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Sugarcane seed response to 2,4-D and alternative herbicides for red morningglory (Ipomoea coccinea L.) control

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SUGARCANE SEED RESPONSE TO 2,4-D AND ALTERNATIVE HERBICIDES FOR RED MORNINGGLORY (*IPOMOEA COCCINEA* L.) CONTROL

A Thesis

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ABSTRACT

Field studies conducted over two growing seasons evaluated the effect of 2,4-D applied at 1.6 kg ai/ha to LCP 85-384 sugarcane (*Saccharum* interspecific hybrid) 7, 5, 3, and 1 wk before planting (WBP). Sugarcane was planted in mid-September using both whole stalk and billet (45 cm) seed pieces. When 2,4-D was applied 5 wk or closer to planting, sugarcane shoot emergence and population averaged across planting methods was reduced 5, 7, and 28 wk after planting (WAP) when compared to the nontreated control. Sugarcane height in one of two years was reduced when 2,4-D was applied 5 wk or closer to harvest of sugarcane for seed and sugarcane and sugar yield were reduced around 11% when compared with the nontreated control. For LCP 85-384 a 7 wk period should be allowed between 2,4-D application and harvest for seed when planted using whole stalks or billets.

In field studies complete control of red morningglory (*Ipomoea coccinea* L.) 30 and 60 cm in height was obtained 14 or 21 days after treatment (DAT) over two years with 2,4-D at 0.53 kg/ha, 2,4-D at 0.4 kg/ha or more plus dicamba, atrazine at 2.23 kg ai/ha, flumioxazin at 0.10 kg ai/ha, sulfentrazone at 0.35 kg ai/ha, and V10064 at 1.75 kg ai/ha. Red morningglory 1.8 m tall was controlled 100% 28 DAT the first year with 2,4-D at 1.06 kg/ha and 78% the second year. In the second year when herbicides were applied three weeks earlier than the previous year and when weed growth was more vigorous, the 2,4-D plus the 2,4-D and dicamba premix at 0.79 + 0.1 / 0.04 kg/ha provided control greater than that of 2,4-D alone at 1.06 kg/ha, but was the only treatment that included dicamba to control red morningglory equal to that of 2,4-D at 1.59 kg/ha (87%). Directed applications to the lower 45 cm of 1.8 m red morningglory plants with

atrazine at 4.47 kg/ha, sulfentrazone at 0.35 kg/ha, and V10064 at 1.75 kg/ha the first year controlled weeds at least 96%, but control was 23 to 30 percentage points less the second year.

CHAPTER 1

LITERATURE REVIEW

In 2001, 773 Louisiana sugarcane (*Saccharum* interspecific hybrids) producers grew approximately 200,000 hectares of sugarcane with an average sugar yield of 7,666 kg/ha (Anonymous 2001b). Based on these statistics Louisiana ranks as the number one sugar producing state in the United States.

Weeds are a major factor limiting production of sugarcane in Louisiana. In a typical production system preemergence herbicides are applied in March and April around the same time that sugarcane starts to emerge from the winter dormant period. Herbicides applied in the "Spring" help to prevent weeds from competing with the developing crop. In May following fertilizer application the sugarcane row middles are cultivated and a preemergence herbicide is applied broadcast. The goal of this layby herbicide application is to keep the crop free from weed competition until harvest.

Atrazine is widely used to control morningglories in Louisiana sugarcane at layby but control failures are common. This is primarily due to the long period of time between atrazine application and sugarcane harvest (at least three months). Red morningglory (*Ipomoea coccinea* L.) is one of the more common and problematic morningglory species found in Louisiana sugarcane fields. In a multi-year study atrazine controlled red morningglory 71 to 83% 45 days after application (DAT) (Viator et al 2002b). Millhollon (1988) reported sugar reductions as high as 30% from morningglory competition.

In addition to losses from competition, morningglories also climb and wrap sugarcane stalks, which can cause lodging and reduce both the number of harvestable stalks removed from the field and the efficiency of mechanical harvesters. Many producers are forced to apply 2,4-D in late season to facilitate harvest. Griffin et al. (2000) reported that 2,4-D was highly effective on morningglory if the rate was matched to weed size. Currently recommended 2,4-D rates for morningglory control are 0.53 kg ai/ha for small plants in the 2 to 3 leaf stage and up to 1.59 kg/ha when plants have climbed the sugarcane stalks (Anonymous 2001a). However, 2,4-D application is restricted in some areas of Louisiana due to problems with off-target movement and injury to sensitive crops, particularly cotton (*Gossypium hirsutum* L.). During the 2001 growing season in Louisiana 8,100 – 10,120 hectares of cotton were injured by 2,4-D with the major problems occurring between May 22 and 28 (B.L. Legendre, personal communication). Because in many cases a single source of the 2,4-D could not be identified, a blanket restriction of 2,4-D use over much of central and south Louisiana was imposed for the 2002 growing season.

The Louisiana Department of Agriculture and Forestry's Office of Agricultural and Environmental Sciences has specified the restrictions and application regulations governing the use of 2,4-D and all products containing 2,4-D in document number LAC 7:XXIII.143. In summary, this document states that 2,4-D or any products containing 2,4-D can not be applied in the area of the state bordered by Hwy 165 on the west, Hwy 190 on the south, and Hwy 1 on the east (Allen, Avoyelles, Evangeline, Pointe Coupee, Rapides, and St. Landry parishes) between May 1 and August 15 except under the specific written authorization by the Assistant Commissioner of the Office of Agricultural and Environmental Sciences. For sugarcane growing areas that fall under this restriction, alternative control measures must be used to manage the morningglory problem. Since sugarcane is grown over such a wide geographic area of the state, the 2,4-D restriction did not apply to the majority of sugarcane growing parishes. In those areas, 2,4-D would remain as the standard treatment for late season control of morningglory. Even so, residential areas and municipalities are in many cases adjacent to sugarcane fields and the off-target movement issue with 2,4-D is still of great concern.

2,4-D, a phenoxy herbicide applied as a foliar treatment, has a half-life of 10 to 12 days under warm and moist soil conditions (Ahrens 1994). High soil organic matter, soil pH (neutral to slightly alkaline), high soil temperature, and soil moisture all tend to reduce persistence of 2,4-D (Erickson and Gault 1950). Once absorbed by foliage 2,4-D is translocated primarily symplastically to the growing points of the root and shoot. Robertson and Kirkwood (1969) reported that absorption of 2,4-D was strongly influenced by cuticle structure of the plant, humidity, light, temperature, herbicide formulation, spray pH, and surfactants. Wall et al. (1991) found that 65% of the 2,4-D applied to bean [*Silene vulgaris* (Moench) Garcke] was absorbed within 72 hours of treatment. Approximately 35% of the 2,4-D absorbed was translocated out of the leaf after 72 hours. Ashton (1958) reported that sugarcane plants absorbed 94.8% of the applied 2,4-D, compared to 83% absorption by bean (*Phaseolus vulgarus* L.) plants in the same experiment, and also documented slower translocation of 2,4-D in sugarcane plants when compared to bean. At the time of harvest, sugarcane leaves still contained 93.5% of the total 2,4-D in the plant, and virtually no 2,4-D was present in the meristematic tissue. It was proposed that tolerance of monocots to 2,4-D could be explained by the slower rate of translocation and the lower concentration in plant tissue.

The use of 2,4-D to control broadleaf weeds in grass crops is common. Even though grass crops are considered tolerant to 2,4-D, application particularly during the reproductive growth stages can result in excessive injury. The label for many 2,4-D products states that application should not be made to cereal grains in the boot to dough stages, to corn during the tassel to dough stages, or to sorghum during the boot, flowering, or dough stages (Ahrens 1994). The specific mode of action for 2,4-D is not completely understood, but like other auxin-type herbicides ethylene evolution is stimulated and uncontrolled growth ensues.

In Louisiana, due to photoperiod, sugarcane rarely flowers and remains in a vegetative state for the entire growing season. Unlike other grass crops the reproductive structures in sugarcane are of no economic importance when the crop is grown for sugar production and injury from 2,4-D would not be expected. Van Overbeek (1947) stated that it would require special conditions, which rarely exist in practical agriculture, to kill or even seriously damage a sugarcane plant with 2,4-D. Sugarcane is least sensitive to 2,4-D and that even young plants appear to be insensitive to 2,4-D at concentrations necessary to kill weeds. Nolla (1950) supported this contention by stating that sugarcane plants under two months of age could be sprayed “indiscrimately” with 2,4-D without injury. This protection from 2,4-D action in young sugarcane was attributed to the closely united leaf sheaths that act as a barrier against entrance of the herbicide solution into the regions of meristematic tissue. Although not yield limiting, bronzing and reddening of midribs, and bleaching or yellowing of the leaf blades were observed. Brown and Holdeman (1947) also observed similar sugarcane injury response to 2,4-D.

Havis (1953) reported that the 2,4-D amine formulation sprayed at rates of up to 1.1 kg ai/ha did not affect the growth of one-month-old sugarcane plants and rates of up to 4.5 kg/ha were safe for plants two months old. However, applications of the isopropyl ester formulation markedly reduced growth of one and two month old sugarcane. Reductions in growth did not occur until the second week after application, and the greatest effect was exhibited the third week after application. The weekly growth rate of the treated plants after the third week, however, was equal to that of nontreated plants and no yield reduction occurred. Richardson (1969) also documented early injury with 2,4-D applied postemergence on several varieties of sugarcane but growth measurements indicated that at normal rates of application yield was unlikely to be affected.

Later research showed a relationship between growth stage and 2,4-D injury (Richardson 1973). The more advanced the growth stage of the crop at the time of application the greater the height reduction and foliar damage observed. When 2,4-D was applied at the same growth stage, crop injury was slightly greater in the plant cane crop than in ratoon crop, however, no residual effects from previous 2,4-D applications were apparent in the subsequent ratoon crops. Rochecouste (1967) reported that plant cane can be very sensitive to 2,4-D injury during root initiation, which was attributed to enhanced 2,4-D uptake associated with the thinness of the cutin layer of the young leaves. The 2,4-D rates in research contributed by Richardson (1973) and Rochecouste (1967) were in excess of 3.4 kg/ha, much higher than present use rates in Louisiana sugarcane of 0.53 to 1.59 kg/ha.

Sugarcane, unlike other monocot crops, is clonally propagated by using the sugarcane stalks as planting material. Sugarcane bud germination is affected by bud position, soil moisture, temperature, pathogens, and variety (Anderson and Dusky 1985). Plant growth regulators such as 2,4-D reduce enzymatic activity affecting sucrose utilization, leaf cell growth, or apical dominance, all of which affect bud germination, tillering, and yield (Gascho et al. 1973). Anderson and Dusky (1985) stated that hormones such as auxins, gibberellins, cytokinins, and abcisic acid significantly delayed germination of sugarcane buds, although overall bud germination was still high. The application of hormones and plant growth regulators to buds can cause cessation or reduction in growth or development, but injury is concentration dependant (Hamphill 1984; Hanish-ten-Cate and Bruinsma 1973; Tromp 1972). The response of buds to auxins is essentially like that of stems, but with the optimum concentration being much lower (Leopold 1955). Auxins have a dual action on bud growth; small concentrations of auxin can promote bud growth whereas larger concentrations inhibit or entirely prevent it. Limited information is available on the effects of late season 2,4-D application on sugarcane bud germination.

Griffin et al. (1990) reported that 2,4-D application between 3 and 7 weeks prior to planting of seed stalks in October reduced stalk population the following spring an average of 23% across nine commercial varieties. This suggests that germination of buds can be affected if sufficient time is not allowed between 2,4-D application and harvest of sugarcane stalks for seed. Since in Louisiana approximately 25% of the acreage is planted each year the injury potential associated with 2,4-D has become a concern for producers.

Currently 84% of the sugarcane acreage in Louisiana is planted to the variety ‘LCP 85-384’. LCP 85-384 is an interspecific hybrid of *Saccharum officinarum* L. and its pedigree includes new germplasm developed by USDA-ARS at Houma, La. LCP 85-384 was selected by the LSU AgCenter sugarcane breeding program and cooperatively released with the USDA-ARS and American Sugar Cane League (Milligan et al. 1994). This cultivar produces very high populations of small diameter stalks and yield is consistently higher than the older standard varieties ‘CP 70-321’ and ‘CP 74-383’. Yields of LCP 85-384 generally increase in successive crops and the variety is known for ratooning longevity. The disadvantage of LCP 85-384 is that it is prone to lodging. Producers who set aside acreage specifically for seed may not be able to use that sugarcane due to lodging, wet field conditions, or other factors. Sugarcane that has been treated with 2,4-D may be the only option for quality seed.

The current recommendation by the Louisiana State University AgCenter is that 2,4-D should be applied no less than 7 weeks prior to harvest of sugarcane to be used for seed (Anonymous 2001a). This recommendation is based on research showing reduced sugarcane seed germination and emergence attributed to 2,4-D (Griffin et al. 1990). In the 18 years since this research was conducted cultural practices have changed. The nine varieties previously evaluated for the most part are no longer grown on significant acreage in the state. Planting no longer occurs in October and is usually completed by August or early September. Additionally, previous research evaluated traditional planting methods where whole stalks were placed in open furrows and covered with 15 cm of soil. Although whole stalks are still used for planting, recommended soil coverage with LCP 85-384 is no more than 10 cm (Anonymous 2001c). When using the whole stalk planting method not all buds germinate prior to the winter dormant period and it is common for buds to remain viable and to germinate the following spring (Anonymous

2001c). This can be advantageous when environmental conditions are detrimental to newly established plants.

Chopper harvesters have recently been adapted for use under Louisiana harvest conditions. These machines cut sugarcane stalks into billets (45 to 60 cm whole stalk sections). The chopper harvester offers the option for planting billets instead of whole stalks. Use of billets as seed results in more rapid emergence of sugarcane shoots compared with whole stalk planting with most buds on the billets germinating when soil moisture is adequate (B. Legendre, personal communication). The increase in germination and emergence observed with billets is attributed to the overriding of apical dominance when the stalks are sectioned. The advantages of the billet planting system (increased bud germination and initial shoot population), may, however, be offset by the possible injury to sugarcane seedlings exposed to cold temperature and wet seed beds during the winter months. The resulting reduced plant populations in the spring due to adverse weather conditions during winter in a billet planting system is often more severe than in a whole stalk planting system (Hoy et al. 2001). Both whole stalk and billet planting methods are used in commercial farming operations; personal preference and schedule flexibility usually determine which method is selected. If sugarcane emergence and response to stress can be attributed to planting method then it is feasible that planting method, with respect to how the plants are harvested, may also affect how sugarcane responds to late season 2,4-D application.

Apical dominance is defined as the control exerted by the shoot apex over the outgrowth of the lateral buds (Cline 1997). It is also referred to as “correlative inhibition” (Hillman 1984) or in the dormancy literature as “paradormancy”, a type of growth control involving a biochemical signal from another structure (Lang 1990). Embryonic lateral buds may have inhibition imposed upon them shortly after their formation or after a period of growth (Fahn 1990). However, after bud formation the dominance of the main apex is expressed in the inhibition of further development of the lateral apecies that remain axillary buds, often for long periods and sometimes permanently, unless the main apex is removed (Steeves and Sussex 1989). Although elongation of buds is inhibited they remain metabolically active. Apically derived auxin in shoots is generally thought to control apical dominance either directly via entry into lateral buds with subsequent repression of outgrowth or indirectly via some other mechanism such as activation of a second inhibitor messenger, auxin – cytokinin ratio, secondary growth substances, or nutrient diversion (Bangerth et al. 2000, Cline 1996, Martin 1987, Stafstrom 1995, Tamas 1995). The release of apical dominance is often repressed by auxin treatment of the decapitated stump just above the lateral bud, but soon after apical dominance has been released and lateral bud elongation is underway, the lateral bud may begin to produce its own auxin, which may enhance elongation (Thimann and Skoog 1934). Application of exogenous auxin to a decapitated plant is sufficient to impose growth inhibition on lateral buds (Tamas et al. 1989, Phillips 1975). The precise mechanism of auxin action in apical dominance has yet to be elucidated.

During sugarcane harvest, whether whole stalk or billet, the active growing point of the sugarcane plant is removed. However, when the stalks remain whole, rather than cut into billets, lateral bud germination is reduced. This could be attributed to "apical control", a response first observed in conifers, where upon removal of a plant's active growing point one of the remaining upper buds replaces it by bending more vertically and elongating. Ethylene, gibberellins, and auxins may play a role in this response (Lake et al. 1980). The difference in germination of lateral buds in whole stalk and billet harvested sugarcane could be attributed to the ability of plants to exhibit apical control; however, the majority of literature referencing this terminology dealt with woody perennial plants.

Morningglories are included in a list of the ten worst weeds in field crops (Houston 1970). In sugarcane production morningglories cause the most problem at harvest especially when the chopper harvester is used (Viator et al. 2002a). The first line of defense against this weed problem is the use of preemergence herbicides at layby just prior to canopy closure. If this treatment is ineffective, a late season aerial application of 2,4-D is used to control morningglory. However, in areas where 2,4-D application is restricted an adequate 2,4-D substitute must be found. Herbicides that do not contain 2,4-D, and that are labeled in sugarcane with postemergence activity on red morningglory are limited. Herbicides that are not labeled for a postemergence over-the-top application could be POST-directed underneath the sugarcane canopy. This method of application, however, would be an option only if the grower has a high clearance sprayer that would not damage the crop late in the season, and only if the sugarcane crop has not lodged. Although not commonly used for this purpose, atrazine and dicamba could legally be applied by air for late season red morningglory control. However, information is limited on their effectiveness on morningglory when applied in this manner. Dicamba is not a phenoxy herbicide but has the same general mode of action as does 2,4-D. Use of dicamba would not be restricted in certain areas of the sugarcane belt as is 2,4-D and all products containing 2,4-D. Another option in the areas where 2,4-D can be used is use of 2,4-D and dicamba combinations as well as alternative 2,4-D formulations.

This research was conducted to improve management of red morningglory in sugarcane using 2,4-D and alternative herbicides. Additionally, the effect of 2,4-D application to sugarcane used for seed on subsequent emergence, growth, and yield when planted using whole stalks and billets was investigated.

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CHAPTER 2

RESIDUAL EFFECT OF 2,4-D ON WHOLE STALK AND BILLET PLANTED SUGARCANE

Introduction

In Louisiana, sugarcane is grown as a perennial crop with three to five annual harvests from a single, vegetatively propagated planting. Preemergence herbicides are applied immediately following the initial planting usually in August or September, in March when sugarcane initiates growth following the winter dormant period, and after the final cultivation at layby in April or May. Herbicide application at layby is especially critical to keep the sugarcane crop free of weed competition until harvest. Following layby environmental conditions of high soil temperature and soil moisture are conducive to rapid herbicide degradation. Morningglories, in particular red morningglory (*Ipomoea coccinea* L.), are problematic in late season and can reduce harvest efficiency in addition to reducing yield through competition (Millhollon 1988). Atrazine is widely used in Louisiana at layby and morningglory control is inconsistent (Viator et al. 2002). In order to manage this weed, a late season aerial application of the phenoxy herbicide 2,4-D is often made.

Once absorbed by the plant foliage 2,4-D is translocated primarily symplastically and moves to the growing points of the root and shoot. The mode of action is not completely understood, but is similar to other auxin-type herbicides where ethylene evolution is stimulated and uncontrolled growth ensues (Ahrens 1994). Since monocots can tolerate 2,4-D application, the herbicide is used for broadleaf weed control in many grass crops. Grass crops are generally considered tolerant to 2,4-D, but application during certain growth stages, particularly the reproductive stages, can cause excessive injury. Unlike other grass crops where seeds are harvested, the sugarcane stalk is crushed and sucrose is extracted. Therefore, the reproductive structures of sugarcane are of no economic importance and injury from 2,4-D should not be expected (Nolla 1950; Van Overbeek 1947).

Sugarcane, unlike other monocot crops, is clonally propagated with the use of sugarcane stalks as planting material. Sugarcane bud germination is affected by bud position, soil moisture, temperature, pathogens, and variety (Anderson and Dusky 1985). Plant growth regulators such as 2,4-D reduce enzymatic activity affecting sucrose utilization, leaf cell growth, or apical dominance, all which affect sugarcane bud germination, tillering, and yield (Gascho et al. 1973). Auxins have a dual action on bud growth, small amounts can promote bud growth whereas larger amounts are inhibitory (Leopold 1955). The application of hormones and plant growth regulators to buds can cause cessation or reduction in growth or development, but injury is concentration dependant (Hamphill 1984; Hanish-ten-Cate and Bruinsma 1973; Tromp 1972). Anderson and Dusky (1985) stated that hormones such as auxins, gibberellins, cytokinins, and abcisic acid significantly delay germination of sugarcane buds, although overall germination was still high.

Griffin et al. (1990) reported that 2,4-D application between 3 and 7 weeks prior to planting of sugarcane stalks as seed in October reduced sugarcane shoot population the following spring an average of 23% for nine commercial varieties. This suggests that germination of buds can be affected if sufficient time is not allowed between 2,4-D application and planting. In the 18 years since this study was conducted cultural practices in Louisiana have changed. The sugarcane variety LCP 85-384, an interspecific hybrid of *Saccharum officinarum* L. (Milligan et al. 1994), was released to growers in 1993 and in 2002 occupied 84% of the over 200,000 hectares of sugarcane grown in the state. Planting is now completed by September rather than October due to lodging problems with LCP 85-384; and planted sugarcane is covered with no more than 10 cm of soil. The recent introduction of the chopper harvester that cuts sugarcane stalks into billets (sectioned stalks) allows mechanical planting of billet seed pieces (45 to 60 cm) rather than whole stalks.

During sugarcane harvest, whether whole stalk or billet, the active growing point of the sugarcane plant is removed. However, when stalks remain whole rather than cut into billets lateral bud germination is reduced (B. Legendre, personal communication). Use of billets as seed compared with whole stalks has resulted in more rapid emergence of sugarcane shoots with most buds germinating when soil moisture is adequate. This increase in germination with billets can be attributed to the overriding of apical dominance when the stalks are sectioned (Cline 1997). Although the precise mechanism of auxin action in apical dominance has yet to be elucidated, ethylene, gibberellins, and auxins may play a role in this response (Lake et al. 1980). Therefore, it may be possible that planting method (with respect to how the sugarcane stalks are harvested) may also affect how sugarcane responds to late season 2,4-D application.

The potential injury from a late-season 2,4-D application is of concern to producers who may have no option other than to use sugarcane treated with 2,4-D as a seed source. The objective of this research was to evaluate the possible residual effect of 2,4-D on sugarcane bud germination, shoot emergence, and subsequent yield when using whole stalk and billet planting systems.

Materials and Methods

Field Study. Experiments were conducted during the 2000 – 2001 and 2001 – 2002 growing seasons at the St. Gabriel Sugar Research Station in St. Gabriel, LA. 2,4-D was applied at the rate of 1.6 kg ai/ha using a CO_2 backpack sprayer calibrated to deliver 30 L/ha at 220 kPa. A spray boom equipped with a TK-5[1] flood tip that extended above the sugarcane canopy was used to simulate a late season postemergence over-the-top application. The initial application of 2,4-D was made to a first ratoon crop of LCP 85-384 sugarcane on July 25, 2000, and July 31, 2001. This application corresponded to 7 wk before planting (WBP) and applications using the same sprayer were repeated each year corresponding to 5, 3, and 1 WBP with the last application made on September 5, 2000, and September 11, 2001. A nontreated control was included as well.

The experimental area to be planted was worked and rows were opened to allow for stalks to be placed in the open furrow. One week after the final application (September 12, 2000 and September 18, 2001) whole stalks from 2,4-D treated and nontreated areas were hand harvested and hand planted at a constant seeding rate of two stalks with a three node overlap. To simulate billet planting, whole stalks were cut into 45 cm pieces while lying in the open row. This procedure was used to assure that the seeding rate was constant for both planting methods and that any differences in germination and emergence could be attributed to planting method rather than seeding rate. Sugarcane stalks were covered with 8 to 10 cm of soil and the row was packed twice. A split-plot experimental design with 5 replications was used. Whole plots consisted of planting method (whole stalk or billet) and sub-plots consisted of 2,4-D

[1] Teejet Spraying Systems Company, North Avenue, Wheaton, IL 60189-7900.

application timings (7, 5, 3, 1, WBP and no 2,4-D). Plot size was 90 m by 1.8 m (1 sugarcane row) for whole plots and sub plots were 18 m by 1.8 m.

The entire experimental area was maintained weed-free and standard sugarcane management practices were followed. Sugarcane shoot population was recorded 3, 5, 7, and 28 wk after planting (WAP) and height was recorded by measuring from the soil line to the last visible collar at 37 and 43 WAP. In September, a year following planting (52 WAP), sugarcane stalk population was determined by counting all millable stalks (stalks at least 1.2 m to the terminal node) per plot. Stalk height 52 WAP was determined by measuring the height to the terminal node of ten millable stalks per plot. Plots were harvested on November 11, 2001, and October 24, 2002, using a commercial single row chopper harvester[2] and a dump wagon fitted with three weigh cells capable of being tarred between plots to determine total yield. Prior to harvesting, samples of 10 randomly selected stalks from each plot were weighed to determine average stalk weight. Samples were then crushed, and the juice was extracted for analysis of sugar concentration[3] using standard methodology (Chen and Chou 1993). Sugar yield was calculated by multiplying TRS by sugarcane yield.

Data were subjected to analysis of variance with partitioning for a two (planting method) by five (2,4-D application timing) factorial treatment arrangement. Tables were constructed according to the interactions, and mean separation was conducted using Fisher's Protected LSD at P = 0.05.

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[2] Cameco Industries, Inc., P.O. Box 968, Thibodeaux, LA 70301.

[3] Sugar content of stalks derived from theoretical recoverable sugar (TRS) expressed as kilograms of sugar per 1,000 kilograms of sugarcane.

Greenhouse Study. Experiments were initiated in the greenhouse on September 4, 2001 and September 17, 2001, to evaluate germination and emergence of 2,4-D treated sugarcane.

The same field of first stubble LCP 85-384 sugarcane that had been treated with 2,4-D at 7, 5, 3, and 1 week before harvest was used and fifteen stalk samples were collected from each of the treated areas along with a nontreated control. Leaf tissue was removed and stalks were sectioned with approximately 5 cm of internode above and below each node. The seed pieces were surface sterilized in a 0.125% solution of Benlate 50 SP[4] for 6 minutes to reduce pathogen infection and rinsed in deionized water. Sugarcane seed pieces were inspected for exterior harvest or insect damage and damaged seed pieces discarded. Eight seed pieces from each 2,4-D treatment and a nontreated were selected at random and placed in an individual cell of a styrofoam germination tray[5] (32 cells / tray, cell size 7.62 cm square) with the apex of the bud pointing up. Plantings were arranged in a randomized complete block design with four replications. Seed pieces were covered with a greenhouse soil mixture containing 50% Commerce silt loam and 50% commercial potting medium[6]. Trays were watered twice a day and plants were grown under natural sunlight supplemented by metal-halide lights (650 $\mu mol/m^2/s$ photosynthetic photon flux density) for a 14-h photoperiod with an average air temperature of 34 C.

[4] Benomyl, Benlate SP. DuPont Agricultural Products. Walker's Mill, Barley Mill Plaza; Wilmington, DE 19898.

[5] Speedling Planter Flats; , Hummert International, 4500 Earth City Expressway, Earth City, MO 63045.

[6] Jiffy-Mix Plus. Jiffy Products of America, Inc. Batavia, IL 60510.

Shoot emergence and height were recorded 2, 4, and 6 WAP. Data were subjected to analysis of variance and means were separated using Fisher's Protected LSD at P = 0.05.

Results and Discussion

Field Study. Analysis of variance indicated that there were no significant planting method by 2,4-D application timing interactions for any of the parameters measured in either growing season. However, there were significant differences attributed to each factor.

At 3 WAP in 2000 when averaged across 2,4-D application timings, sugarcane shoot population was 1,760 more shoots/ha for billet planted sugarcane compared with whole stalk (Table 2.1). This advantage to billet planting was also observed in 2001 but difference in shoot population between planting methods was 3.8 times greater when compared with the previous year. A year by planting method interaction was not observed for sugarcane shoot population 5, 7, or 28 WAP and shoot population was 1.3 to 2 times greater when sugarcane was billet planted. This response held true a year after planting (52 WAP) when 7,350 more millable stalks/ha were present in the billet planted treatment compared with whole stalk.

In 2000 at 3 WAP, 2,4-D application did not affect sugarcane shoot emergence when averaged across planting methods (Table 2.2). However, in 2001, shoot population 3 WAP in plots not treated with 2,4-D was greater when compared with the 2,4-D timings except the 3 WBP application. The same response was also observed at 5 and 7 WAP. An explanation as to why the 3 WBP 2,4-D application was not detrimental to shoot emergence compared with no 2,4-D but yet shoot emergence was reduced when

Table 2.1. Sugarcane shoot population as influenced by whole stalk and billet planting methods[a].

Planting method	3 WAP[b] 2000	3 WAP[b] 2001	5 WAP[c]	7 WAP[c]	28 WAP[c]	52 WAP[c]
	no. shoots or stalks / ha					
Whole stalk	420b[d]	5,700b	14,380b	20,180b	44,560b	91,030b
Billet	2,180a	12,410a	28,750a	34,120a	56,580a	98,380a

[a]Experiments planted September 10, 2000, and September 18, 2001, at St. Gabriel Sugar Research Station, St. Gabriel, LA. Data averaged across timing treatments of no 2,4-D and 2,4-D applied 7, 5, 3, and 1 week before planting.

[b]Abbreviation: WAP = weeks after planting.

[c]Data averaged over years.

[d]Means within each column followed by the same letter are not significantly different using Fisher's Protected LSD at P=0.05.

Table 2.2. Sugarcane shoot population as influenced by 2,4-D application timing[a].

2,4-D application timing	3 WAP[b] 2000	3 WAP[b] 2001	5 WAP[c]	7 WAP[c]	28 WAP[c]	52WAP[c]
	no. shoots or stalks/ ha					
No 2,4-D	1,760	11,520	24,560	29,450	56,090	97,960
7 WBP[d]	1,130	7,860	20,320	26,950	49,610	94,610
5 WBP	740	7,200	19,780	25,240	47,730	92,420
3 WBP	1,340	10,660	22,640	28,950	50,310	95,370
1 WBP	1,520	8,010	20,540	25,170	49,110	93,150
LSD (0.05)	NS	2,980	2,450	2,740	3,920	NS

[a]Experiments planted September 10, 2000, and September 18, 2001, at St. Gabriel Sugar Research Station, St. Gabriel, LA. Data averaged across whole stalk and billet planting methods.

[b]Abbreviation: WAP = weeks after planting.

[c]Data averaged over years.

[d]Abbreviation: WBP = weeks before planting.

2,4-D was applied at 1 or 5 WBP is not apparent. It may be just an anomaly related to variability in germination of buds and shoot emergence that can occur in response to soil moisture and temperature. At 28 WAP, 2,4-D application reduced sugarcane shoot population regardless of timing when compared with no 2,4-D by at least 10.3%. A year after planting (52 WAP) there were no differences in millable stalks per hectare whether or not 2,4-D was applied to sugarcane prior to harvest for seed, indicating that sugarcane was able to compensate from the early season injury.

Sugarcane height averaged across 2,4-D timings was equivalent for whole stalk and billet planted sugarcane at 37 and 52 WAP, but sugarcane planted using billets was 4% taller than whole stalk plantings 43 WAP (Table 2.3). In 2001, sugarcane height averaged across planting methods was reduced 37 WAP when 2,4-D was applied 5 weeks or closer to planting when compared with the nontreated (Table 2.4). When 2,4-D was applied 7 WBP height was equal to the nontreated. In 2002 at 37 WAP, 2,4-D did not affect plant height. Sugarcane height was reduced at least 5.3% 43 WAP with 2,4-D application at 5, 3, and 1 WBP compared with the nontreated, but this response did not occur with the 7 WBP application. The same response was observed 52 WAP in 2001, but there was no significant height differences among herbicide treatments 52 WAP in 2002.

As noted for the other parameters, both planting method and 2,4-D application timing affected sugarcane and sugar yield. When sugarcane was billet planted, sugarcane and sugar yield in 2001 was approximately 18% greater when compared with whole stalk planting (Table 2.5). However, in 2002 sugarcane and sugar yield were equal regardless of planting method. Sugarcane and sugar yield response to 2,4-D application timing

Table 2.3. Sugarcane height as influenced by whole stalk and billet planting methods[a].

Planting method	37 WAP[b]	43 WAP	52 WAP
		cm	
Whole stalk	81a[c]	124b	260a
Billet	82a	129a	259a

[a]Experiments planted September 10, 2000, and September 18, 2001, at St. Gabriel Sugar Research Station, St. Gabriel, LA. Data averaged across timing treatments of no 2,4-D and 2,4-D applied 7, 5, 3, and 1 week before planting.

[b]Data averaged over years. Abbreviation: WAP = weeks after planting.

[c]Means within each column followed by the same letter are not significantly different using Fisher's Protected LSD at P=0.05.

Table 2.4. Sugarcane height as influenced by 2,4-D application timing[a].

2,4-D application. timing	37 WAP[b] 2001	37 WAP[b] 2002	43 WAP[c]	52 WAP[b] 2001	52 WAP[b] 2002
	cm				
No 2,4-D	124	43	133	267	259
7 WBP[d]	124	41	128	267	257
5 WBP	112	43	121	254	257
3 WBP	117	43	126	259	254
1 WBP	117	43	124	259	262
LSD (0.05)	7	NS	7	7	NS

[a]Experiments planted September 10, 2000, and September 18, 2001, at St. Gabriel Sugar Research Station, St. Gabriel, LA. Data averaged across whole stalk and billet planting methods.

[b]Abbreviation: WAP = weeks after planting.

[c]Data averaged over years.

[d]Abbreviation: WBP = weeks before planting.

Table 2.5. Sugarcane and sugar yield as influenced by planting method[a].

Planting method	Sugarcane yield 2001	Sugarcane yield 2002	Sugar yield 2001	Sugar yield 2002
	1000 kg/ha		kg/ha	
Whole stalk	76.3 b[b]	79.6 a	9,060 b	7,890 a
Billet	90.3 a	77.7 a	10,670 a	7,690 a

[a]Experiments harvested November 11, 2001, and October 24, 2002 at St. Gabriel Sugar Research Station, St. Gabriel, LA. Data averaged across timing treatments of no 2,4-D and 2,4-D applied 7, 5, 3, and 1 week before planting.

[b]Means within column followed by the same letter are not significantly different using Fisher's Protected LSD test at P = 0.05.

varied between years. In 2001, sugarcane and sugar yield were reduced at least 10.5 and 11.7%, respectively, when 2,4-D was applied 5 weeks or closer to planting when compared with the nontreated, but yield was not negatively affected when 2,4-D was applied 7 WBP (Table 2.6). In 2002, sugarcane and sugar yield were each equal whether or not 2,4-D was applied.

The year by treatment interactions observed for sugarcane plant population, height, and yield may be attributed to the physiological condition of the sugarcane plants at the time of 2,4-D application. Although monthly growth rate in 2000 and 2001 was approximately the same, the summer of 2000 was the third driest in history with only 22.9 cm of rainfall received in July, August, and September (Table 2.7). This compares to 2001, a year in which Louisiana received 20% more rainfall than normal with 50.7 cm of rainfall received in July, August, and September. The greater rainfall the second year may have enhanced translocation and metabolism of 2,4-D in the sugarcane plants, resulting in less residual effect on the plant cane crop. It is documented that plant growth regulators cause cessation of bud growth and that injury is concentration dependent (Anderson and Dusky 1985; Hamphill 1984; Hanish-ten-Cate and Bruinsma 1973; Tromp 1972). Griffin et al. (1990) also observed variability between years in response of nine sugarcane varieties used for seed following a late season 2,4-D application.

Greenhouse Study. A significant experiment by treatment interaction was observed for sugarcane shoot height 2 WAP. In experiment 1 a significant reduction in shoot height was observed when 2,4-D was applied 5 WBP when compared to the 7 WBP treatment; however, shoot height for all other treatments was equal to the 5 or 7 WBP treatments (Table 2.8). In experiment 2, a height reduction at all 2,4-D application

Table 2.6. Sugarcane and sugar yield as influenced by 2,4-D application timing[a].

2,4-D application timing	Sugarcane yield 2001	Sugarcane yield 2002	Sugar yield 2001	Sugar yield 2002
	1000 kg/ha		kg/ha	
No 2,4-D	89.9	84.8	10,740	8,210
7 WBP[b]	86.5	77.0	10,300	7,700
5 WBP	80.3	79.4	9,400	7,890
3 WBP	79.2	76.4	9,380	7,720
1 WBP	80.5	75.8	9,480	7,450
LSD (0.05)	4	NS	880	NS

[a]Experiments harvested November 11, 2001, and October 24, 2002, at St. Gabriel Sugar Research Station, St. Gabriel, LA. Data averaged across whole stalk and billet planting methods.

[b]Abbreviation: WBP = weeks before planting.

Table 2.7. Growth rate for LCP 85-384 and rainfall data for the duration of the 2,4-D and sugarcane planting method study conducted at the St. Gabriel Sugar Research Station, St. Gabriel, LA[a].

	Sugarcane height[b]		Rainfall[c]	
Date	2000	2001	2000	2001
	cm		cm	
6/30 – 7/14	148.3 – 165.4	125.7 – 145.3	3.94	14.78
7/14 – 7/28	197.4 (+ 32.0)[d]	177.8 (+ 32.5)	3.56	6.68
7/28 – 8/11	225.8 (+ 28.4)	211.8 (+ 34.0)	5.97	11.30
8/11 – 8/25	248.9 (+ 23.1)	235.0 (+ 23.2)	0.38	5.33
8/25 – 9/8	267.2 (+ 18.3)	260.1 (+ 25.1)	1.91	12.42
9/8 – 9/22	283.2 (+ 16.0)	269.5 (+ 9.4)	7.11	0.18

[a]Growth rate and rainfall data for June 30 – September 22, 2000 and 2001.

[b]Data provided by USDA, ARS, Sugar Research Unit, 5883 USDA Road, Houma, LA 70360.

[c]Data provided by Dr. Richard Bengston, Department of Biological and Agricultural Engineering, Louisiana State University, Baton Rouge, LA 70803.

[d]Values represent sugarcane height on the last day of the 14-day period. Values in parentheses represent total growth for the 14-day period.

Table 2.8. Sugarcane shoot height and emergence as influenced by 2,4-D application timing in a greenhouse study[a].

	Height				Shoot emergence[b]		
	2 WAP						
Treatments	Exp 1	Exp 2	4 WAP	6 WAP	2 WAP	4 WAP	6 WAP
	cm				%		
No 2,4-D	21	12	33	39	88	88	88
7 WBP[c]	24	10	31	40	88	100	100
5 WBP	20	10	29	37	88	88	88
3 WBP	23	10	33	42	100	100	100
1 WBP	23	9	30	38	88	88	88
LSD (0.05)	4	2	2	2	NS	1	NS

[a]Data averaged across experiments for all variables except height 2 weeks after planting (WAP).

[b]Percentage values represent number of plants emerging from eight node pieces that were planted.

[c]Abbreviation: WBP = weeks before planting.

timings was observed when compared with the nontreated. Sugarcane height data collected 4 and 6 WAP was consistent across experiments. At 4 WAP, sugarcane shoot height was reduced when 2,4-D was applied 5 or 1 WBP when compared to the nontreated control. At 6 WAP, sugarcane shoot height was greatest when 2,4-D was applied 3 WBP.

No significant differences were observed for the 2,4-D treatments for shoot emergence 2 or 6 WAP (Table 2.8). However, sugarcane emergence 4 WAP, was 100% for the 7 and 3 WBP treatments and 88% for the other treatments. Based on the 6 WAP data from the greenhouse study, sugarcane height was not affected by 2,4-D applied 7 WBP when compared with the nontreated. These findings agree with the field study. However, unlike the field study, sugarcane emergence 6 WAP was equal whether or not 2,4-D was applied. This discrepancy between the greenhouse and field study in regard to the effect of 2,4-D may be due to elimination of apical dominance associated with cutting stalks into small node pieces for the greenhouse study. In addition, differences may be attributed to the stage of physiological development of individual buds depending on bud position on the stalk and overall maturity of the harvested stalk (Anderson and Dusky 1985).

Results from this research indicate that 2,4-D applied 5 weeks or closer to harvest of sugarcane for seed can inhibit subsequent germination and shoot emergence. This effect was consistent over the two growing seasons and extended out to 28 WAP. However by 52 WAP, sugarcane was able to compensate and stalk population was equal whether or not 2,4-D was applied. In regard to the effect of 2,4-D on sugarcane height, response varied between years. In 2001 sugarcane height was reduced at 37 and 52 WAP when 2,4-D was applied at 1, 3, or 5 WBP, but no negative effect was observed with application 7 WBP. Application of 2,4-D did not affect sugarcane height in 2002. The negative effect of 2,4-D on sugarcane height in 2001 was manifested in reduced sugarcane yield and sugar yield when 2,4-D was applied 5 weeks or closer to harvest of seed cane when compared with the 7 WBP treatment or the nontreated. However, in 2002 sugarcane and sugar yield were not adversely affected by 2,4-D regardless of application timing. The variation in response between years may very well be related to rainfall and growing conditions around the time of 2,4-D application (Table 2.7). The drier conditions during this time the first year may have reduced metabolism of 2,4-D within the sugarcane plant allowing more 2,4-D to accumulate in meristematic tissue. However, this was not quantified.

Another aspect of this research involved the comparison of residual effect of 2,4-D as influenced by planting method. Sugarcane response to 2,4-D was the same whether planted using whole stalks or billets. Seeding rate was maintained constant to allow for a direct comparison of the two planting methods. In a typical planting system, growers plant approximately 3 times more sugarcane per hectare when using billets compared with whole stalks. One aspect not evaluated in the study was the possibility that higher seeding rate may offset the negative effect of the 2,4-D application. Preliminary studies, however, indicate that this is not the case. The present study does show that when planted at the same seeding rate yields can be greater for billet planting compared with whole stalk planting, but this response was not consistent over years.

Overall this study demonstrates that 2,4-D applied late season to sugarcane to be used for planting can affect yields of the crop the following year. This response is consistent whether sugarcane is billet or whole stalk planted. The possibility of yield reductions associated with late season 2,4-D application emphasizes the need for effective alternatives to 2,4-D for morningglory control late season. Until such alternative weed management strategies are available producers should allow 7 weeks between 2,4-D application and harvest of LCP 85-384 for planting purposes to reduce the negative effect on yield that can occur in the plant cane crop.

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CHAPTER 3

RED MORNINGGLORY (*IPOMOEA COCCINEA* L.) CONTROL WITH 2,4-D AND ALTERNATIVE HERBICIDES

Introduction

In 2001 approximately 200,000 hectares of sugarcane were grown in Louisiana, ranking the state first in U.S. sugar production (Anonymous 2001a). Sugarcane is grown as a perennial crop in Louisiana with three to five annual harvests from a single planting. During the crop cycle the row top remains relatively undisturbed, which contributes to the difficulty in weed control.

Sugarcane weed control programs are based around the use of preemergence herbicides applied both in spring when sugarcane is emerging from the winter dormant period and at layby usually in April or May. The intent of the layby application is to remove weed competition until the crop is harvested beginning in September. Atrazine is estimated to be used on 75% of the hectarage in the spring and at layby to control morningglories (Rogers et al. 1996). Rainfall and warm soil temperatures at the time of layby application are conducive to rapid herbicide degradation in Louisiana often resulting in late season weed infestations, particularly red morningglory (Viator et al. 2002a). Studies have documented reductions in sugarcane stalk population, sugar yield, and harvest efficiency associated with morningglory competition (Millhollon 1988; Thakar and Singh 1954). Season long morningglory competition reduced sugar yield 24 to 30% (Millhollon 1988).

Atrazine is widely used to control morningglories in Louisiana sugarcane at layby but control failures are common. This is primarily due to the long period of time between atrazine application and sugarcane harvest (at least three months). Red morningglory

(*Ipomoea coccinea* L.) is one of the more common and problematic morningglory species found in Louisiana sugarcane fields. In a multi-year study atrazine controlled red morningglory 71 to 83% 45 days after treatment (DAT) (Viator et al 2002b).

In addition to losses from competition, morningglories also climb and wrap sugarcane stalks, causing lodging that reduces both the number of harvestable stalks removed from the field and the efficiency of mechanical harvesters. Many producers are forced to apply 2,4-D in late season to facilitate harvest. Griffin et al. (2000) reported that 2,4-D was highly effective on morningglory if the rate was matched to weed size. Currently recommended 2,4-D rates for morningglory control are 0.53 kg ai/ha for small plants (2 to 3 leaf) and up to 1.59 kg/ha when plants have climbed the sugarcane stalks (Anonymous 2001b). However, 2,4-D application is restricted in some areas of Louisiana due to problems with off-target movement and injury to sensitive crops, particularly cotton (*Gossypium hirsutum* L.). During the 2001 growing season in Louisiana 8,100 to 10,120 hectares of cotton were injured by 2,4-D with the major problems occurring between May 22 and 28 (B.L. Legendre, personal communication). Because in many cases a single source of the 2,4-D could not be identified, a blanket restriction of 2,4-D use over much of central and south Louisiana was imposed for the 2002 growing season.

In addition to concerns over drift from 2,4-D there is evidence to suggest that 2,4-D can affect sugarcane to be used for vegetative planting material (Griffin et al. 1990; Siebert et al. 2002). Consequently alternative control strategies for 2,4-D use in sugarcane should be evaluated.

Limited information is available on the control of red morningglory with postemergence (POST) herbicides applied either postemergence overtop of the crop or postemergence-directed (POST-DIR) underneath the crop canopy. The objective of this research was to evaluate alternative herbicide treatments for red morningglory that could be used where 2,4-D is restricted by law and where 2,4-D has caused injury to sugarcane subsequently used as a seed source.

Materials and Methods

Red Morningglory Control Studies (30 and 60 cm). Experiments were conducted in 2001 and 2002 near Port Allen, LA in West Baton Rouge Parish to evaluate red morningglory control with POST herbicides. The experimental area had previously been fallowed and red morningglory plants had produced seed the year before the study was initiated. Before initiation of the experiments soil was prepared and metolachlor at 2.1 kg ai/ha was applied PRE to control annual grasses and sedges.

For the first study herbicide treatments included 2,4-D at 0.27 (2002 only), 0.53, 1.06, and 1.59 kg ai/ha; a 2,4-D and dicamba premix at 0.2 / 0.07, 0.4 / 0.14, and 0.8 / 0.28 kg ai/ha; and combinations of 2,4-D plus the 2,4-D and dicamba premix at 0.27 + 0.2 / 0.07 (2002 only), 0.53 + 0.2 / 0.07, 0.53 + 0.4 / 0.14, and 0.79 + 0.1 / 0.04 kg /ha. The 2,4-D plus the 2,4-D and dicamba premix was included to determine if spiking the premix with additional 2,4-D was beneficial.

In the second study, alternatives to 2,4-D were evaluated and treatments included atrazine at 1.12 (2002 only), 2.23, 3.35, and 4.47 kg ai/ha; flumioxazin at 0.05 and 0.08 (2002 only), 0.10, and 0.14 kg ai/ha; sulfentrazone at 0.26 and 0.32 (2002 only), 0.35, and 0.42 kg ai/ha; and V10064 at 1.75 kg ai/ha. Additional herbicide treatments included in 2002 for the second study were CGA 362622 at 0.02 kg ai/ha, carfentrazone at 0.02 kg ai/ha, dicamba at 0.84 kg/ha, and triclopyr at 0.42 kg ai/ha. Crop oil concentrate[7] at 1% (v/v) was added to the atrazine, flumioxazin, and sulfentrazone treatments and non-ionic surfactant[8] at 0.25% (v/v) was added to the CGA 362622 and carfentrazone treatments. Adjuvant was not added to the dicamba or triclopyr treatments.

Herbicide treatments in both studies were applied July 12, 2001, and August 15, 2002. Individual plot size was 1.5 m x 3 m and within each plot weeds were hand thinned to 10 plants, each of which was approximately 30 or 60 cm in height. Each plant was considered as an individual replicate. All herbicide treatments were applied using a CO_2-pressurized backpack sprayer calibrated to deliver 140 L/ha at a pressure of 180 kPa. The experimental design was a randomized complete block with a factorial arrangement of treatments and ten replications. The factors consisted of weed size (30 or 60 cm) and herbicide treatment.

In both studies visual estimates of red morningglory control were made 7, 14, and 21 DAT unless complete control was observed 14 DAT. Weed control was compared to a nontreated using a scale of 0 to 100% where 0 represented no control and 100 equaled dead plant. Data for each study were subjected to analysis of variance where interactions were tested for significance. Tables were constructed according to the interactions observed and means were separated using Fisher's protected LSD at the 0.05 significance level.

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[7] Agridex, a blend of polyol fatty acid esters and polyexothylated derivatives; Helena Chemical Company, 6075 Poplar Avenus, Suite 500, Memphis, TN 38119.

[8] Induce, a blend of alkyl aryl polyoxylkane ether free fatty acids; Helena Chemical Company, 6075 Poplar Avenue, Suite 500, Memphis, TN 38119.

Red Morningglory Control Study (1.8 m). A study was conducted in 2001 and 2002 at the same site described previously. Herbicide treatments used to evaluate control of 1.8 m red morningglory were applied August 22, 2001, and August 1, 2002. Plot size was 1.5 m by 3 m, and red morningglory population in each plot was thinned to five plants. A 10-m wide buffer area separated each plot. A 1.8 m, plastic sturdy stake[9] was driven 15 cm deep into the soil next to each plant and plants were allowed to climb the stake. Each plant was considered an individual replicate. When plant growth reached the top of the stake, herbicide treatments were applied. Herbicide treatments applied POST over-the-top to simulate a late season aerial application included 2,4-D at 1.06 and 1.59 kg/ha, a 2,4-D and dicamba premix at 0.8 / 0.28 kg/ha, and combinations of 2,4-D plus the 2,4-D and dicamba premix at 0.53 + 0.2 / 0.07, 0.53 + 0.4 / 0.14, and 0.79 + 0.1 / 0.04 kg/ha. Other herbicide treatments POST-DIR to the lower 45 cm of the plant included atrazine at 4.47 kg/ha, flumioxazin at 0.10 and 0.14 kg/ha, sulfentrazone at 0.35 and 0.42 kg/ha, and V10064 at 1.75 kg/ha. Crop oil concentrate at 1% (v/v) was included with all POST-DIR treatments. Adjuvant was not added to the 2,4-D treatments.

Postemergence over-the-top treatments were applied using a CO_2-pressurized backpack sprayer calibrated to deliver 140 L/ha at a pressure of 180 kPa. POST-directed treatments were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 140 L/ha at a pressure of 207 kPa. A two-nozzle boom equipped with OC-04[10] tips was used to direct the herbicide to the base of the morningglory plants. Precautions were taken to avoid herbicide movement among the POST and POST-DIR treatments. The

[9] Sturdy Stakes, Hummert International, 4500 Earth City Expressway, Earth City, MO 63045.

[10] Teejet Spraying Systems Company, North Avenue, Wheaton, IL 60189-7900.

experimental design was a randomized complete block with five replications. Visual estimates of red morningglory control were made 7, 14, and 28 DAT. Weed control was compared to a nontreated using the same rating scale described previously. Data were subjected to analysis of variance where interactions were tested for significance. Tables were constructed according to the interactions observed and means were separated using Fisher's protected LSD at the 0.05 significance level.

Results and Discussion

Red Morningglory Control Studies (30 and 60 cm). Due to a treatment by year interaction, results for the first experiment (2,4-D alone and in combinations) are presented separately for each year. In both years a herbicide treatment by weed size interaction was observed at 7 and 14 DAT, but not at 21 DAT (Tables 3.1 and 3.2).

In 2001 7 DAT, 2,4-D alone at 1.59 kg/ha, the 2,4-D and dicamba premix at 0.8 / 0.28 kg/ha, and 2,4-D plus the 2,4-D / dicamba premix at 0.79 + 0.1 / 0.04 kg/ha controlled 30 cm red morningglory 87, 81, and 83%, respectively (Table 3.1). For each of these treatments weed control was greater than 2,4-D applied at lower rates. Results show that 2,4-D applied alone at the high rate was effective and that addition of dicamba did not further increase control. Control of 60 cm red morningglory 7 DAT was equally effective for 2,4-D at 1.59 kg/ha and for the high rate of 2,4-D with the 2,4-D / dicamba premix (average of 94%), and greater than for the 2,4-D and dicamba premix at the high rate with 84% control. An application of 2,4-D plus the 2,4-D and dicamba premix (0.53 + 0.4 / 0.14 kg/ha) controlled 60 cm red morningglory 88% 7 DAT. The lowest control of either 30 or 60 cm red morningglory 7 DAT was obtained with the lowest rate of the 2,4-D and dicamba premix (38%).

Table 3.1. Control of 30 and 60 cm red morningglory 7, 14, and 21 days after treatment (DAT) with 2,4-D and a 2,4-D and dicamba premix in 2001[a].

		7 DAT		14 DAT		
Treatment	Rate	30 cm	60 cm	30 cm	60 cm	21 DAT[b]
	kg ai/ha	%				
2,4-D	0.53	43	52	100	94	100
2,4-D	1.06	54	73	100	100	100
2,4-D	1.59	87	91	100	100	100
2,4-D / Dicamba	0.2 / 0.07	38	38	62	77	92
2,4-D / Dicamba	0.4 / 0.14	47	46	100	96	100
2,4-D / Dicamba	0.8 / 0.28	81	84	100	100	100
2,4-D + 2,4-D / Dicamba	0.53 + 0.2 / 0.07	57	62	100	100	100
2,4-D + 2,4-D / Dicamba	0.53 + 0.4 / 0.14	75	88	100	100	100
2,4-D + 2,4-D / Dicamba	0.79 + 0.1 / 0.04	83	96	100	100	100
Nontreated	--	0	0	0	0	0
LSD (0.05)		7		3		NS

[a]Experiments conducted in Port Allen, LA. Treatments applied July 12, 2001.

[b]Data represent an average across red morningglory treated at 30 and 60 cm.

Table 3.2. Control of 30 and 60 cm red morningglory 7, 14, and 21 days after treatment (DAT) with 2,4-D and a 2,4-D and dicamba premix in 2002[a].

Treatment	Rate	7 DAT		14 DAT		
		30 cm	60 cm	30 cm	60 cm	21 DAT
	kg ai/ha	%				
2,4-D	0.27	34	31	100	81	100
2,4-D	0.53	55	43	100	98	100
2,4-D	1.06	85	68	100	100	100
2,4-D	1.59	96	87	100	100	100
2,4-D / Dicamba	0.2 / 0.07	64	54	100	96	100
2,4-D / Dicamba	0.4 / 0.14	94	80	100	100	100
2,4-D / Dicamba	0.8 / 0.28	100	100	100	100	100
2,4-D + 2,4-D / Dicamba	0.27 + 0.2 / 0.07	89	79	100	100	100
2,4-D + 2,4-D / Dicamba	0.53 + 0.2 / 0.07	100	89	100	100	100
2,4-D + 2,4-D / Dicamba	0.53 + 0.4 / 0.14	100	84	100	100	100
2,4-D + 2,4-D / Dicamba	0.79 + 0.1 / 0.04	91	83	100	98	100
Nontreated	--	0	0	0	0	0
LSD (0.05)		5		2		NS

[a]Experiments conducted in Port Allen, LA. Treatments applied August 15, 2002.

[b]Data represent an average across red morningglory treated at 30 and 60 cm.

At 14 DAT in 2001 control of 30 or 60 cm red morningglory was at least 94% for all treatments except the 2,4-D and dicamba premix at the lowest rate with no more than 77% control (Table 3.1). At 21 DAT a significant interaction between herbicide treatment and weed size was not observed and red morningglory control was equivalent for all herbicide treatments, averaging 99%.

In 2002 the experiment was repeated with the inclusion of a lower rate of 2,4-D (0.27 kg/ha) applied alone and with the 2,4-D and dicamba premix. At 7 DAT, 2,4-D alone at 1.59 kg/ha, the 2,4-D / dicamba premix at 0.8 / 0.28 kg/ha, and 2,4-D plus the 2,4-D and dicamba premix at 0.53 + 0.2 / 0.07 and 0.53 + 0.4 / 0.14 kg/ha provided equal control of 30 cm red morningglory (96 to 100%) (Table 3.2). Thirty centimeter red morningglory was controlled 85 to 94% with 2,4-D at 1.06 kg/ha, the 2,4-D and dicamba premix at 0.4 / 0.14 kg/ha, and 2,4-D plus the 2,4-D and dicamba premix at 0.27 + 0.2 / 0.07 and 0.79 + 0.1 / 0.04 kg/ha. For 60 cm red morningglory, control 7 DAT was 100% for the high rate of the 2,4-D and dicamba premix (0.8/0.28 kg/ha), 87% for 2,4-D at 1.59 kg/ha and 89% for 2,4-D plus the 2,4-D and dicamba premix at 0.53 + 0.2 / 0.07 kg/ha.

At 14 DAT in 2002 all herbicide treatments provided complete control of 30 cm red morningglory. For 60 cm red morningglory, control was 81% for the low rate of 2,4-D (0.27 kg/ha) but at least 96% for the other herbicide treatments. As also noted the previous year there was no treatment by weed size interaction 21 DAT and complete control in 2002 was obtained for both 30 and 60 cm red morningglory for all herbicide treatments. It appears that the treatment by year interaction was due in part to the poorer performance for the low rate of the 2,4-D and dicamba premix (0.2/0.07 kg/ha) 7 and 14 DAT in 2001 compared with 2002 (Tables 3.1 and 3.2). However, by 21 DAT, the low rate of the premix controlled red morningglory equal to the other treatments in both years.

For the 2,4-D alternative study herbicide treatment by weed size interactions were not observed for red morningglory control 7 or 14 DAT in either year (Table 3.3). In 2001 red morningglory control was at least 98% 7 and 14 DAT with atrazine, flumioxazin, sulfentrazone, and V10064. In 2002 lower rates of atrazine, flumioxazin, and sulfentrazone were included. At 7 DAT in 2002, all rates of flumioxazin and sulfentrazone provided complete control of red morningglory (Table 3.3). Atrazine at 1.12 kg/ha controlled red morningglory 89% 7 DAT compared with 100% for higher rates. However, by 14 DAT complete control was obtained with all rates of atrazine. In 2002, CGA 362622 at 0.02 kg/ha, dicamba at 0.84 kg/ha, and triclopyr at 0.42 kg/ha resulted in no more than 61% control 7 DAT, but control with these treatments was at least 93% 14 DAT (Table 3.3). Complete control of red morningglory was obtained with carfentrazone at 0.02 kg/ha at 7 DAT.

Red Morningglory Control Study (1.8 m). A significant year by treatment interaction was observed for control of 1.8 m red morningglory and data are presented separately for each year. In the second year of the study application of herbicides was made three weeks earlier than in the previous year. Also, red morningglory plants were more vigorous and robust the second year.

In 2001, 2,4-D, 2,4-D plus dicamba, atrazine, flumioxazin, sulfentrazone, and V10064 controlled red morningglory 11 to 75% 7 DAT (Table 3.4). A single application of 2,4-D at 1.06 and 1.59 kg/ha controlled red morningglory 60 to 62% and did not differ from the 2,4-D and dicamba premix (0.8 + 0.28 kg/ha) with 72% control. The addition of

Table 3.3. Red morningglory control 7 and 14 days after treatment (DAT) with POST herbicide alternatives to 2,4-D[a].

Treatment[b]	Rate	2001[c]		2002[c]	
		7 DAT	14 DAT	7 DAT	14 DAT
	kg ai/ha	%			
Atrazine	1.12	--	--	89	100
Atrazine	2.23	98	100	100	100
Atrazine	3.35	100	100	100	100
Atrazine	4.47	100	100	100	100
Flumioxazin	0.05	--	--	100	100
Flumioxazin	0.08	--	--	100	100
Flumioxazin	0.10	99	100	100	100
Flumioxazin	0.14	99	100	100	100
Sulfentrazone	0.26	--	--	100	100
Sulfentrazone	0.32	--	--	100	100
Sulfentrazone	0.35	99	100	100	100
Sulfentrazone	0.42	100	100	100	100
V10064	1.75	100	100	100	100
CGA 362622	0.02	--	--	61	97
Carfentrazone	0.02	--	--	100	100
Dicamba	0.84	--	--	60	93

Table 3.3 continued on next page.

Triclopyr	0.42	--	--	46	96
Nontreated	--	0	0	0	0
LSD (0.05)		2	NS	3	1

[a]Experiments conducted in Port Allen, LA. Treatments applied July 12, 2001 and August 15, 2002.

[b]Crop oil concentrate added to atrazine, flumioxazin, and sulfentrazone treatments at 1% (v/v). Nonionic surfactant added to CGA 362622 and carfentrazone treatments at 0.25% (v/v).

[c]Data represent an average across red morningglory treated at 30 and 60 cm.

Table 3.4. Control of 1.8 m red morningglory 7, 14, and 28 days after treatment (DAT) with 2,4-D, a 2,4-D and dicamba premix, and other POST herbicides in 2001[a].

Treatment[b]	Rate	Application method[c]	7 DAT	14 DAT	28 DAT
	kg ai/ha			%	
2,4-D	1.06	POST	60	94	100
2,4-D	1.59	POST	62	94	100
2,4-D / Dicamba	0.8 / 0.28	POST	72	95	100
2,4-D + 2,4-D / Dicamba	0.53 + 0.2 / 0.07	POST	56	94	100
2,4-D + 2,4-D / Dicamba	0.53 + 0.4 / 0.14	POST	42	94	100
2,4-D + 2,4-D / Dicamba	0.79 + 0.1 / 0.04	POST	63	84	100
Atrazine	4.47	POST-DIR	19	71	100
Flumioxazin	0.10	POST-DIR	11	16	66
Flumioxazin	0.14	POST-DIR	11	26	74
Sulfentrazone	0.35	POST-DIR	65	64	96
Sulfentrazone	0.42	POST-DIR	75	89	100
V10064	1.75	POST-DIR	40	62	100
Nontreated	--	--	0	0	0
LSD (0.05)			14	12	2

[a]Experiments conducted in Port Allen, LA. Treatments applied August 22, 2001.

[b]Crop oil concentrate added to atrazine, flumioxazin, sulfentrazone, and V10064 treatments at 1% (v/v).

[c]POST = postemergence over-the-top and POST-DIR = postemergence directed.

2,4-D to the 2,4-D and dicamba premix did not improve weed control when compared with 2,4-D alone or with the 2,4-D and dicamba premix. By 14 DAT in 2001, red morningglory control was equivalent where 2,4-D was applied alone, in a premix with dicamba, and when applied in addition to the 2,4-D and dicamba premix (84 to 95% control). By 28 DAT all treatments containing 2,4-D provided complete control of red morningglory.

Rather than being applied over the top, the atrazine, flumioxazin, sulfentrazone, and V10064 treatments were applied POST–DIR. At 7 and 14 DAT in 2001, atrazine controlled red morningglory 19% and 71%, respectively (Table 3.4). Flumioxazin controlled red morningglory no more than 26% 14 DAT. Sulfentrazone at 0.35 kg/ha controlled red morningglory approximately 65% 7 and 14 DAT, but when applied at 0.42 kg/ha, control was 89% 14 DAT. This high level of red morningglory control with sulfentrazone 14 DAT was equal to that obtained with 2,4-D treatments. Viator et al. (2002b) also reported excellent red morningglory control with sulfentrazone but in their study the herbicide was applied preemergence rather than POST-DIR. V10064 at 1.75 kg/ha controlled red morningglory 40 and 62% 7 and 14 DAT, respectively. By 28 DAT in 2001, red morningglory control was no more than 74% for flumioxazin, but was at least 96% for atrazine, sulfentrazone, and V10064.

In 2002, the experimental site received 8.5 cm rainfall during the four weeks following herbicide application and when weed growth was prolific, red morningglory control in most cases was less than what was observed the previous year (Table 3.4 and 3.5). None of the herbicide treatments in 2002 provided more than 49% control 7 DAT (Table 3.5). By 14 DAT, 70 to 72% control was obtained with the high rate of 2,4-D and

Table 3.5. Control of 1.8 m red morningglory 7, 14, and 28 days after treatment (DAT) with 2,4-D, a 2,4-D and dicamba premix, and other POST herbicides in 2002[a].

Treatment[b]	Rate	Application method[c]	7 DAT	14 DAT	28 DAT
	kg ai/ha			%	
2,4-D	1.06	POST	39	52	78
2,4-D	1.59	POST	43	72	87
2,4-D / Dicamba	0.8 / 0.28	POST	24	48	61
2,4-D + 2,4-D / Dicamba	0.53 + 0.2 / 0.07	POST	34	42	54
2,4-D + 2,4-D / Dicamba	0.53 + 0.4 / 0.14	POST	31	48	71
2,4-D + 2,4-D / Dicamba	0.79 + 0.1 / 0.04	POST	49	70	87
Atrazine	4.47	POST-DIR	11	23	77
Flumioxazin	0.10	POST-DIR	20	61	77
Flumioxazin	0.14	POST-DIR	14	70	79
Sulfentrazone	0.35	POST-DIR	24	39	66
Sulfentrazone	0.42	POST-DIR	40	50	70
V10064	1.75	POST-DIR	17	22	70
Nontreated	--	--	0	0	0
LSD (0.05)			10	8	9

[a]Experiments conducted in Port Allen, LA. Treatments applied August 2, 2002.

[b]Crop oil concentrate added to atrazine, flumioxazin, sulfentrazone, and V10064 treatments.

[c]POST = postemergence over-the-top and POST-DIR = postemergence directed.

for 2,4-D plus the 2,4-D and dicamba premix at 0.79 + 0.1 / 0.04 kg/ha applied over the top, and for the high rate of flumioxazin applied POST-DIR. The other treatments controlled red morningglory 22 to 61% 14 DAT.

In 2001 28 DAT, many of the treatments completely controlled red morningglory (Table 3.4), however, this was not the case in 2002. Red morningglory was controlled 87% 28 DAT with the high rate of 2,4-D and 2,4-D plus the 2,4-D and dicamba premix (0.79 + 0.1 / 0.04 kg/ha) (Table 3.5) and control was greater than all other treatments except for the high rate of flumioxazin with 79% control. In contrast to 2001 atrazine, sulfentrazone, and V10064 in 2002 controlled red morningglory 66 to 77% 28 DAT. It appears from the variable weed control response observed between years that performance of flumioxazin is more consistent when compared with the other herbicides evaluated.

Results indicate that there are excellent control options in sugarcane for red morningglory plants no more than 60 cm in height. Currently labeled herbicides to include atrazine, dicamba, and sulfentrazone, can be substituted for the standard 2,4-D treatment in areas where application of 2,4-D is restricted without sacrificing red morningglory control. CGA 362622, carfentrazone, and triclopyr offer potential to control 60 cm red morningglory but these herbicides are not currently labeled in sugarcane and were only evaluated in one year. Excellent morningglory control has been reported with CGA 362622 (Porterfield et al. 2002) and this herbicide should be further evaluated for use in sugarcane. In areas where 2,4-D use is not restricted, 2,4-D in addition to a 2,4-D and dicamba premix did not enhance or reduce 60 cm red morningglory control 28 DAT when compared with 2,4-D applied alone at 1.59 kg/ha.

When morningglories were 1.8 m tall weed control was more inconsistent regardless of herbicide when compared with application to weeds no more than 60 cm in height. Application of 2,4-D at 1.59 kg/ha controlled 1.8 m red morningglory 28 DAT 100% in 2001 and 87% in 2002. Weed control with 2,4-D at 0.53 kg/ha plus the 2,4-D and dicamba premix was less compared with 2,4-D alone at 1.59 or 2,4-D at 0.79 kg/ha plus the premix. Postemergence directed applications of atrazine, sulfentrazone, and V10064 controlled 1.8 m red morningglory equivalent to that of 2,4-D treatments the first year, but control was inferior to 2,4-D applied alone at 1.59 kg/ha the second year.

Alternatives to 2,4-D are available and can be effective when applied to red morningglory no more than 60 cm tall. When environmental conditions are conducive to prolific growth of morningglory and weeds climb sugarcane stalks, 2,4-D remains the most effective herbicide treatment.

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CHAPTER 4

SUMMARY

Field and greenhouse studies were conducted to evaluate the residual effect of 2,4-D application prior to harvest of 'LCP 85-384' sugarcane used as whole stalk and billet vegetative planting material. Application of 2,4-D 5 wk or closer to harvest of sugarcane for seed inhibited subsequent germination and shoot emergence. This effect was consistent over the two growing seasons and extended out to 28 wk after planting (WAP). However by 52 WAP, sugarcane was able to compensate and stalk population was equal whether or not 2,4-D was applied. In regard to the effect of 2,4-D on sugarcane height, response varied between years. In 2001 sugarcane height was reduced at 37 and 52 WAP when 2,4-D was applied 1, 3, or 5 wk before planting (WBP), but no negative effect on height was observed with application 7 WBP. Application of 2,4-D did not affect sugarcane height in 2002. The negative effect of 2,4-D on sugarcane height in 2001 was manifested in reduced sugarcane and sugar yield when 2,4-D was applied 5 weeks or closer to harvest of seed cane when compared with the 7 WBP treatment or the nontreated. In 2002, however, sugarcane and sugar yield were not adversely affected by 2,4-D regardless of application timing. The variation in response between years may be related to rainfall and growing conditions around the time of 2,4-D application. The drier conditions during this time in 2001 may have reduced metabolism of 2,4-D within the sugarcane plant allowing more 2,4-D to accumulate in meristematic tissue.

Another aspect of this research involved comparison of residual effect of 2,4-D as influenced by planting method. Sugarcane response to 2,4-D was the same whether planted using whole stalks or billets (45 cm seed pieces). For this research seeding rate was maintained constant to allow for a direct comparison of the two planting methods. In a typical planting system, growers use approximately 3 times more sugarcane per hectare with billets compared with whole stalks. One aspect not evaluated in the study was the possibility that the higher seeding rate for billets may offset the negative effect of the 2,4-D application. Preliminary studies, however, indicate that this is not the case. The present study does show that when planted at the same seeding rate sugarcane yields can be greater for billet planting compared with whole stalk planting, but this response was not consistent over years.

Overall this research demonstrates that 2,4-D applied late season to sugarcane used for planting can have a residual effect on crop yield the following year. This response was consistent whether sugarcane is billet or whole stalk planted. The possibility of yield reductions associated with late season 2,4-D application emphasizes the need for effective alternatives to 2,4-D for morningglory control late season. Until such alternative weed management strategies are available, producers should allow 7 wk between 2,4-D application and harvest of LCP 85-384 for planting purposes to reduce the residual effect on yield that can occur in the plant cane crop.

To address the need for effective alternatives to 2,4-D for late season red morningglory control in sugarcane, studies were initiated to evaluate several broadleaf herbicides applied either postemergence over-the-top or as postemergence directed treatments. Results indicate that there are excellent red morningglory control options when plants are no more than 60 cm in height. Currently labeled herbicides atrazine, dicamba, and sulfentrazone, can be substituted for the standard 2,4-D treatment in areas where application of 2,4-D is restricted without sacrificing red morningglory control.

CGA 362622, carfentrazone, and triclopyr offer potential for control of 60 cm red morningglory but these herbicides are not currently labeled in sugarcane and were only evaluated in one year. In areas where 2,4-D use is not restricted, the addition of 2,4-D to a 2,4-D and dicamba premix did not enhance or reduce 60 cm red morningglory control 28 days after treatment (DAT) when compared with 2,4-D applied alone at 1.59 kg/ha.

When morningglories were 1.8 m tall weed control was more inconsistent regardless of herbicide when compared with application to weeds no more than 60 cm in height. Application of 2,4-D at 1.59 kg/ha controlled 1.8 m red morningglory 28 DAT 100% in 2001 and 87% in 2002. Weed control with 2,4-D at 0.53 kg/ha plus the 2,4-D and dicamba premix was less when compared with 2,4-D alone at 1.59 or 2,4-D at 0.79 kg/ha plus the premix. Postemergence-directed applications of atrazine, sulfentrazone, and V10064 controlled 1.8 m red morningglory equivalent to that of 2,4-D treatments the first year, but control was inferior to 2,4-D applied alone at 1.59 kg/ha the second year.

Alternatives to 2,4-D are available and can be effective when applied to red morningglory no more than 60 cm tall. When environmental conditions are conducive to prolific growth of morningglory and weeds climb sugarcane stalks, 2,4-D remains the most effective herbicide treatment. This research is significant in that it provides researchers as well as producers and private consultants with information critical for making informed decisions for red morningglory control in sugarcane. Because the injury and yield reduction potential exist for 2,4-D-treated LCP 85-384 sugarcane used as planting material, more emphasis can be focused on means to reduce morningglory infestation and the need for a late season herbicide application. In the event that 2,4-D must be applied to sugarcane to be used as seed, this research delineates the optimum time of application that maximizes morningglory control and minimizes injury to the subsequent plant cane crop.

APPENDIX: RAW DATA

Table 1. Sugarcane shoot population 3 weeks after planting.

2,4-D application timing	2000 - 2001 Planting method		2001 - 2002 Planting method	
	Whole stalk	Billet	Whole stalk	Billet
	no. shoots / hectare			
No 2,4-D	1,012	2,500	7,680	15,359
7 WBP	238	2,024	4,167	11,549
5 WBP	60	1,429	3,155	11,252
3 WBP	357	2,322	7,084	14,288
1 WBP	417	2,619	6,429	9,585

Results of analysis of variance (ANOVA) for sugarcane shoot population 3 weeks after planting.

Source of variation	$P \leq F$
Year	< 0.0001
Planting method	< 0.0001
Year x Planting method	< 0.0001
Application timing	0.0023
Year x Application timing	0.0450
Planting method x Application timing	0.5812
Year x Planting method x Application timing	0.2962

Table 2. Sugarcane shoot population 5 weeks after planting.

2,4-D application timing	2000 - 2001 Planting method		2001 - 2002 Planting method	
	Whole stalk	Billet	Whole stalk	Billet
	no. shoots / hectare			
No 2,4-D	8,632	21,789	28,040	39,767
7 WBP	6,251	16,907	19,586	38,517
5 WBP	2,322	15,121	22,205	39,470
3 WBP	5,120	19,050	25,361	41,018
1 WBP	3,036	20,419	23,217	35,481

Results of analysis of variance (ANOVA) for sugarcane shoot population 5 weeks after planting.

Source of variation	$P \leq F$
Year	< 0.0001
Planting method	< 0.0001
Year x Planting method	0.3107
Application timing	0.0009
Year x Application timing	0.2214
Planting method x Application timing	0.8129
Year x Planting method x Application timing	0.0755

Table 3. Sugarcane shoot population 7 weeks after planting.

2,4-D application timing	2000 – 2001 Planting method		2001 - 2002 Planting method	
	Whole stalk	Billet	Whole stalk	Billet
	no. shoots / hectare			
No 2,4-D	12,978	24,884	34,707	45,244
7 WBP	10,835	22,086	30,242	44,649
5 WBP	5,298	19,348	31,135	45,185
3 WBP	8,751	24,825	32,564	49,650
1 WBP	6,608	23,694	28,694	41,672

Results of analysis of variance (ANOVA) for sugarcane shoot population 7 weeks after planting.

Source of variation	$P \leq F$
Year	< 0.0001
Planting method	< 0.0001
Year x Planting method	0.8806
Application timing	0.0039
Year x Application timing	0.1721
Planting method x Application timing	0.3581
Year x Planting method x Application timing	0.7453

Table 4. Sugarcane shoot population 28 weeks after planting.

2,4-D application timing	2000 - 2001 Planting method		2001 - 2002 Planting method	
	Whole stalk	Billet	Whole stalk	Billet
	no. shoots / hectare			
No 2,4-D	32,981	45,899	66,378	79,118
7 WBP	32,862	41,627	56,258	67,628
5 WBP	25,182	35,362	57,865	72,510
3 WBP	28,040	38,220	61,437	73,522
1 WBP	26,313	41,077	58,282	70,784

Results of analysis of variance (ANOVA) for sugarcane shoot population 28 weeks after planting.

Source of variation	$P \leq F$
Year	< 0.0001
Planting method	< 0.0001
Year x Planting method	0.6024
Application timing	0.0008
Year x Application timing	0.0705
Planting method x Application timing	0.9039
Year x Planting method x Application timing	0.9272

Table 5. Sugarcane shoot population 32 weeks after planting.

2,4-D application timing	2000 - 2001 Planting method		2001 - 2002 Planting method	
	Whole stalk	Billet	Whole stalk	Billet
	no. shoots / hectare			
No 2,4-D	57,448	70,605	135,078	131,804
7 WBP	55,901	67,688	131,209	129,899
5 WBP	35,005	55,067	124,303	132,340
3 WBP	39,529	59,711	130,792	126,446
1 WBP	37,386	62,270	125,017	135,852

Results of analysis of variance (ANOVA) for sugarcane shoot population 32 weeks after planting.

Source of variation	$P \leq F$
Year	< 0.0001
Planting method	< 0.0001
Year x Planting method	< 0.0001
Application timing	0.0010
Year x Application timing	0.0825
Planting method x Application timing	0.1812
Year x Planting method x Application timing	0.8719

Table 6. Sugarcane stalk population 52 weeks after planting.

2,4-D application timing	2000 - 2001 Planting method: Whole stalk	2000 - 2001 Planting method: Billet	2001 - 2002 Planting method: Whole stalk	2001 - 2002 Planting method: Billet
	no. stalks / hectare			
No 2,4-D	84,118	95,787	99,835	112,099
7 WBP	83,762	91,441	100,669	102,574
5 WBP	80,487	89,953	95,966	103,288
3 WBP	82,809	90,846	102,395	105,431
1 WBP	82,273	88,286	97,990	104,062

Results of analysis of variance (ANOVA) for sugarcane stalk population 52 weeks after planting.

Source of variation	$P \leq F$
Year	< 0.0001
Planting method	< 0.0001
Year x Planting method	0.3979
Application timing	0.1402
Year x Application timing	0.9625
Planting method x Application timing	0.5189
Year x Planting method x Application timing	0.9374

Table 7. Sugarcane height 37 weeks after planting.

2,4-D application timing	2000 - 2001 Planting method		2001 - 2002 Planting method	
	Whole stalk	Billet	Whole stalk	Billet
	cm			
No 2,4-D	124	126	43	42
7 WBP	128	121	41	41
5 WBP	108	116	44	43
3 WBP	116	118	43	43
1 WBP	112	123	46	42

Results of analysis of variance (ANOVA) for sugarcane height 37 weeks after planting.

Source of variation	$P \leq F$
Year	< 0.0001
Planting method	0.3875
Year x Planting method	0.0624
Application timing	0.0107
Year x Application timing	0.0004
Planting method x Application timing	0.4250
Year x Planting method x Application timing	0.0801

Table 8. Sugarcane height 43 weeks after planting.

2,4-D application timing	2000 - 2001 Planting method		2001 - 2002 Planting method	
	Whole stalk	Billet	Whole stalk	Billet
	cm			
No 2,4-D	128	135	133	135
7 WBP	126	128	128	132
5 WBP	105	121	123	131
3 WBP	118	117	129	135
1 WBP	115	121	127	132

Results of analysis of variance (ANOVA) for sugarcane height 43 weeks after planting.

Source of variation	$P \leq F$
Year	< 0.0001
Planting method	0.0090
Year x Planting method	0.8535
Application timing	0.0052
Year x Application timing	0.2006
Planting method x Application timing	0.5665
Year x Planting method x Application timing	0.8354

Table 9. Sugarcane height 52 weeks after planting.

2,4-D application timing	2000 - 2001 Planting method		2001 - 2002 Planting method	
	Whole stalk	Billet	Whole stalk	Billet
	cm			
No 2,4-D	268	265	263	259
7 WBP	267	265	259	254
5 WBP	252	258	254	261
3 WBP	259	261	257	251
1 WBP	255	262	261	260

Results of analysis of variance (ANOVA) for sugarcane height 52 weeks after planting.

Source of variation	$P \leq F$
Year	0.0275
Planting method	0.8972
Year x Planting method	0.1782
Application timing	0.0284
Year x Application timing	0.0508
Planting method x Application timing	0.1346
Year x Planting method x Application timing	0.8702

VITA

Jonathan Daniel Siebert was born September 3, 1978, in Eunice, Louisiana. He remained in Eunice where he attended and graduated from Eunice High School in 1996. In August of 1996 Jonathan enrolled at Louisiana State University at Eunice and transferred to the Baton Rouge campus of Louisiana State University in August 1997 where he pursued a Bachelor of Science degree with a major in agronomy. After completing his degree in August of 2000, Jonathan enrolled in the Weed Science graduate program in the Department of Plant Pathology and Crop Physiology at Louisiana State University under the direction of Dr. James L. Griffin (Department of Agronomy). He is currently a Research Associate for the Louisiana State University Agricultural Center and a candidate for a Master of Science degree. He will receive his Master of Science degree at the May 2003, commencement.