AN ABSTRACT OF THE THESIS OF

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Title: Coldhardiness of Cogongrass, Imperata cylindrica (L.) Beauv.

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The cold hardiness of cogongrass, Imperata cylindrica, and johnsongrass, Sorghum halapense, was studied in growth chamber and greenhouse experiments. The cogongrass specimens were obtained in Florida and were grown in the growth chamber for rhizome production. Johnsongrass rhizomes were collected from a field near Emporia, Kansas. The harvested rhizomes were sized and subjected to different temperatures initially set at 25 C. Every two hours, the temperature was lowered by 5 C and rhizome samples were taken for viability tests. Viability was determined by using 1 % TTC solution and by planting the rhizomes. Cogongrass rhizomes were more sensitive to cold temperatures than johnsongrass. Its rhizomes were killed after exposure to 4 C, whereas johnsongrass rhizomes had -3 C tolerance limit. In addition, during the period of November 22 to February 9, some of the johnsongrass rhizomes survived the -4 C temperature treatment, i.e. showed slight acclimation to cold weather. It was concluded that cogongrass is not likely to become established in Kansas.

COLDHARDINESS OF COGONGRASS, *IMPERATA CYLINDRICA* (L.) BEAUV.

A Thesis

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INTRODUCTION

Cogongrass, *Imperata cylindrica* (L) Beauv., has been listed as the seventh worst weed in the world (Holm et al. 1977). This perennial is native to tropical areas where it aggressively competes with field crops and plantations (Holm et al. 1977). Cogongrass is found in 73 countries affecting 35 different crops (Table 1 and Figure 1). It was introduced into the southern United States in the early 1900's and is currently listed as a noxious weed in Alabama, Mississippi and Florida (Elmore 1986). This species has a tendency to become a troublesome weed like johnsongrass. Johnsongrass, *Sorghum halapense* L., a well established weedy and noxious species in Kansas, is a native of the mediterranean area. It was included in the study for comparative purposes. This vigorous species was introduced into the southern United States in the early 1800's for livestock forage. The exact date of its introduction was difficult to trace due to the poor documentation and the various common names, over 40, used to describe this grass (McWhorter 1971). The first written name, however, was recorded in 1874, derived from a farmer William Johnson in Marion Junction, Alabama, who was said to be responsible for its introduction into Alabama. This species is found in 53 countries in 30 different crops and is listed as the sixth worst weed in the world (Holm et al. 1977: Table 1). The distribution and spread of these two weedy species has been restricted by cold temperatures. The northern limit of their ranges appears to be the limit of rhizome cold hardiness.

Cogongrass was first introduced into the United States accidentally as packaging material in a shipment of citrus from Japan. The shipment arrived in 1911 at Grand Bay, Alabama (Dickens 1974). In

1943, some specimens were brought from the Philippines for forage studies, and several plots were planted at the Auburn Experimental Station. These plantings were supposedly destroyed in 1949 (Dickens 1974; Patterson et al. 1980). Several authorized and unauthorized plantings were later made in Alabama, Mississippi and Florida. The infestation of this species in Mobile county, Alabama has increased from 500 acres in 1951 to 10,000 acres in ten years, and by 1974 it was found in 19 counties in Mississippi (Dickens 1974).

In tropical areas, cogongrass is a major weed of rubber tree, oil palm, citrus and cotton plantations, and also some vegetable crops (Holm et al. 1977; Figures 2 and 3). In Malaysia, over two million hectares of rubber plantations are severely infested. A severe invasion of cogongrass reduces growth of the rubber trees up to 50 %, resulting in lower latex production (Holm et al. 1977). The sharply pointed rhizomes of cogongrass can penetrate the roots of trees which increases their susceptibility to fungal infections. Harvest time is also prolonged on plantations or field crops infested by this species. As with johnsongrass, its persistence is due to vigorous rhizomes (Ayeni and Duke 1985). Both of these species reproduce by seeds as well as rhizomes. Cogongrass has a dense, fluffy, silvery white, cylindrical, spikelike panicle (Hitchcock 1971) and produces about 3,000 seeds per head (Holm et al. 1977). The plumed seeds can be wind-transported long distances. The rhizomes, up to 1 m in length, are hard and scaly. Johnsongrass has a pyrimidally shaped inflorescence and produces larger seeds and rhizomes than cogongrass (Hitchcock 1971). Some of the characteristics of these two grasses are listed in Table 2. The rhizomes of both species are found at varying depths. These

Table 1. Ten of the most serious weeds in the world (Holm et al. 1977).

	Scientific name	Common name	Family name	Native habitat	# countries & crops *
1 -	Cyperus rotundus L.	Purple nutsedge	Cyperaceae	India	92 - 52
2 -	Cynodon dactylon L.	Bermuda-grass	Poaceae	Indo-Malaysian	80 - 40
3 -	Echinochloa crusigalli L.	Barnyard-grass	Poaceae	Europe & India	61 - 36
4 -	Echinochloa colonum Link.	Jungle rice	Poaceae	India	60 - 35
5 -	Elusine indica (L.) Gaertn.	Goosegrass	Poaceae	Asia	60 - 46
6 -	Sorghum halapense (L.) a noxious weed in Kansas	Johnsongrass	Poaceae	Mediterranean	53 - 30
7 -	Imperata cylindrica (L.) Beauv.	Cogongrass	Poaceae	Asia and Africa	73 - 35
8 -	Eichornia crassipies Mart.	Waterhyacinth	Pontederiaceae	Amazon	rivers and swamps
9 -	Portulaca oleraceae L.	Common purslane	Portulacaceae	Europe & Africa	81 - 45
10 -	Chenopodium album L.	Lambs quarter	Chenopodiaceae	New & Old World	47 - 40

* number of countries and crops affected by the species

Figure 1. Cogongrass, *Imperata cylindrica* (L.) Beauv.

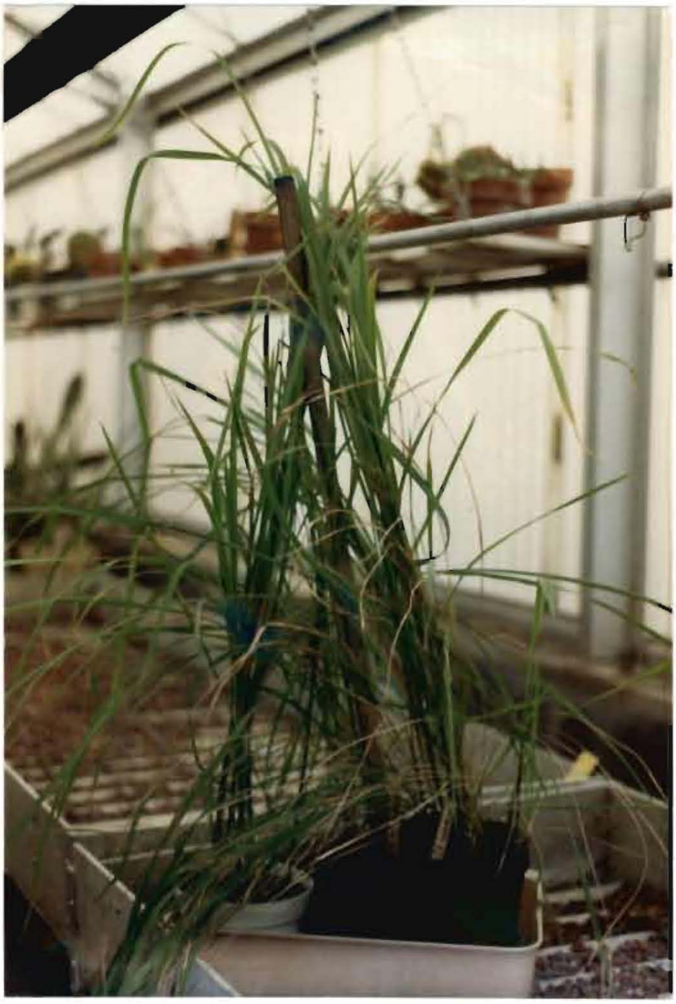


Figure 2. A rubber tree plantation infested by _Imperata cylindrica_.

Figure 3. An oil palm plantation infested by *Imperata cylindrica*.

rhizomes have immense propagative ability (Ayeni and Duke 1985). The sprouting of johnsongrass rhizomes is favored by darkness and high temperatures (Hull 1970). Cogongrass rhizomes are found in the top 15 cm in heavy soil, and in the top 40 cm in light soil. Some of the rhizomes have been found as deep as 1.2 m under favorable conditions (Holm et al. 1977). As for johnsongrass, 80 % of the rhizomes are distributed in the top 7.5 cm in clay soil and 12.5 cm in sandy loam soil (McWhorter 1972). Under favorable conditions, most of the rhizomes are distributed in the top 20 cm (Holm et al. 1977). The rhizomes of cogongrass are capable of accumulating high concentrations of glucose. In a normal site, they can accumulate up to 10 x 10^3X 2-deoxy-D-glucose than the surrounding soil (Harun et al. 1984). This grass also uses nutrients very efficiently, especially K and NO_3^- (Holm et al. 1977; Dickens and Moore 1974). This is also true of johnsongrass, as it grows vigorously in fields where nitrate fertilizers are extensively used (Wakeman 1986).

These weedy species also have an allelopathic effect on other plants which enhances their competitiveness and persistence (Holm et al. 1977). Both species release chemical exudates that can have deleterious effect on other plants over a period of time. Wilcut (1988) reported that when grown together, bermudagrass yields were reduced 40 % by competition from johnsongrass and 16 % by cogongrass.

An established field of johnsongrass or cogongrass is very difficult to eradicate due to the vigor of the rhizomes (Holm et al. 1977). Cogongrass for example, requires 4 kg/ha of glyophosate (Round-up) or a double applications of 15-20 kg/ha of dalapon per year to control its density (Dickens and Buchanan 1975). These applications do

Table 2. Characteristics of *Imperata cylindrica* and *Sorghum halapense* (Hitchcock 1971; Holm et al. 1977).

	S. halapense	*I. cylindrica*
Distribution	55° N to 45° S lat.	45° N and S lat.
First Photosynthetic product	4-Carbon atom (oxaloacetic acid) phosphoenolenol pyruvate to oxaloacetate	
Height	0.5 to 3 m	0.15 to 1.5 m (*3m)
Leaf - width	0.5 to 5.0 cm	0.4 to 1.8 cm
- length	20.0 to 60.0 cm	up to 150.00 cm
Infloresence	panicle, pyrimidal, purplish	spikelike panicle, cylindrical, dense, white and fluffy
- length	15.0 to 50.0 cm	3.0 to 20.0 cm (*60.0)
Reproduction	seeds and rhizomes	
Rhizomes production	33 metric tons per ha	6 metric tons per ha
Depth of rhizomes	20.0 cm (*1 m)	15.0 cm - heavy soil 40.0 cm - light soil
Rhizome	up to 1.2 cm	0.8 or less diameter
Habitat	warm, humid, summer rainfall areas	tropical and sub-tropical areas
Optimum rhizome	20 C	30 C temperature

* under favorable conditions

not eradicate this weedy species. Johnsongrass rhizomes are difficult to kill with herbicides because they will not accumulate translocated herbicides such as 2,2-dichloropropionic acid (McWhorter 1971). Cogongrass which has a light saturation of 80,000 lux and a high net CO_2 exchange rate, 48.03 mg $CO_2 dm^{-2} h^{-1}$ as measured on a young leaf, can be controlled economically and effectively by shading (Holm et al. 1977; Sajise and Musgrave 1980). In the rubber tree and oil palm plantations, a legume, Centrosema pubesence L., is widely used to reduce cogongrass density by shading (Holm et al. 1977). Patterson (1980) reported that a cogongrass specimen grown in full available sunlight produced 3X more dry-weight than in 56 % full sunlight, and 20X as much in 11 % full sunlight. The plants tend to produce larger leaves and fewer rhizomes and roots under shaded conditions. Burning can also be used to temporarily reduce the density of cogongrass (Figure 3). This practice, common in Africa, also stimulates the growth of tender young leaves for livestock forage. The mature cogongrass leaves are high in fiber and of low palatability (Holm et al. 1977).

The distribution and spread of these two grasses in the United States appears to be restricted by temperature. Johnsongrass is near its northern limit in Kansas. Throughout the world its distribution is between 55 N to 45 S latitude. Johnsongrass rhizomes are cold hardy to a limited extent. The optimum temperature for bud germination is 30 C and germination is suppressed at 15 C (Hull 1970). Hull (1970) also reported that an exposure to -3.5 C for 24 hours is lethal to johnsongrass rhizomes. Another study indicated that rhizomes in the field at a depth of 20 cm or more were still viable when the air

Figure 4. A cogongrass field a few days after burning.

temperature reached -17 C (Stroller 1977). Most of them however, were killed when the soil temperature reached -7 C. These studies indicated that this species exhibits freezing injury, which damages or kills the plants after exposure to temperatures below 0 C. This injury involves the formation of ice crystals inside the plant cells. Another type of injury is chilling injury, which takes place after exposure to temperatures above the freezing point (Levitt 1980). Low temperature exposure chills sensitive plants which causes a primary change in the cell membrane structure. This is followed by metabolic disorders, such as an imbalance between respiration and glycolysis (Lyons et al. 1979). Chilling injury can be observed in tropical and subtropical species. Cogongrass appears to exhibit this type of injury.

There have been very few studies of cold tolerance in cogongrass. Currently, this grass is confined to the southern areas of the United States (Holm et al. 1977). The purpose of this study was to determine the cold temperature limit of the cogongrass rhizomes and determine if the species can establish successfully in Kansas. Transportation of cattle from the southern states to Kansas feed lots may transport some seeds and rhizomes. If the species is cold hardy, it may establish and become a troublesome weed like johnsongrass.

MATERIALS AND METHODS

Growth conditions and rhizome productions

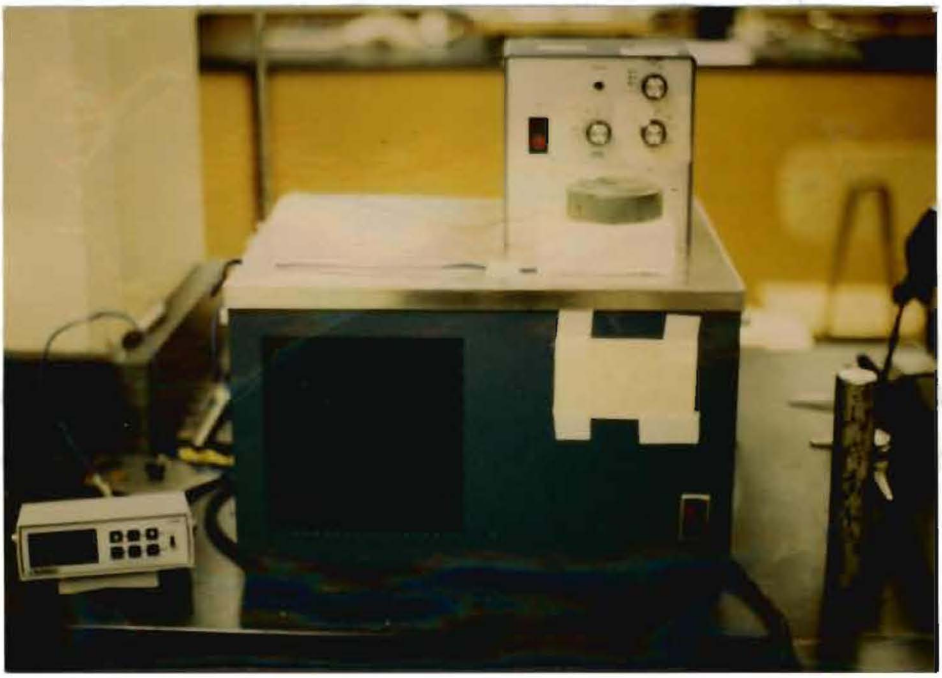
Cogongrass rhizomes, I. cylindrica (L.) Beauv. var. major, were obtained in Florida from Connie Carlson, a former Emporia State University student. The grass was planted in several pots containing Sphagnum peat moss-based soil, a standard greenhouse mix. These pots were placed in a controlled environment chamber. This study was limited to greenhouse and growth chamber experiments. The plants were not allowed to produce seeds and were killed before disposal. The length of day and night was maintained at 13 and 11 hours respectively. The daytime and nighttime temperatures were set at approximately 30 C and 20 C respectively. These conditions simulated the optimum environment for its growth.

The cogongrass was left to grow and produce rhizomes in the growth chamber. Plants were watered with tap water every two days. The plants were also watered with 10 % KNO_3 twice a week. At the end of eight weeks, the first rhizomes were harvested from one of the pots. Harvesting then took place every two weeks. Twenty five to thirty cuttings, 5 to 7 cm long, were obtained during each two week interval. After rhizome removal, the remaining plants were repotted with new soil and returned to the growth chamber to produce additional rhizomes.

Cold hardiness testing

Cold hardiness testing was adopted from McLester et al. (1968). After each harvest, five pieces of the rhizomes were planted in the potting soil as the control. The remaining rhizomes were wrapped in a damp paper towel to avoid subjecting them to water stress. A Cu-Co thermocouple, connected to a digital thermometer (Omega, CL6503), was inserted into one of the rhizomes to monitor its temperature throughout the experiment. The prepared rhizomes were placed in a cylindrical metal container. The container, covered with a styrofoam lid, was immersed in a controlled temperature bath (Polytemp, 90T: Figure 5) containing a mixture of 50 % methanol and 50 % distilled water. Another Cu-Co thermocouple was immersed in the bath to measure its temperature throughout the experiment. Preceeding each experiment, the temperature was set at 25 C. The first two experiments were carried out to determine the approximate range of the cold tolerance of cogongrass. The temperature was lowered by 5 C every two hours from 25 to 15, 10, 5, 0 and -4 C. Rhizome samples were removed from the bath after treatment at 25, 10, 0 and -4 C. The remaining experiments used the same range of temperatures, but four or five rhizome samples were removed from the bath at the end of every two hours. In addition to these temperature treatments, some of the rhizomes were subjected to 4, 3 and 2 C. At the end of every two hours, one rhizome from each temperature treatment was sliced longitudinally and immersed in a 1 % Triphenyltetrazolium chloride (TTC) solution. TTC solution was used to detect dehydrogenase activity. In the presence of this enzyme, TTC solution will be reduced to an insoluble red formazan by the H^+ released (Robert 1953; Smith 1951). Any development of reddish coloration on the rhizomes sections after two hours indicated viability. Prolonged exposure to TTC solution, i.e. over two hours, will give a false positive result due to bacterial activities. This test, however, was only used to verify the more positive and accurate method described below. The actual viability determination was

Figure 5. Apparatus for the cold hardiness determination.



accomplished by planting the remaining rhizomes in potting soil. These pots were placed in the growth chamber and watered every two days using tap water and 10 % KNO_3. The number of rhizomes that sprouted each day was recorded. At the end of five to six weeks all viable rhizomes were killed by placing them in hot water.

Cold hardiness in johnsongrass

Similar procedures were used to determine the cold hardiness of johnsongrass rhizomes, *S. halapense* L.. Fresh rhizomes were collected from an abandoned field north of the Emporia State University, a day before the experiment. The rhizomes were cleaned and sized to 5 to 7 cm. The same apparatus and methods described above were used on johnsongrass, but the temperature treatment was lowered to -5 C. Tap water and 10 % KNO_3 were used to water the rhizomes. Viability was determined in the same way as cogongrass. In addition to these procedures, the air and the soil temperatures were recorded during the rhizome collection. The experiment was carried out from June, 1987 to February, 1988.

RESULTS

Cogongrass

Cogongrass rhizomes were first harvested and tested on April 3, 1988, about seven weeks after planting. The remaining harvests and temperature tests were made on April 17, May 2, 23 and June 13. Some of the rhizomes were subjected to TTC test (Triphenyltetrazolium chloride) following the temperature treatments. The results were observed after one to two hours. Cogongrass rhizomes did not stain as well as johnsongrass rhizomes. The remaining rhizomes were planted and frequently monitored for sprouting. The earliest any sprout emmerged was four days after planting. Most of the rhizomes were left in the potting soil for four weeks before being discarded. The percent survival and the average temperature treatments are given in Tables 3 and 5. Cogongrass had the highest survival percentage of 44.44 at 15 C. The lowest tolerable temperature treatment was 5 C with only a 25.00 % survival rate. The rhizomes were killed after exposure to 4 C or lower. The average rhizome diameter was 0.3 cm which was small when compared to that of johnsongrass (Figure 6).

Johnsongrass

Johnsongrass rhizomes were collected directly from the field prior to the cold temperature treatment. Collections were made from September 2, 1987 to February 9, 1988. Air and soil temperatures were recorded on November 22, 29, December 13, 24, January 5, 15, and February 9, during the rhizome collection. Soil temperatures were recorded at a depth of 6 cm. The coldest soil temperature recorded was -1.7 C, when the air temperature was -7.8 C. The soil surface was usually frozen during this period. Johnsongrass rhizomes were considerably larger than those of cogongrass, averaging 0.75 to 1.00 cm in diameter. The rhizomes were also more rigid and hard. The results of the TTC test are given in Table 4. The staining period for johnsongrass rhizomes was slightly faster than the cogongrass. These rhizomes showed a higher viability percentages (Table 6) compared to cogongrass rhizomes (Table 5). Most of the rhizomes survived the temperature treatment of -3 C. During the period of November 22 to February 9, some rhizomes survived the treatment of -4 C. Sprouting of the rhizomes appeared as early as three days after planting.

Figure 6. Comparison of *Imperata cylindrica* and *Sorghum halapense* rhizomes.


CAROLINA BIOLOGICAL SUPPLY CO.
Johnsongrass
Speargrass (cogongrass)

Table 3. The average bath and rhizome temperatures of the Imperata cylindrica experiment.

T	n*	Temperature, C (± 0.2)		Triphenyl-tetrazolium chloride test
		bath	rhizomes	
25	4	23.8	24.3	+
15	3	15.7	16.1	+
10	3	11.3	12.1	+
5	5	5.4	5.4	+
4	2	4.1	4.2	+
3	1	3.2	3.4	-
2	5	2.1	2.9	-
0	3	0.0	1.7	-
-4	1	-4.2	-4.1	-

* number of replicates

Table 4. The average bath and rhizomes temperatures of the Sorghum halapense experiment.

T	n*	Temperature, C (± 0.2)		Triphenyl-tetrazolium chloride test
		bath	rhizomes	
25	3	25.1	24.6	+
15	3	14.9	15.2	+
5	4	4.9	5.5	+
0	2	-0.1	1.3	+
-3	5	-3.0	-2.1	+
-4	4	4.0	-2.6	+/-*
-5	5	-5.0	-3.8	-
-8	3	-7.8	-5.6	-
-10	2	-10.2	-9.1	-

* red coloration developed after two hours and rhizomes taken after late October were positive to TTC test
n = number of replicates

Table 5. The viability of the Imperata cylindrica rhizomes after the temperature treatments.

T	n*	No. of rhizomes		% survived (± SE)*
		planted	survived	
Control	4	17	10	58.82 (5.11)
25	4	21	8	38.10 (3.48)
15	3	18	8	44.44 (7.01)
10	3	12	4	33.33 (11.59)
5	5	28	7	25.00 (5.50)
4	2	6	0	0.00
3	1	5	0	0.00
2	5	23	0	0.00
0	3	11	0	0.00
-4	1	5	0	0.00

* n = number of replicates
SE = standard error

Table 6. The viability of the Sorghum halapense rhizomes after the temperature treatments.

T	n*	No. of rhizomes		% survived (± SE)*
		planted	survived	
Control	4	25	18	72.00 (9.41)
25	3	20	16	80.00 (5.24)
15	3	16	13	81.25 (7.91)
5	4	21	17	80.95 (1.97)
0	2	10	8	80.00
-3	5	32	27	84.38 (5.73)
-4	4	33	14 **	42.42 (8.28) **
-5	5	32	2	6.25 (2.74)
-8	3	10	0	0.00
-10	2	7	0	0.00

* n = number of replicates
SE = standard error
** all from rhizomes collected after October 17, 1987

Figure 7. Viability of the *Imperata cylindrica* rhizomes after the temperature treatments. Vertical bars are standard errors.

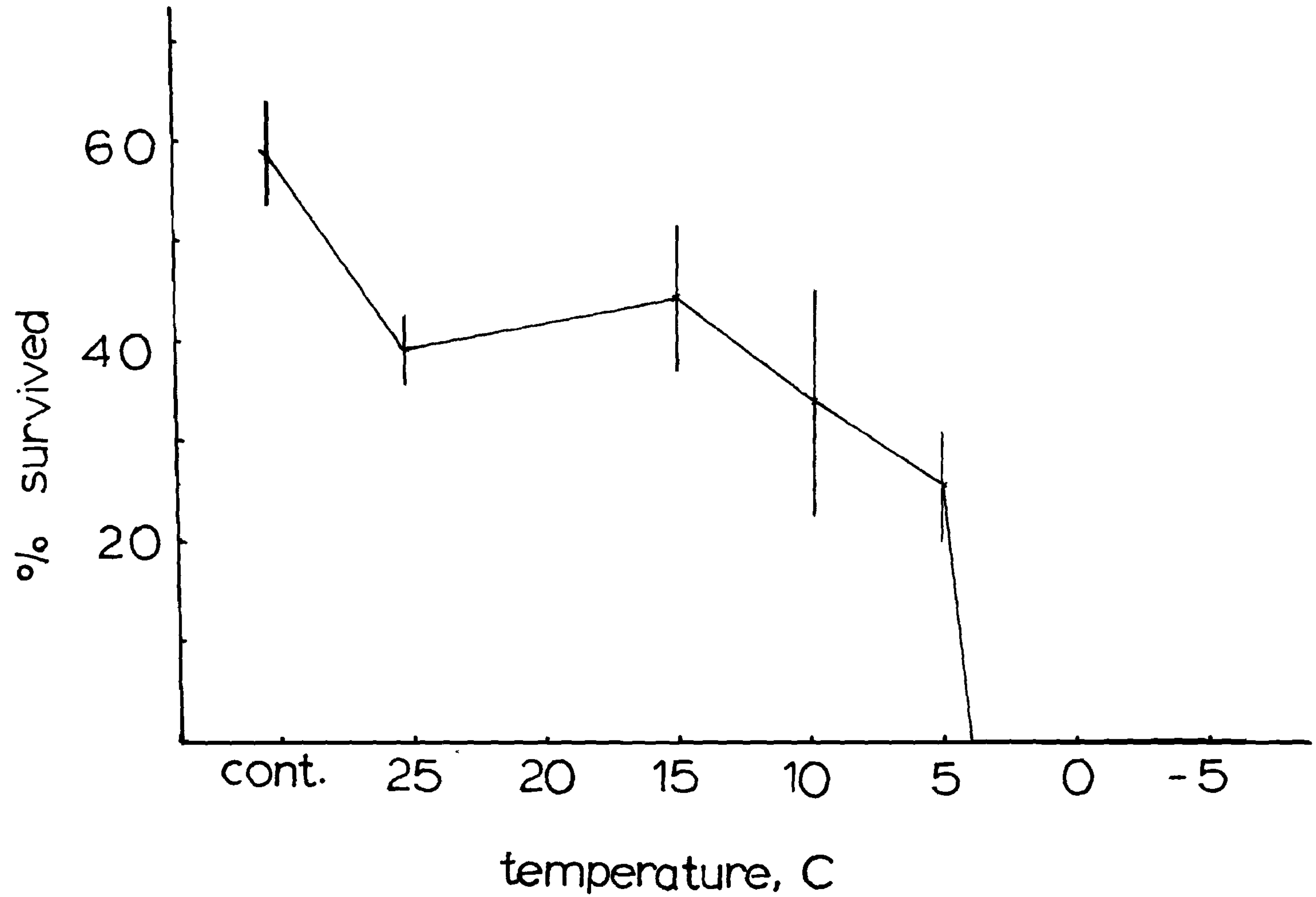
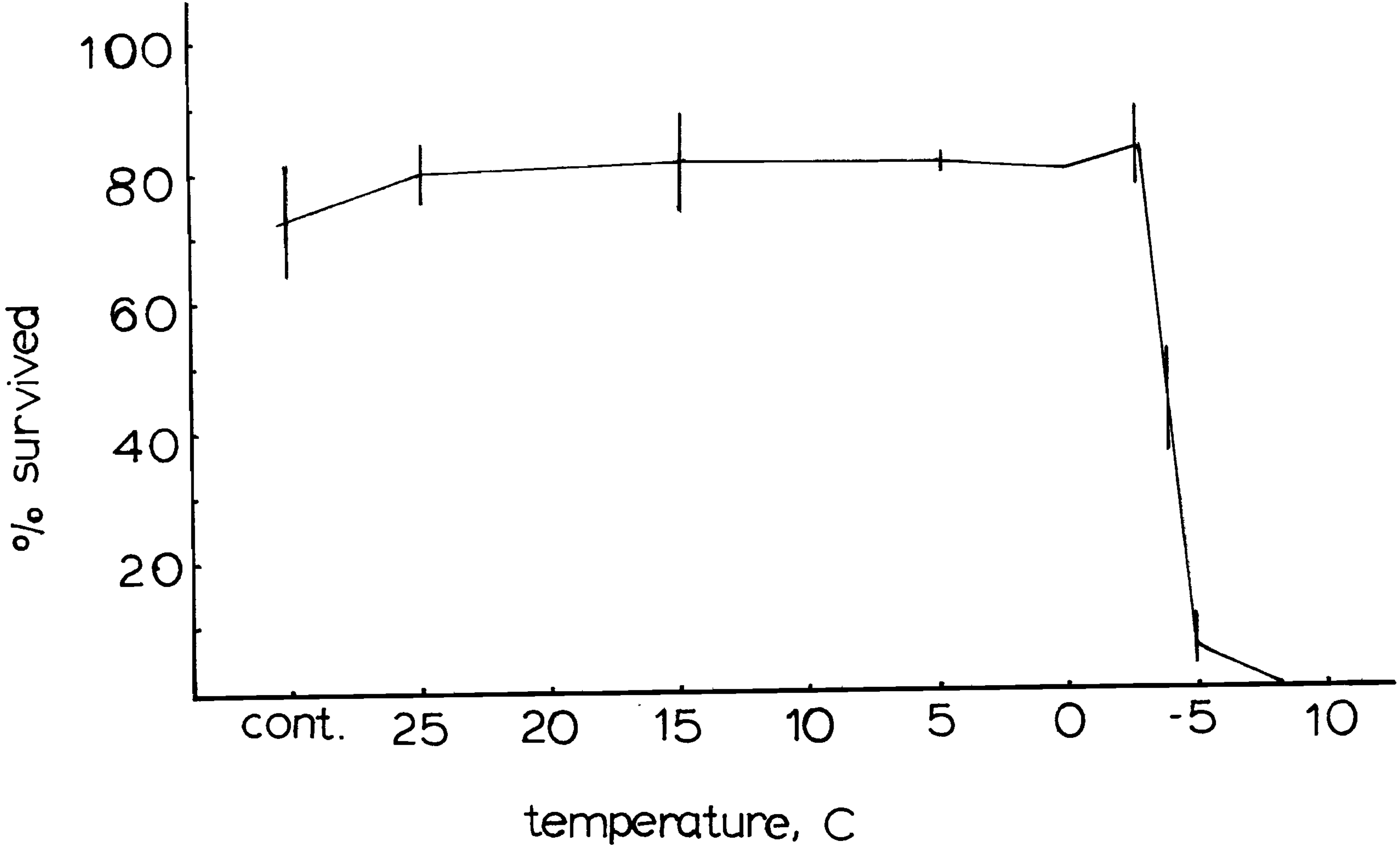

60
40
20
% survived
cont.
25
20
15
10
5
0
-5
temperature, C

Figure 8. Viability of the _Sorghum halapense_ rhizomes after the temperature treatments. Vertical bars are standard errors.


100
80
60
40
20
% survived
cont.
25
20
15
10
5
0
-5
10
temperature, C

CONCLUSIONS

Cogongrass, unlike johnsongrass, does not exhibit sufficient cold tolerance to survive the winter soil temperatures in Kansas (Table 7). The study indicated that this species exhibits chilling injury, i.e. damage at low but not freezing temperatures, whereas johnsongrass exhibits freezing injury and some acclimation to fall-winter conditions. Cogongrass has a distribution similar to that of bermudagrass, Cynodon dactylon (L) Pers., (Table 1), which is listed as the second worst weed in the world (Holm et al. 1977). This grass is also chilling sensitive and is effectively controlled by the cold winter temperature. An example of a very cold hardy species is quackgrass, Agropyron repens (L) Beauv.. This taxon is a principal weed of corn and other cereals and is causing problems in northern United States, Alaska, Soviet Union and Europe. Like johnsongrass, this species exhibits freezing injury when exposed to extreme temperatures. Its rhizomes can be killed by freezing and thawing. Rhizomes from cogongrass were killed after exposure to bath temperature of 4 C (Tables 3 and 5, and Figure 7). The rhizomes have a low overall germination percentage (Table 5) as compared to johnsongrass (Table 6). In the control experiment, less than 60 % of the rhizomes emerged. At 5 C, the lowest surviving temperature, only 25 % of the rhizomes survived. This may be due to the delicate young rhizomes used in the experiment. Ayeni and Duke (1985) found in their study that the regenerative ability of the rhizomes increased with age and weight.

Johnsongrass rhizomes survived laboratory induced temperatures to -3 C during the period from June to October. The survival rate at -3 C was 84.38 % (Table 6). In addition, the species exhibited a slight

Table 7. The average monthly temperatures for central Kansas in 1986 (Climatological Data, Kansas. Vol. 100. 1986).

Month	Temperature, C (± 0.2)			
	soil[1]	high[2]	low[2]	monthly lowest
Jan.	0.5	9.9	-6.5	-20.6
Feb.	4.4	6.6	-4.5	-25.0
Mar.	10.0	16.5	1.7	12.2
Apr.	15.0	20.9	7.1	-6.7
May.	18.9	24.1	12.6	-2.2
Jun.	24.4	30.7	18.8	8.8
Jul.	25.5	32.4	21.2	10.0
Aug.	24.4	28.7	17.6	6.1
Sep.	26.1	27.3	17.0	1.7
Oct.	13.9	19.1	8.8	-6.7
Nov.	5.8	9.8	-2.4	-23.3
Dec.	3.1	6.3	-3.6	-17.2

1 - recorded at 10.00 cm deep
daily variation was ± 1.5 C
variation between depth of 5.00 and 10.00 cm was ± 3.0 C
average temperature at 5.00 cm from Nov. to Feb. was 2.0 C
2 - monthly average (ambient temperature)

cold hardening as the winter progressed. In November and December, some of the rhizomes were able to survive the -4 C treatment (Table 3). Perhaps johnsongrass evolved adaptations to the colder temperatures. During the winter, the average temperature of Kansas soil at 5 cm deep was 2 C, with some ice formation on the surface. This indicated that a minimum of 2 C cold tolerance was necessary for winter survival. Hull (1970), found similar result with johnsongrass where the rhizomes were killed at -3.5 C. Stroller (1977), however, found slightly lower cold tolerance where rhizomes at 2 cm were still viable when the air temperature reached -17 C. Cogongrass, as observed in this study, did not exhibit this kind of cold tolerance. I found that the rhizomes were killed after exposure to 4 C, which indicates that this taxon is chilling sensitive. This agrees with the conclusion of a study by Willcut (1988). His study, however, is equivocal. He observed that some of the cogongrass rhizomes survived the winter in Alabama where the lowest soil temperature recorded was -4 C. Cogongrass was killed in Texas when the air temperature reached -28.9 C. Table 7 on page 53 (Willcut 1988), indicates the viability of the rhizomes of cogongrass, torpedograss and johnsongrass. It appears, from this table, that cogongrass and johnsongrass have similar cold tolerance limits. Both species were killed after exposure to -4 C. This indicates that cogongrass has the potential to survive winter temperatures in Kansas, and become a troublesome weed like johnsongrass in this temperature region. However, Willcut did not cool the experimental rhizomes in a stepwise manner as suggested in most cold hardiness determinations (Levitt 1980; McLeester et al. 1975). A stepwise cooling allows the specimen to undergo certain chemical changes which adapts it to survive cooler temperatures. He also lacked precise control of the micro-environment where the rhizome temperatures were recorded.

My study, a strict greenhouse and growth chamber experiment, indicated that cogongrass is not likely to become a weedy species, like johnsongrass, in Kansas. Unlike Willcut's study, cogongrass and johnsongrass were found to be of unequal hardiness. However, cogongrass might be able to establish and grow in Kansas like barnyardgrass or bermudagrass (Table 1), which are among the most serious weed in the world, but not in Kansas. The normal soil temperature in Kansas over the winter, averaging 3.45 C at 10.00 cm deep (Table 7), will kill most of the rhizomes and only those that are deeply buried will survive. In this study, the rhizome size may have played an important role in the cold tolerance of the cogongrass rhizomes. Johnsongrass has larger rhizomes (Table 2 and Figure 3) with a thicker and harder cuticle which allows more energy storage and better protection. It also produces more rhizomes per hectare than cogongrass. Furthermore, cogongrass is not as competitive as johnsongrass (Willcut et al. 1988). He reported a 16 % reduction in bermudagrass yield occurred when grown with cogongrass whereas 40 % reduction was observed with johnsongrass.

A closely related species to cogongrass, Brazilian satintail, <u>Imperata brasiliensis</u> Trin., which is found in Louisiana, posses a threat of interspecific hybridization. If this occurred, a hybrid that is more cold tolerance and vigorous might be produced (Willcut et al. 1988). Another concern is that if the greenhouse effect does result in warmer temperatures, cogongrass and other tropical and subtropical weedy species (Table 1) might become pests in Kansas.

Johnsongrass, along with other species, could also extend its range northward. A consequense of the greenhouse effect could be an altered, for the worse, weed flora. I. cylindrica L., for the moment, does not appear to pose a threat to farmers in the Mid-West.

SUMMARY

Cogongrass and johnsongrass are among the most serious weeds in the world. Both of these grasses cause great losses in field crops and plantations. Cogongrass is a major weed in the tropical and subtropical areas, especially in rubber tree and oil palm plantations. Currently, this species is causing problems in the southern United States. Johnsongrass is a vigorous, well established and troublesome weed in Kansas and most parts of the southern United States.

Unlike johnsongrass, cogongrass was found to be very sensitive to cold temperature. Cogongrass rhizomes have a tolerance limit of only 5 C, and were killed at 4 C, whereas johnsongrass has -3 C. Johnsongrass also appeared to exhibit some cold hardening during the winter months, where its rhizomes were still viable after the -4 C treatment.

The cold tolerance limit of the cogongrass rhizomes indicated that it cannot establish in Kansas as a weedy species. The low soil temperature during the winter, averaging 2 C at 3 cm deep, will kill cogongrass rhizomes. This temperature, however, is not cold enough to kill johnsongrass rhizomes.

Hybridization of cogongrass with its close relative, *I. brasiliensis* could produce a more cold hardy plant. If the warming trend from the greenhouse effect results in a significant increase in the temperature, cogongrass and other tropical species may be able to extend their distributions northward.

If cogongrass was introduced into Kansas, it might establish populations of low vigor like bermudagrass or barnyardgrass but probably would not become a competitive weed.

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