribuzin to glyphosate, linuron to paraquat, or diuron to paraquat affected the control of common ragweed. 2,4-D added to low rate of glyphosate increased effectiveness but no better than a higher rate of glyphosate. The addition of alachlor to glyphosate lowered effectiveness for ragweed control (residual effects of alachlor were antagonistic to glyphosate), but this treatment had the highest soybean yield of the glyphosate treatments. The addition of 2,4-D had no effect when added to paraquat. The addition of linuron or diuron to paraquat significantly improved the effectiveness of ragweed control while also producing higher soybean yields than the paraquat and/or 2,4-D treatments. For common ragweed control it would appear that paraquat + linuron or diuron are the most effective choice to keep yield high.

Another study in soybean looked to check the effects of bentazon mixed with either imazethapyr or thifensulfuron. Bentazon at 1120 g/ha controls four-leaf common ragweed and can be improved with the addition of acifluorfen(Hager et al., 1994). In the laboratory, bentazon, imazethapyr, and thifensulfuron reduced dry weight of common ragweed. However, mixing of imazethapyr or thifensulfuron with bentazon did not increase ragweed control past the efficiency of bentazon alone. However, in the field, the tank-mixes of bentazon with either imazethapyr or thifensulfuron both increased control of common ragweed but yield was reduced when compared to handweeded control areas.

Another crop in which herbicide effectiveness for ragweed control was studied is the potato. Potato is an economically important vegetable crop in Virginia, the United States, and the world(Ackley et al., 1996). Common ragweed control in potato by rimsulfuron was 50 to 90% when applied pre-emergently, and 30 to 84% when applied post-emergently. Metribuzin applied pre-emergently gave 40 to 71% ragweed control and 78% control when applied post-emergently. The mixing of metribuzin and rimsulfuron did not give statistically significant increases in common ragweed control. Use of these herbicides either alone or in mixture did increase yield.

The last study I would like to share with you was based on the use of p hytopathogenic bacteria to control weeds. Bacterial bioherbicides should be more economical to produce than fungi, and may become commercially successful if practical methods of host wounding or water soaking were developed(Johnson et al., 1996). In the following study to be discussed, this was accomplished by use of surfactants or by wounding. The organosilicone surfactant Silwet L-77 allowed the bacteria to enter the stomata without host injury. Without surfactant only 5% of the ragweed seedlings were infected compared to 100% when surfactant was used. In field trials the bacteria(Pseudomonas syringae pv. targelis) was sprayed on common ragweed using the Silwet L-77 surfactant. The number of common ragweed infected with the disease was 100% and the mortality was also 100%. The severity of the disease was given a 4.5 which indicates severe chlorosis and necrosis ranging from some to much. The control of ragweed by the bactefia (Pseudomonas syringae pv. targetis) was complete and future treatments with this bacteria should be considered. Chemical companies who produce herbicides which are used in common ragweed would probably not want this product on the market and would probably buy the fights to keep it off the market. This is one of the problems with biological control methods.

As you can see, common ragweed is found in many crops as well as being a human health concern. Its presence as an alternative host has produced increases in Sclerotinia rot in cabbage.

Much research has been conducted on possible methods to reduce common ragweed while maintaining good yields in the desired crops. Tillage, row spacing, herbicide mixtures, and even biological controls have been studied to reduce the incidence of common ragweed. Until a treatment is found to prevent the allergic reactions or to reduce or eliminate common ragweed in commercial crops, research into common ragweed control will most likely continue.

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**WATER HYACINTH: WEED CONTROL WITH HERBICIDES AND BIOLOGICAL CONTROLS.** Jennifer Wilson, North Carolina State University.

**Outline**

- **Introduction**
- **Physiology**
- **Control Methods**
- **E. Crassipes as a nutrient remover**
- **Conclusion**

**Introduction**

Water hyacinth, *Eichhomia crassipes,* is an aquatic weed which was imported to the U.S. from northern South America around 1860. It quickly spread to many continents, arriving in Egypt in about 1879, and in Asia around 1888, and India in 1894. It was in Japan by 1900, and in Australia in 1890. It has become a common reservoir pest in Suriname, El Salvador, and other places in S. America. It is believed that one reason for the quick spread may have been by horticulturists who desired the beautiful flowers as part of the plant. While it originally thrived in only a few ecosystems in the country, it began to become more widespread in 1950s with the advent of chemical controls. Today it is found in many aquatic environments in the Gulf states, namely in the Louisiana, Texas, Florida corridor.

Pieterse refers to aquatic weed as "an aquatic plant (or group of plants) which is not desired by the manager of the water body where it occurs, either when growing in abundance or when interfering with the growth of crop plants or ornamentals." Aquatic weeds are of three types, submerged, emergent, and floating. Floating plants are considered to be the worst possible aquatic weeds due to the fact that they interfere with navigation, fisheries, and recreation , and can harbor life threatening diseases in some countries. Water hyacinth and other floating weeds are extremely invasive because of their clonal reproductive action. They sit on the water surface and spread in two dimensions. Growth rates are high. Hyacinth has a doubling time of approximately 13 days. H. Physiology The E. crassipes is a floating weed, often rooted in mud, with thin, perennial roots, and rosettes of inflated leaves and fibrous, branching roots. Petioles appear inflated. Flowers are on a spike-like pedicel and are showy and can be blue, violet or white. Plants reproduce by vegetative means and are connected by stolons. Plants range any where in size from a few centimeters to one meter in height. Seeds are set infrequently once the mat has been established. Seeds may sink and remain dormant until periods of drought. E. crassipes grows in various water habitats. Plants often appear in moist soil around the shoreline of wetlands, marshes and ponds, and are persistent over several months. to years. In winter, E. crassipes leaves and petioles are smaller, at about less than 30 cm long and only 20 cm. above the water surface. 2,8

Floating plants acquire ample amounts of water, light, and C02, thus they are highly productive at photosynthesis and their vegetative growth make them some of the most productive on earth. In much of the tropical world, E. crassipes is considered the most voracious of the aquatic weeds. It has a high doubling time, and its leaves mesh together to form a dense mat on the water surface. Under high temperatures, and shallow water, it thrives. Hyacinth will grow in 10 cm of water. In 1969, Ueld and Old found in growth studies that hyacinth will produce more seed per plant than other floating plants, or any rooted plants. Here, they found that seed germination occurred more often in shallow water.

**Reproduction**
These large growth rates are attributed to clonal growth. The clone has a long life span and the individual ramets are for the most part shorter lived. These produce many ramets, or daughter plants, from meristernatic areas on the rhizomes of parent plants. The ramets then produce new ramets over time. The number of ramets can double every three to ten days. In three months, E. crassipes produced 1610 plants from the 10 parent plants set out. Seeds can remain dormant for five years. 2,3,4

**Photosynthesis**
E. Crassipes fixes C02 mainly via using rubisco and some PEPC, but the ratio of the former is high, at 16. It has a high C02 compensation point, thus it is a C3 plant. Floating weeds photosynthesize in air and are not exposed to C02 limitations. For C3 plants, photosynthesis is increased by increasing C02 levels. Thus, with elevated C02 levels, the vegetative production of E. crassipes increases. E. crassipes is very intolerant of low light levels. When light is reduced by 25 percent, E. crassipes has a reduced leaf weight, protein content, stomatal and mesophyll conductance. 5.

**Temperature**
Temperature differences also effect E. crassipes. An optimum temperature is about 1840 degrees celcius. However, both roots and leaves of E. crassipes are prone to freeze damage. Vegetative tissue does not normally survive the winter in most areas of the U.S. The weed is not capable of producing tubers or turions. They have only limited reproduction from seed. 6.

**Nutrient Requirements**

N and P are the most limiting factors for most C3 floating plants. N and P levels below 42 iind 7.8 mg/L respectively had a limiting effect on E. crassipes. Clock, 1968 and Sheffield, 1967, found that N qnd P reduction levels under E. crassipes were 75-94 percent and 32-61 percent, respectively. Nutrient uptake occurs almost exclusively through the roots. The rate of absorbtion through the roots is related to the metabolic activitity in the upper portion of the plant. The portion of photosynthesis is aerial, so the pH of the water has little effect on them, so tolerance levels range from 6-12 pH. 7.

**Control Methods**

E. crassipe control has been attempted using a number of methods. Prior to the advent of the chemical industry, manual labor was the only means of controlling the weed. Weeds were hand removed, and burned to get rid of the seeds. Often small attempts at dredging the shoreline would rid the area of seeds, but this was not an effective long-term method. Flooding of reservoirs was also attempted in the early 1960's but this method soon proved damaging to ecosystems and the fluctuation of precipitation in many areas of the country made this difficult. With the advent of herbicides, aerial spraying became an option.

**Chemical Control**

In 1960, the reservoir at Harbeesport Dam in S. Africa had been nearly covered by the E. crassipes. The registered herbicide Clarosan (ciba-geigy) with the active ingredient terbutryn (in the triazine family of herbicides), was used. Terbutrym is partially systemic, and affects the photosynthetic processes of weeds, and had no effect on aquatic animals. Weeds were killed or damaged by after one spraying. The proportion of dead plants was greatest in the larger-leaved plants. The spraying resulted in 26 percent effected by herbicidal spray and 61-68 percent of the plants were dead, while ten percent remained undamaged. Due to the systemic nature of terbutryn, the plants damaged by the herbicide would eventually die. The death of the rest of the damaged weeds occurred over the next 4-5 weeks. An important note in the previous research was that aerial spraying did not immediately kill plants in the spring when flowers are produced, housing -viable seed. It was difficult to kill plants sufficiently before flowering. 11.

The alkanoic herbicides, of which 2,4-D is a member, have been most used on E. crassipes. 2,4-D was used successfully in reservoirs such as Dam B. Reservoir in Texas in 1965. 2,4-D is commonly used in water weed control because their effects mimic hormonal growth in plants. Their mode of action is thought to occur within the nucleic acid metabolism. 2,4-D is most effective out of the water on broad-leaved weeds, but can affect monocots in the aquatic environment. If gibberlic acid is increased in the E. crassipes, the level of control in vitro from 2+13 increased 10 fold. The presence of surfactants also influences 2,4-D control of E. crassipes, most likely by influencing the uptake of the herbicide. 2,4-D can be mixed with dalapon, or paraquat, ametryene can produce synergistic effects on the control of E. crassipes. 12

The persistence of 2,4-D after spraying can be up to 9 weeks in aquatic environments in the U.S. 2,4-D is not absorbed into clays and sediments. Microbial degradation is the method of breakdown in a water body, which is influenced by pH, temperature, and nutrient availability. 2,4-D is persistent for a short time in most soils. It is moderately persistent in water. Degradation of the acid occurs through microbial action. In warm moist soils with a high organic content, 2,4,-D can degrade in a few days. With a lower pH and less organic matter, leaching of 2,4,-D is more prevalent. Many derivatives of 2,4-D are used in the control of E. crassipes, the most common of which are esteric derivatives of 2,4-D. The esters are spread at a rate of 10-40 1b/A over the water surface or with below surface injection. 13,17

The bi-pyridinium salt herbicides, or most commonly, Paraquat and Diquat, has also been used alone and with other herbicides for control of E. crassipes. Both are non-selective contact herbicides, which kill any green plant tissue on immediate contact. Their mode of action is on the electron flow in the photosynthetic process in plants and are reduced to free radicals within the cell. The free radical oxidizes and produces hydrogen peroxide, which kills the cell.

Diquat is more commonly used on E. crassipes. It is most effective in the early part of the growing season when plants are actively photosynthesizing and the tissues are more fleshy. Performance of both herbicides is significantly reduced if the waters become turbid or muddv, or where plants become covered with sediments. Both herbicides are strongly absorbed into clays and soils, and are very persistent. Some photo-degradation occurs in breakdown, but the main breakdown process is due to microbial decomposition. Both herbicides are often formulated with wetting agents that make them toxic to aquatic fauna. Thus, in many countries they are limited or banned for use in certain situations. 14

Glyphosate use was first used for E. crassipes control ca. 1974. It is sprayed onto foliage at a rate of 1.8-2.1 kg1ha. Application techniques include conventional nozzles, aerial spraying and rope wicks. Glyphosate's mode of action is on the amino acid chains. Cells die due to termination of synthesis of proteins and phenolic compounds. It concentrates on the germination of the buds on rhizomes. A few days after spraying, the leaves will yellow and die soon after. As glyphosate remains on the cuticle for a few hours after spraying, it can wash off the cuticle before it has a chance to penetrate.

It is important to have two days without precipitation in order to apply glyphosate. Treatment should begin during mid-season growth, as spraying too early is not effective, and spraying too late does not allow the chemical to effect the new buds on rhizomes. Glyphosate is quickly absorbed by particulate matter in the water and falls to the bottom sediments where it is degraded by microbial action. 21

**Biological Control**
**Insects**
Research scientists are beset with the problem of having to manage floating plant infestation when the plant has gotten out of control due to the fact is was a non-native invasive species that has no natural enemies. In many countries, including the U.S., imported species have been a helpful addition to traditional control treatments. 15 Two weevil species were used to control E. crassipes. Neochetina bruchi and N. eichhorniae are among five of the most promising species for E. crassipes control to be used in the U.S. Both species would not attach economic crops in Florida and reaches south, so it was determined they would continue to be used. Deloach and Cordo found that damage to E. crassipes was lowest in the spring,, but increased rapidly in December and January, about 3 weeks after rapid growth began again. In the May-July, the feeding on the leaves was the highest at about 120-140 feeding spots per leaf. Damage by the larvae occurred in November through December. Each successive generation of larvae in the fall added to the cumulative petiole damage. Both N. bruchi and N. eichorniae produced three generations per year during the two year study. The two species mixed and segregated, but did not affect the feeding habits on the weed. It is thought that the two species co-existed, due to the difference in population levels during summer and winter. 9.

N. eichhorniae and paclobutrazol (a new plant growth retardant that effects gibberelin biosynthesis), were used in a study at the University of Florida in 1983. One application of 1. 1 kg ai/ha paclobutrazol reduced growth in pools of 52 percent. Whereas, the reduction from N. eichhorniae alone was 24 percent. The combination of the herbicide and the weevils was most efficient, at 95 percent. 10

Introduction of biological control insects or fungi should have the following protocol: 1. The need for an introduction must be clearly understood 2. The organism must have a desirable ecological and economical impact. 3. The species must have minimal niche overlap with native species; 4. It should cause minimal reduction of nontarget species; 5. Field rel eases should be studied and ecological impact determined, as well as disease potential should be carefully monitored. 15

**Herbivorous fishes**
Grass Carp, Hybrid Carp Both species have been used infrequently in conjunction with other treatments. These fish are not used that often in large, municipal projects due to the changes in

water quality that have taken place with the use of carp species. The grass carp east broadleaf plants, and has had a mediocre effect on aquatic weed control. The hybrid carp is considered more advantageous due to the fact that it consumes plants and algae. 16.

**Manual Control**
Manual control has been most prevalent in history in countries where the wealth in labor availability and where labor is cheap. Long ago, it was common to use hand tools like sythes, sickles, grass hooks, rakes, forks, hoes., chain channels. In India, removal of e. crassipes has achieved some success where 25 percent of ponds were totally cleared, and another 25 percent had the weed remained, in trials. In manual experiments, more than 10 percent is often left uncleared and free to propagate the next season.

**Mechanical Control**
**Booms**
Booms were first used in the U.S. in the 1900's to keep E. crassipes from encroaching into ports and navigation parts of large water bodies. However, it usually was a temporary approach and did little to stop the progressive growth of the weed.

**Machinery**
Physical control of aquatic weeds is the most prevalent in the history of weed control, second only to manual weed control. Larger devises have been used in mechanical control in last two decades , floating booms, ropes or nets for removal. In fact, some of the first floating machinery was specially designed to combat E. crassipes in the Gulf states. One device, built in 1900, used a conveyor belt and a sugar can crusher attached to a floating barge. In 1937, the barge was redesigned, and consisted of a balast to push the crushed plants overboard to decompose in the water. Sawboats were also manufactured to shred the biomass as it traveled. Propulsion for these boasts was typically by paddle wheel. Leaving the biomass to decompose in the water proved detrimental to oxygen demand in ponds and lakes. Harvesting, or removing the weed from the water became a necessary part of treatment, sometime after WWII. Such machines included drag-line cranes, a boat with a conveyor belt to remove the mass and leave it on shore, even a dewatering baling facility.

Even though moving the biomass elsewhere can be beneficial to control, it is time consuming and the cost of labor often expensive. A fresh weight of E. crassipes biomass weighed 376 ton/ha and a modern barge system can remove 1 ha of weed per hour. Working on a lake of 200 ha, the laborers would work more than 2 months to get the biomass cleared. In 1978, Culpepper and Decell calculated that harvesting systems should be able to move 80-100 ton/hour for species such as E. crassipes and Hydrilla verticillata in order to economically effective. 18

A variation on the barge theme was the machines operating from the bank- A heavy chain could be dragged by a team of horses, or by a tractor and was effective in controlling E. crassipes in Africa and India. However, the reach of these machines is approximately 7.5 meters, and a mounted hydraulic reach is 11 meters. The machines are often fit with weed cutting buckets which cut the weeds while being pulled on the hydraulic arm and then sweep the biomass into the bucket for collection. This has been the most widely used in the U.S. for bank based machinery. 19

Dredging has been a popular approach in the last two decades. Dredging solves the important problem of pulling up the macrophytes by the roots, which aids in the termination of regeneration after harvesting is finished. Dredging of E. crassipes pulls up the plant materials, stem, leaf growth, and accumulated sediments, which might contain dormant seed. Dredging provides control as a last ditch effort, when other controls have proved ineffective. Dredging of shallow water can have many limitations. In shallow waters, fragments of plants such as rhizomes, turions, and stolons often remain in the water. Dredged material is often laid out on the banks adjacent to the water body and spread over unused land. In the U.S., even though the cost of chemical controls for E. crassipes can be three times as great as a rake-bottom drag machine, it often turns out that a water facility will decide to use the chemical treatment over the mechanical due to effectiveness results over the long-term. Another option for removing stored vegetation is burning the dry biomass after it has been piled on the banks. This option is best for preventing plants and seeds from being washed back into the river or lake. 18, 19,20.

### Laser radiation and ultrasound

The use of lasers was researched for E. crassipes by Long and Smith in 1975. There has been some advance with this type of control, but it has not been widely used due to limited budgets in weed control. 21

### E. crassipes as a Nutrient Remover

The effects of nutrient uptake by E. crassipes has been used for studies and has been incorporated as treatment in the management of wastewater projects for three decades. Many researchers have an interest in E. crassipes for its uptake values and its quick growth qualities. Studies done by Yount and Crossman, and Ryther et al. reported mean annual biomass production of 45 to 88 mt dry wt/ha /yr. respectively. 24, 26.

Rogers and Davis reported that a single water hyacinth has the capability of removing more than 3 mg P and over 20 mg N per day from solution. 25 Scarsbrook and Davis , reported uptakes of 2.87 g of P and a6.03 ), g N and 8.73 g K in wastewater effluent over a 23 week span. Many researchers, however. have found that increase N concentration effects P uptake in wastewater treatment systems and in laboratory (Shalipor et al. 198 1, Shalipor at et. 1980, Wolverton et al. 1976). In 1972, Rogers and Davis also found that one hectare of E. crassipes growing in certain conditions, absorbed the N and P waste production of the equivalent of 800 people. Still other uses are being found for the weed. In 1983, Widyanto et al. found that E. crassipes absorbed sodium, silica, chlorine and sulfur from waste water from a paper factory. The absorption terminated after 72 hours. The researchers found that E. crassipes is also a potential material for paper pulp. Crushed petioles of 100 cm length yielded 52 to 83 percent pulp. 23.

### Conclusion

It is apparent that E. crassipes has been a worldwide problem, especially in countries where harvested crops are grown in watery environments, and places like India and Southeast Asia where transportation is highly dependent upon navigating waterways. In these areas, it will always be necessary to use a combination of systemic broadleaf herbicides with biological controls in order to control infestations. However, the U.S. has been turning to new ways of utilizing a problem weed for economically removing nutrients like N and P from municipal wastewater systems. Certain areas of Florida and the Gulf Coast will always need herbicides to clear navigable areas, however, more emphasis should be placed on the harvesting of living plants and growing them in cultured mediums for production in wastewater treatment facilities. E. crassipes should be looked at as more a beneficial weed when managed and harvested for its nutrient removals.

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**COGONGRASS (*Imperata cylindrica*).** Scott B. Clewis, North Carolina State University.
Cogongrass, *Imperata cylindrica (L.)* Beauv., is a member of the Poaceae grass family. It is a dense, erect, spreading perennial up to 1.2 m tall from scaly, creeping rhizomes. The leaf blades are 8-133 cm long, 2.8 mm wide, glabrous except for tuft of hairs on upper surface at the base, basal portion of some blades marrowed and resembling a petiole, midvein not in center (Bryson et al., 1993). The seed head is branched but compacted in a dense, white, fluffy spike-like head. The flowers of Cogongrass each have two stamens. This distinguishes it from the native *Imperata brasifiensis* Trin. which has only one stamen per flower (Patterson et al., 1980).

Cogongrass has many names. It is known as "lalang" in Nigeria and "japgrass" in Alabama. It grows to a height of 1-4 ft in Alabama and can grow to over 9 ft in other areas of the world. Its short intemodes and compact growth of rhizomes allow it to choke out other plants (Dickens et al., 197 1).

Cogongrass is a perennial grass native to southeast Asia. It is distributed throughout the tropical and subtropical regions of the world. It was introduced into the southern United States about 1911, as packing material in a shipment of horticultural plants from Japan. Another early introduction the United States was in Mississippi at an experimental station where Cogongrass from the Philippines was evaluated as a potential pasture grass (Patterson et al., 1980). Later in Alabama, Mississippi, and Florida, authorized and unauthorized plantings were made and now it is well established there. In the late 1940s, farmers began to recognize the plant as a weed and began trying to control it.

This species of grass has been planted along highways and canals where it is effective as a soil-stabilizing grass. However, this grass spreads into undisturbed areas of nearby pastures and forests. The wind seems to help spread the seeds over the open, flat land. Once Cogongrass gets established in an area, it is extremely hard for any other plant seedling to survive in the same area (Tanner et al., 1992).

It is a major weed of 35 crops in 73 countries throughout the world (Bryson et al., 1993). Cogongrass creates the most serious problems in plantation crops that receive little cultivation. It is also an important weed in cotton, soybeans, corn, sugarcane, peanuts, and various vegetable crops. It has the potential for creating serious weed control problems in the southern United States in areas that are cultivated infrequently and in agronomic crops gown with minimum tillage (Wilcut et al., 1988). The spread of Cogongrass outside the southern and gulf states seems unlikely due to its lack of lowtemperature tolerance (Bryson et al., 1993).

In Cogongrass now present in the United States, considerable growth variability has been found. This may be due to the genetic changes which have occurred since its introduction here. Also, since there were two separate introductions of this weed into the United States, it has a greater potential for genetic variability. Studies have been conducted to see if Cogongrass plants from different locations would respond differently to temperature and photoperiod (Patterson et al., 1980). In these studies, temperature did have an affect on the growth of the plants. Continued studies have been conducted to determine if Cogongrass can withstand cooler or even freezing conditions.

In studies conducted to determine the shading effects on the growth of Cogongrass, it was determined that it can grow under a wide range of light conditions. Its growth under low light conditions shows that it can grow under the shade of other crops for some time. Also, its production of rhizomes under shade conditions would allow it to continue from year to year (Patterson et al., 1980).

This weed has the potential to extend north and westward in the United States if more winter-tolerant types are introduced (Bryson et al., 1993). Nurseries now'are selling a variety of Cogongrass, 'Japanese Blood Grass' or 'Red Baron'. This has caused some concern as it could rapidly increase the spread of this grass (Bryson et al., 1993).

It cannot survive cultivated areas but establishes itself along roadways, in forests, parks, and mining areas. Cogongrass invades pastures, nurseries, pecan plantations, highway rights-of-way, and lawns. The occurrence of this tall-growing species along highway rights-of-way presents a safety hazard. Also, the mowed rights-of-way appear to provide a means of rapid movement of the grass into new areas (Shilling et al., 1996).

This grass grows and spreads from seeds and rhizomes. Cogongrass reproduces asexually by rhizomes and sexually by seeds (Patterson et al., 1980). The central cylinders of Cogongrass rhizomes and roots possess mechanism to conserve water and resist breakage and disruption. Roots and rhizomes are also resistant to fire and are able to survive in plantations where other weeds are destroyed by controlled burning. This factor will probably increase the seriousness of Cogongrass in the state of Florida with the recent fires of the past summer.

Rhizomes may penetrate soils up to 1.2 m deep, but most occur within the top 0. 15 m in heavy clay soils and 0.4 m of sandy soils. The rhizomes are responsible for the short distance spread of Cogongrass. Rhizome production from a seedling plant takes about four weeks (Willard et al., 1996). Cogongrass is capable of producing up to 3,000 seeds by a single plant. Seeds are capable of germinating immediately (Wilcut et al., 1988). Cogongrass does not require an after ripening period.

It is a warm-season plant and is widely distributed on all continents except Antarctica. It occurs as far north and south as Japan and New Zealand. In the United States, this weed starts growing in February and remains green into fall. It then turns brown following a severe frost. Flowering may occur year-round but usually occurs in April-May and in October. This species of grass is rated among the ten worst weeds in the world, falling between Johnsongrass and water hyacinth as number seven (Patterson et al., 1980).

Cogongrass has been reported to be a weed problem in many annual and perennial crops where it competes for light, water, and nutrients. It may adversely affect banana, citrus, coconut, pasture, pineapple, pine, rubber, and tea crops. In addition, it has become a problem in many non crop areas, such as forests, road sides, reclaimed mined areas, and recreational areas (Willard et al., 1996). It cannot survive in cultivated areas, but can become established in forests, parks, and mining areas, as well as along roadways.

Its habitats are quite diverse, including the coarse sands found in desert dunes or along shorelines, as well as the fine sands or sandy loam soils of swamps and rivers. Cogongrass is adapted to full sun, but can thrive under the moderate shade of savannahs. It is less frequently found in soils with low nutrient levels (Patterson et al., 1980).

Cogongrass rapidly invades abandoned or disturbed areas following cultivation and row crop production, establishment of orchards, and along utility lines and pipe lines. It can withstand dry periods or tolerate water logged clay soils (Willard et al., 1996).

There are three native North American skipper butterfly species (Hesperiidae), *Ancyloxypha numitor* (Fabricus), *Atalopedes campestris* (Boisduval), and *Hylephild phyleus* Drury, which have been reported to feed on Cogongrass (Bryson et al., 1993). It is probably not practical to expect these butterfly species to be used as a biological control agent, since the larvae may feed on other grass species. In addition, the butterflies have natural parasites and predators (Bryson et al., 1993).

Research on Cogongrass was begun in 1970 after the grass had spread rapidly in southern Alabama. It has become a serious pest there. The grass has no economical value for forage or other uses. Its tall growth along roads and streets reduces visibility and may be a traffic hazard (Dickens et al., 1971). One reason for concern about this pest is its fairly rapid spread in recent years. The upright plant is highly inflammable even when it is green, so it presents a fire hazard problem (Wilcut et al., 1985).

Some results of studies done in Alabama indicate that cultivation can help the spread of Cogongrass by cutting off a one inch portion of the rhizomes. This prevented the rhizomes' ability to produce new plants. The remainder of the rhizomes does not normally produce buds, therefore, it cannot produce new plants. The study also showed that burying Cogongrass rhizomes deeper than 2-3 inches greatly reduced the production of new shoots. So, cultivation may kill Cogongrass by burying it deep enough so that it cannot emerge again (Wilcut et al., 1985).

Short-term suppression of Cogongrass has been successful, but long-term control has failed due to large rhizome reserves and quick regrowth following burning, tillage, mowing, or herbicide treatment. Mowing and tillage must be done consistently over two or more years to deplete the starch reserves that support growth of new shoots (Shilling et al., 1996).

Tillage knocks down new shoots and helps dry out the rhizomes. Deep tillage is important since Cogongrass rhizomes rarely re-sprout from depths greater than 15 cm. In order to completely control Cogongrass, repeated tillage is required until there is no regrowth. However, tillage presents a problem in most natural areas because of the ecological impact. With either mechanical approach, re-vegetation is the key to prevent recolonization (Patterson et al., 1980). Fire seems to work in Cogongrass's favor because it may destroy other plants, but does not seem to seriously damage its rhizome system (Dickens et al., 1971).

Only a few herbicides have proven effective in controlling Cogongrass. Fall applications of glyphosate and imazapyr seems to provide greater control than spring or summer applications (Dickens et al., 1975). These two herbicides do have some draw backs because both kill all plants in the area that is treated. Imazapyr can remain active and prevent other plants from growing in the area where it is used. Glyphosate (Roundup) needs to be used on a dry day for maximum effectiveness since it is sensitive to rain. Both herbicides leave the soil bare, so other plants need to be planted immediately (Shilling et al., 1996). In studies, discing alone provided only short-term control, but two discings and split applications of imazapyr controlled Cogongrass regrowth up to 96%, twelve months after treatment. A combination of discing, herbicides, and revegetation with desirable plant species also provide control in some areas (Willard et al., 1997). Burning of Cogongrass to remove dead plant material before applying herbicide treatment should help reduce the amount of herbicide needed to treat the area (Tanner et al., 1992).

The key to long-term control of Cogongrass is replacing it with a competitive plant capable of closing in and resisting re-invasion (Hauser et al., 1974). Establishing new species in Cogongrass-infested areas is difficult because Cogongrass secretes toxic chemicals, has an extensive system of rhizomes, and creates a dense canopy (Miller et al., 1998). There are several species of weeds that show promi'se in competing with Cogongrass including hairy indigo, Bermuda grass, and bahiagrass (Shilling et al., 1996).

In the South Pacific and Southeast Asia, Cogongrass infects millions of acres of land. These regions do not have the resources to effectively control Cogongrass on a large-scale basis, therefore, the most widely used control methods are slash-and-bum, grazing, and tillage. Studies on the effectiveness of these techniques have indicated that: (Bryson et al., 1993) shift agriculture, in which a fallow of local plant species is maintained, may provide control long enough to produce one or two crops prior to reinfestation often at higher populations, (Dickens et al., 197 1) repeated burning followed by grazing will marginally support animal production, but provides little control, and (Dickens et al., 1975) intensive tillage has repeatedly shown to be an effective method for Cogongrass management, however, the availability of implements, soil type, climatic conditions, and terrain limit its use in Southeast Asia (Willard et al., 1996).

Cogongrass is a problem weed throughout tropical and subtropical regions of the world, along with the southeastern United States. Research has been conducted in greenhouses, laboratories, and fields to study Cogongrass reproduction and integrated management of Cogongrass. Combinations of discing, herbicides, and revegetation with desirable plant species provided control in some areas. Additional research is needed to determine the most desirable plant species for rovegetation.

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