Abstract

MacRae, Andrew Wayne. Evaluation of Halosulfuron, Thifensulfuron, and Trifloxysulfuron Herbicides for their use in Sweetpotato. (Under the Direction of Dr. David Monks.)

Studies were conducted to determine the safety of halosulfuron, thifensulfuron, and trifloxysulfuron on sweetpotato. Halosulfuron applied at 39 g ai/ha four weeks after transplanting was found to be safe on sweetpotato, with a yield reduction potential of only seven percent. The yield reduction may be a delay in crop maturity that may be recovered if harvest was delayed. Halosulfuron was tested on the cultivars 'Beauregard', 'Covington', 'Diane', 'Jewel', 'O'Henry', and 'Poinatta'. Halosulfuron from 13 to 65 g/ha applied four weeks after sweetpotato transplant did not reduce yield for any of the cultivars tested. Only 'Diane' was observed to have a yield reduction of ten percent when halosulfuron was applied two weeks after transplanting. Halosulfuron from 13 to 65 g/ha applied one and three days prior to transplant did not reduce yield of sweetpotato. Halosulfuron applied seven days prior to transplant reduced yield of sweetpotato. This reduction may be related to rainfall. The seven day pre-transplant treatment received more than 2.5 cm of rain after application. Halosulfuron may have leached into the root zone causing the reduction in yield. No reduction in yield was observed Thifensulfuron at 4.5 g/ha applied six or eight weeks after transplanting was found to be safe to sweetpotato and have a potential of yield reduction of only ten percent. Trifloxysulfuron from 1.1 to 8.5 g/ha is safe to apply to sweetpotato five weeks after transplant with only two percent possibility of yield reduction. The yield reduction for the thifensulfuron and trifloxysulfuron applications may be a delay in crop maturity that could be recovered by delaying harvest. Trifloxysulfuron applied one, three, and seven days prior to

sweetpotato transplant did not reduce yield of sweetpotato. Halosulfuron was observed to have the smallest concentration of herbicide that inhibited the acetolactate synthase enzyme by fifty percent followed by primisulfuron, trifloxysulfuron, and nicosulfuron in increasing order. The use of this data for identifying tolerance in sweetpotato is not feasible since we already know from field trials that trifloxysulfuron is more likely to reduce sweetpotato yield than halosulfuron.

EVALUATION OF HALOSULFURON, THIFENSULFURON, AND TRIFLOXYSULFURON HERBICIDES FOR THEIR USE IN SWEETPOTATO

by
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APPROVED BY:

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Chair of Advisory Committee

Dedication

I would like to dedicate this research to my parents Alec and Gayle MacRae. Their moral support of my education from my childhood on is something that I can never repay. The sacrifice made by them emotionally and financially to have their only son move away from home to live so far away is something I hope I will one day have the courage to do. Simple words cannot express my love and devotion to them and I thank them with all my heart. If only everyone in the world was as kind and caring as you both.

My sister Elaine has had to bear the responsibility of being the only child left at home while having to deal with the emotional consequences of her only sibling moving away. She has been my best friend through life and it is hard believe that we ever fought when we were kids. In fact I can't remember the last time that I thought anything but great love for her. I am so proud that she has found a person as kind as Ryan to spend the rest of her life with. If I had a brother I would hope he was like him. The joy they brought to my life with the birth of Shannon was something I would never have imagined. That little fellow is less than two but still shows the intelligence and kindness of his parents. I am eagerly waiting the arrival of the next niece/nephew in September. To the whole Grant family I thank them for their support and their love and I dedicate the following pages to you.

I have four grandparents to thank for all their love. Grannie who is always willing to talk about everything going on in my life. She is a living angel and her love of her children, grandchildren, and great grandchildren is something that takes so much time and effort that we all thank you. Nennie who we lost last year, was a woman who had great love for everyone. She was as close to angel as a person can be, we miss you and we love you, thank you for all you did for your family. Grampie and Papa we lost you both too soon. You both had time to talk about what was going on in my life. Your comfort and love were something that I will remember always.

For all the family members that are too numerous to mention, I thank you for all your love and support. I hope one day I can get back home so that we can catch up on everything that has gone on. Thank you and my love to you all.

Keith Silver is the person who first turned me on to the field of weed science. It is because of him that I am in this profession. He took a chance on a student to be his summer helper and spent time teaching the lessons that I now depend on everyday in the field of weed science. I can still remember him telling me that the growers are the reason that we do what we do. Ever since then I have always thought of the growers first before conducting any research. They are sometimes forgotten when we have to deal with the day to day dealings of our profession. By joining this profession I have dedicated my work to the growers that are feeding the world. I will always have time to talk and learn from them, that is the most important lesson that Keith has taught me and I shall carry it with me always. I dedicate all I do in weed science to Keith and can only hope that I can one day be half as good as he was.

To everyone I have mentioned above I thank you all. You all are the reason that I am what I am today. I hope that I take the lessons I have learned from your teachings and apply them to make things better for the growers who I will be working for. I dedicate this research to you all.

Biography

Andrew Wayne MacRae was born in Truro, Nova Scotia, Canada in August of 1975. He grew up in a rural community consisting of beef and dairy cattle farming with both his parents raised on a farm. He helped on his grandparents' and uncle's farm while discovering his own love for agriculture at a young age. In 1993 he enrolled at the Nova Scotia Agricultural College where he graduated in 1997 with a B.S. in Agriculture with a major of Pest Management. While in college he took a position with the Nova Scotia Department of Agriculture and Marketing as a summer assistant which continued through his senior year resulting in his appointment as the intern weed science technician when his mentor Keith Silver retired. It was during this time that he learned to focus on the grower and developed his skills of extension and teaching to aid in their knowledge of weed science. During his time with NSDAM he was also granted a research contract from the Canadian Department of Agriculture to research the registration of two herbicides for processing carrot production. In the spring of 1998 Andrew received the opportunity to further his education at North Carolina State University. Upon arrival he worked in tree fruit and small fruit weed management as well as the IR-4 program with David Monks, Wayne Mitchem, and Roger Batts as he obtained his M.S. in Horticultural Science (Weed Science) which he graduated with in December 2001. He branched out to include vegetable weed management as his time at North Carolina State University continued resulting in his PhD program being based on sweetpotato weed management.

Acknowledgements

I have many people to thank for helping me with my research and taking the time to become my friend. Upon arrival at NC State I was wondering what relationship I would have with David Monks and Wayne Mitchem. They didn't treat me like hired help, instead like that of a colleague. While further expanding my knowledge of weed science they also remained close friends. To treat me so well is something I hope all graduate students have the luxury to experience. When Roger Batts joined the faculty in January of 2000 to take over the IR-4 duties from Wayne I wasn't sure how we were going to get along. We have such strong personalities I wasn't sure if we would ever have anything more than a working relationship. I was wrong. Roger has taught me so much and yet still become a close friend. For him to have so much to do and still find time to help me is something I am truly thankful for. I have truly enjoyed working with him as well as socializing with him. To work with someone that you can talk to about anything is something special. The lessons I have learned from Roger will last throughout my career. I am truly thankful for David, Wayne, and Roger and everything they have done for me. I dedicate the following pages to them and hope I have managed to meet their expectations and that I will continue to do so throughout my career.

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I would like to thank Julia Kornegay for taking over the reins of the department after Tom Monaco retired. She has kept the department going and has done a great job making the learning experience in the department second to none.

I have so many friends from home and those that I have met down here. I would like to mention them all personally but they know who they are. They have given their time to help me take my mind of things that were stressing me out. All the fun times we have spent together are something I can remember always.

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I must thank the secretaries that keep this department running. We all know that you are the ones that keep this ship afloat. Dot Duke who has retired was always a great ear to talk to. Jenny Ferrell was always willing to help when I needed something done. Betty Coleman seems to have the largest collection of forms on earth but still could find the one I needed. Barb Amos for helping me find people and being a great source of information. But the greatest thanks goes to Rachel McLaughlin. She is the one who kept me in line and kept me in the country. Her knowledge of rules and regulations makes her a target for graduate students to go ask instead of trying to find the information online. She is always friendly and helpful and for that I thank her greatly.

Thanks to all the members of the department who have made me feel apart of horticultural science, especially Robbie Wooten, the person I have shared the lab with for seven plus years. He is always a good distraction from the hours spent in front of the computer and his friendship and comedy relief was greatly appreciated.

Last but certainly not least, I would like to thank Brandy Silvey. She has helped me with my research and has become a close friend. She has taught me that I enjoy spreading what I have learned to others. I now realize that I have an ability to teach and I hope that one day I will be in a situation where I can use this ability. She is such a good person, one that everyone should strive to be like, and I must thank her for her close friendship as I know you can never have too many best friends.

To everyone I have mentioned above I thank you all. You have helped make me what I am today. I can only hope that I keep all the lessons learned from you and apply them to make things better for the growers who I will be working for.

Table of Contents

List of Tables

Page

List of Figures

Evaluation of ALS Inhibiting Herbicide Screening Trials in the Lab and the Field for Sweetpotato (*Ipomoea batatas*)

Sweetpotato (*Ipomoea batatas*) Tolerance to Halosulfuron POST[1]

ANDREW W. MACRAE, DAVID W. MONKS, ROGER B. BATTS, ALAN C. THORNTON, JONATHAN R. SCHULTHEIS, and BRANDY D. SILVEY[2]

Abstract: Studies were conducted in 2003 and 2004 to determine the effect of timing and rate of halosulfuron on sweetpotato. Halosulfuron was applied 1, 2, and 4 weeks after sweetpotato transplant (WAP) in 2003, and 2, 3, and 4 WAP in 2004. Treatments within each timing were halosulfuron at 13, 26, 39, 52, and 65 g ai/ha plus a non-treated weed-free check. Across rate, site, and cultivar in 2003, weight of the number one grade roots and marketable yield, for the 1 and 2 WAP timings of halosulfuron POST, were both reduced compared to the 4 WAP timing. In 2004, no differences were found between the 2, 3, and 4 WAP timings of halosulfuron POST for any grade of sweetpotato. Halosulfuron rates were regressed within each timing. Linear relationships were observed for all timings for number one and marketable yield. Yield of number one roots was reduced 0.71, 0.57, 0.19, and 0.19 % per 1 g/ha of halosulfuron for the 1, 2, 3, and 4 WAP timings, respectively, corresponding to a 46, 37, 12, and 12 % reduction of number one roots, respectively, for the 65 g/ha rate of halosulfuron. Marketable yield was reduced 0.55, 0.61, 0.28, and 0.19 % per 1 g/ha of halosulfuron for the 1, 2, 3, and 4

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WAP timings, respectively, corresponding to a marketable yield reduction of 46, 40, 28, and 12 %, respectively for the 65 g/ha rate of halosulfuron. Halosulfuron was found to be safe on sweetpotato if applied four wks after transplant. Halosulfuron at 39 g/ha applied 4 wks after transplant was found to reduce yield of number one and marketable roots seven percent. This yield reduction may be due to a delay in crop maturity, so with a delay in harvest time, yields may be recovered.

Nomenclature: halosulfuron; sweetpotato, *Ipomoea batatas* (L.) Lam.

Additional Index Words: Timing, rate, yield, injury.

Abbreviations: WAP, weeks after planting

INTRODUCTION

Sweetpotato [*Ipomoea batatas* (L.) Lam.] transplants are produced in propagation beds by placing storage roots on the soil surface, covering them with 7 to 10 cm soil and then placing clear polyethylene mulch over the beds (Monks et al. 1991). Sweetpotato shoots sprout and then emerge from the soil. They are cut just above the soil surface when they reach approximately 25 cm tall. These rootless plants are then transplanted using a mechanical transplanter into a production field with bedded rows (Schultheis 1998). Preplant herbicides such as EPTC or flumioxazin are usually applied after bedding but prior transplanting (Anonymous 2005c, 2005f). Preemergence herbicides such as clomazone, napropamide, or dimethenamid are usually applied after transplanting (Anonymous 2005a, 2005b, 2005d).

The preemergence herbicides registered in sweetpotatoes do not control all weed species present in the sweetpotato fields. These herbicides often do not provide season long weed control of the weeds listed on their labels (Monks, personal communication). This lack of weed control leads to the weeds being cultivated, hand pulled or cut at the soil surface, or mowed at great expense to the growers. The lack of season long weed control and limited control of all weed species present in a field often leads to growers not applying herbicides. A survey conducted by Toth et al. (1997) revealed that of those who responded, 30 % of North Carolina sweetpotato growers do not apply herbicides and 97 % use cultivation 3 to 4 times during the growing season. Thus, effective postemergence herbicides are needed to control weeds that escaped control during the growing season and to reduce the number of cultivations, mowings, or hand pulling or cutting during the season.

‘Beauregard’ is the most commonly planted cultivar of sweetpotato in North Carolina. High yielding varieties such as ‘Beauregard’ have been found to be poor competitors with weeds, with yields being reduced significantly with heavy weed infestations (La Bonte et al. 1996). Seem et al. (2003) observed that season long weed interference in ‘Beauregard’ sweetpotato would result in 85 % yield reduction. Weeds that emerged 6 weeks after transplant did not affect yield while removal of weeds before 2 weeks after transplant prevented any yield loss. This critical weed-free period (2 to 6 weeks after transplant) for sweetpotato would be the optimal time for weed control using either a POST herbicide, cultivation, hand removal or mowing to remove weeds from the crop row. However, there are currently no POST herbicides registered in sweetpotato that will control broadleaf weeds.

Yellow nutsedge (*Cyperus esculentus* L.) and purple nutsedge (*Cyperus rotundus* L.), are commonly found in sweetpotato production fields in North Carolina. Previous studies have shown that halosulfuron PRE and POST can effectively control yellow nutsedge and reduce regrowth and tuber production with rates ranging from 35 to 106 g ai/ha (Ackley et al. 1996; Blum et al. 2000; Earl et al. 2004; Ferrel et al. 2004; Nelson and Renner 2002; Vencill et al. 1995). Similar results were seen with halosulfuron PRE and POST controlling purple nutsedge and reducing regrowth and tuber production with rates ranging from 10 to 106 g/ha (Blum et al. 2000; Grichar et al. 2003; Molin et al. 1999; Rao and Reddy 1999; Vencill et al. 1995).

In a recent survey of 25 field locations (260 on-farm sample sites) in North Carolina beginning with the most common weed species, pigweed species (*Amaranthus* sp.), nutsedge species, large crabgrass [*Digitaria sanguinalis* (L.) Scop.], tropic croton (*Croton glandulosus* var. septentrionalis Muell.-Arg.), Florida pusley (*Richardia scabra* L.), common cocklebur (*Xanthium strumarium* L.), common ragweed (*Ambrosia artemisiifolia* L.), common lambsquarters (*Chenopodium album* L.), prickly sida (*Sida spinosa* L.), smartweed species (*Polygonum* sp.), groundcherry species (*Physalis* sp.), morningglory species (*Ipomoea* sp.), eastern black nightshade (*Solanum ptycanthum* Dun.), annual sedge (*Cyperus compressus* L.), common bermudagrass [*Cynodon dactylon* (L.) Pers.], and horsenettle (*Solanum carolinense* L.) were the most common weed species reported (Brill 2005). Halosulfuron has been shown to control some of these weed species. Halosulfuron PRE at 110 g/ha gave greater than 95 % control of redroot pigweed (*Amaranthus retroflexus* L.), velvetleaf (*Abutilon theophrasti* Medicus), and common lambsquarters (Brown and Masiunas 2002) 45 days after treatment. Halosulfuron PRE at 84 g/ha provided 92 % or greater control of common lambsquarters, Pennsylvania smartweed (*Polygonum pensylvanicum* L.), velvetleaf, common cocklebur, tall morningglory [*Ipomoea purpurea* (L.) Roth], and jimsonweed (*Datura stramonium* L.) (Sprague et al. 1997). Isaacs et al. (2002) observed 95 % control of common ragweed 26 days after treatment, with halosulfuron POST at 36 g/ha.

Research has documented that halosulfuron gives excellent control of yellow and purple nutsedge, and many broadleaf weeds in crops other than sweetpotato. However, halosulfuron is a member of the sulfonylurea family and certain members of the sulfonylurea herbicide family have caused foliar injury, root malformation and reduced yields even at reduced rates (Whitwell et al. 1989). Research on halosulfuron in sweetpotato is limited. Thus, the objective of this study was to determine the tolerance of sweetpotato to halosulfuron POST at different timings and rates.

MATERIALS AND METHODS

Studies were conducted in Clinton (2003 and 2004), Turkey (2003), and Faison (2004), North Carolina. The Clinton site was transplanted on June 25, 2003 and May 27, 2004 with ‘Beauregard’ and ‘Hernandez’ sweetpotato transplants on an Orangeburg loamy sand (Fine-loamy, kaolinitic, thermic Typic Kandiudults) with pH 5.8 (2003) and 5.9 (2004) and 0.7 % and 0.8 % humic matter, respectively. Plots consisted of two rows 105 cm apart by 5.5 m long. The Turkey and Faison sites were transplanted on June 4, 2003 and June 7, 2004, respectively with ‘Beauregard’ in two row plots with a 105 cm row spacing by 4.5 m long. Soil in 2003 was an Autryville loamy sand (Loamy, siliceous, subactive, thermic Arenic Paleudults) with pH 5.6 and in 2004 a Norfolk loamy sand (Fine-loamy, kaolinitic, thermic Typic Kandiudults) with pH 5.9 and 0.8 and 0.6 % humic matter, respectively.

The experiment was a factorial design with halosulfuron timing as the main effect and halosulfuron rate as the secondary effect. In 2003, the Clinton and Turkey sites had halosulfuron applied POST at 1, 2, and 4 weeks after transplant (WAP). Treatments within each timing were halosulfuron at 13, 26, 39, 52, and 65 g ai/ha plus a non-treated weed-free check. All applications of halosulfuron included a non-ionic surfactant[3] at 0.25% v/v. Applications were made using a CO_2 pressurized backpack sprayer calibrated to deliver 187 L/ha using 8003XR[4] tips at 152 kPa. Application dates at Clinton were July 4, 2003, July 13, 2003, and July 26, 2003 for the 1, 2, and 4 WAP timings, respectively. At the Turkey site the application dates were June 13, 2003, June 20, 2003, and July 9, 2003 for the 1, 2, and 4 WAP timings, respectively. In 2004 the 1 WAP timing was removed due to excessive yield loss and a 3 WAP timing was added. In 2004, the Clinton and Faison sites had halosulfuron applied POST at 2, 3, and 4 weeks after transplant (WAP). Treatments within each timing were halosulfuron at 13, 26, 39, 52, and 65 g/ha plus a non-treated weed-free check. All applications of halosulfuron included a non-ionic surfactant[3] at 0.25% v/v. Applications were made using a tractor

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[3] Induce, a mixture of alkyl aryl polyoxylkane ethers, free fatty acids, and dimothyl polysiloxane. Helena Chemical Company, 225 Schilling Boulevard, Suite 300, Collierville, TN 38017.

[4] Spraying Systems Co., P.O. Box 7900, Wheaton, IL 61089-7900.

mounted CO_2 pressurized sprayer calibrated to deliver 187 L/ha using 11003XR[4] tips at 145 kPa. Application dates at Clinton were June 11, 2004, June 18, 2004, and June 25, 2004 for the 2, 3, and 4 WAP timings, respectively. At the Faison site the application dates were June 24, 2004, July 1, 2004, and July 8, 2004 for the 2, 3, and 4 WAP timings, respectively.

In 2003, plots were maintained weed-free with hand removal and clomazone PRE at 0.63 kg/ha and napropamide PRE at 2.2 kg/ha. A single POST application of sethoxydim at 0.21 kg/ha plus crop oil at 1% v/v was also used to control grasses in the studies. In 2004, plots were maintained weed-free with hand removal and clomazone PRE at 0.63 g/ha and metolachlor PRE at 0.80 kg/ha. A single POST application of clethodim at 0.14 kg/ha plus crop oil at 1% v/v was also used for grass control.

Data recorded were visual stunting (0 = no crop injury, 100 = complete crop death) and yield by weight. Sweetpotato yield data was graded at three levels, jumbos (greater that 8.8 cm in width), ones (greater than 4.4 cm but less that 8.8 cm), and canners (greater than 1.9 cm but less than 4.4 cm) (Anonymous 2005e). Marketable yield was determined by combining the jumbo and number one grades. Data was subjected to analysis of variance at a significance level of p=0.05 and means separated using Fisher's protected LSD (SAS 2005). Where possible, data was regressed using the proc glm function in SAS (SAS 2005).

RESULTS AND DISCUSSION

Halosulfuron Timing. No timing by rate by site by cultivar interactions were observed so data were pooled over rates, sites, and cultivars. In 2003, halosulfuron applied at 1 and 2 weeks after planting (WAP) caused less visual stunting (8.6 and 7.3 %, respectively) eight wks after planting compared to the 4 WAP timing (Table 1). This observation may be due to the longer interval between application and rating, for the 1 and 2 WAP timings, allowing for the plants to recover. At 12 weeks after planting no visual stunting was observed (data not shown) as all plants had recovered from the halosulfuron.

The initial stunting seen with the 1 and 2 WAP timings may have delayed crop maturity so that when harvested, yield of ones for the 1 and 2 WAP timings were both reduced 17 % of the weed-free check compared to no reduction for the 4 WAP timing (0 %) (Table 1). Marketable yield showed the same results with the 1 and 2 WAP timings having reduced yields (84 % of the weed-free check) compared to the 4 WAP timing (101 %). In 2004, the 1 WAP timing was dropped and replaced with the 3 WAP timing. Stunting for halosulfuron across all timings ranged from 10 to 12 %. However, no differences were found between the 2, 3, and 4 WAP timings for visual stunting or any grade of sweetpotato. A trend existed for reduced marketable yield with the 2 and 3 WAP timings having 87 % of the weed-free check yield and the 4 WAP timing having 96 % of the weed-free check yield. Unlike 2003, in 2004 the sweetpotato plants may have recovered in time for harvest, thus limiting the amount of yield loss. These results suggest that any yield loss seen may in fact be a delay in crop maturity and further studies are necessary to determine if delaying harvest would produce a mature crop and maximize yields.

<u>Halosulfuron Rate.</u> The halosulfuron rate data were split into the individual timings to determine if there was a rate response within any of the four halosulfuron timings. No

rate by year by site by cultivar interactions were observed so data were pooled over year, site and cultivar and regressed to obtain dose response curves relative to sweetpotato injury and yield. Sweetpotato stunting was observed to have a linear response for all timings of halosulfuron. The 1, 2, 3, and 4 WAP timings of halosulfuron had responses of 0.14, 0.21, 0.26, and 0.25 % stunting per g ai/ha of halosulfuron, respectively (Figure 1) when rated 8 wks after transplant. The larger slopes for the 3 and 4 WAP timings may be related to less recovery time from application to the rating data. For all treatments of halosulfuron no stunting was observed 12 wks after transplant (data not shown).

A linear relationship was found at all timings for the effect of halosulfuron rate on the reduction in yield of number one sweetpotatoes. When halosulfuron was applied 1 and 2 WAP, yield of number one roots was reduced 0.71 and 0.57 %, respectively, per 1 g /ha of halosulfuron applied (Figure 2) corresponding to a 46 and 37 % reduction in yield, respectively, for the 65 g/ha rate of halosulfuron, the maximum rate tested. The 3 and 4 WAP timings of halosulfuron reduced yield of number one roots 0.19 % per g/ha of halosulfuron. The 65 g/ha rate of halosulfuron would reduce yield of number one roots 12 % for the 3 and 4 WAP timings. However, the proposed field rate of halosulfuron is 39 g/ha and at this rate yield of number one roots would be reduced 7 %.

The effect of halosulfuron rate on marketable yield was found to have a linear response for all timings. The 1 and 2 WAP timings of halosulfuron reduced marketable yield 0.70 and 0.61 %, respectively, per 1 g/ha of halosulfuron corresponding to a 46 and 40 % reduction in yield, respectively, of marketable roots for the 65 g/ha rate of halosulfuron, the maximum rate tested. The 3 WAP timing reduced yield of marketable roots 0.28 %

per 1 g/ha of halosulfuron, an 18 % reduction in yield for the 65 g/ha rate of halosulfuron. The 4 WAP timing reduced yield of marketable roots 0.19 % per 1 g/ha of halosulfuron resulting in a 12 % reduction in yield of marketable roots with the 65 g/ha rate of halosulfuron. With the proposed field rate of halosulfuron being 39 g/ha, this would be a 7 % reduction in marketable yield. This reduction in yield may be caused by a delay in crop maturity and may be recovered if the plants remained in the field longer than our time of harvest.

Our results show that halosulfuron is safe on sweetpotatoes if applied four wks after transplanting. Applying 65 g/ha of halosulfuron four wks after transplant may reduce yield 12 %. Grichar et al. (2003) observed that halosulfuron POST at 33 g/ha provided 95 % control of purple nutsedge. Nelson and Renner (2002) observed 97 % control, 100 % reduction in shoot density and dry weight, and an 83 % reduction in height of yellow nutsedge with halosulfuron POST at 35 g/ha. They also found a reduction in tubers of 95 % and tuber sprouting was reduced 19 % compared to the non-treated control. With a proposed halosulfuron rate of 39 g/ha applied four wks after transplant, we could expect excellent control of yellow and purple nutsedge with our predictive curve showing a yield loss of 7 %. This yield loss may in fact be a delay in crop maturity that could be recovered if the plants were harvested later than normal. Further study is needed to determine if halosulfuron will delay crop maturity.

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Table 1. Sweetpotato injury and yield in 2003 and 2004 by halosulfuron timing combined across site, cultivar and rate.

Halosulfuron timing	Sweetpotato stunting[b]		Sweetpotato yield							
			Jumbos		Ones		Canners		Marketable	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
WAP[a]	—— % ——		——————— % of the weed-free check ———————							
1	9	——	119	——	83	——	84	——	84	——
2	7	10	112	61	83	97	85	123	84	87
3	——[c]	11	——	78	——	94	——	117	——	87
4	16	12	136	68	100	102	82	121	101	96
LSD (<0.05)	2	NS	NS	NS	12	NS	NS	NS	12	NS
Weed-free check value (t/ha)			1.7	10.2	23.7	20.5	10.1	5.6	25.3	30.6

[a] WAP = weeks after planting.

[b] Stunting based on visual scale of 0% = no stunting, 100% = crop death.

[c] Dashes indicate that this timing was not studied in the year's trials.

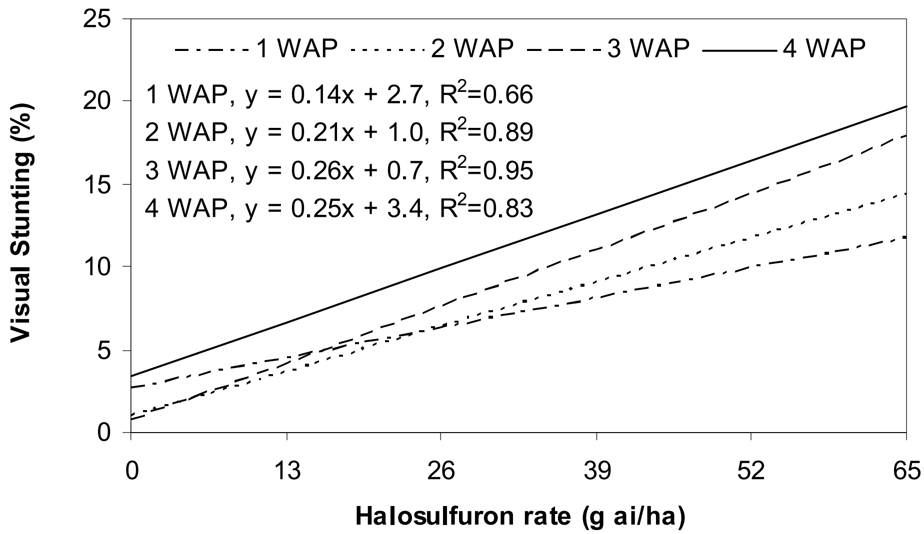

Figure 1. Sweetpotato stunting by halosulfuron rate for the 1, 2, 3 and 4 WAP timings combined across year (2 and 4 WAP timings), site and cultivar rated 8 wks after transplant.

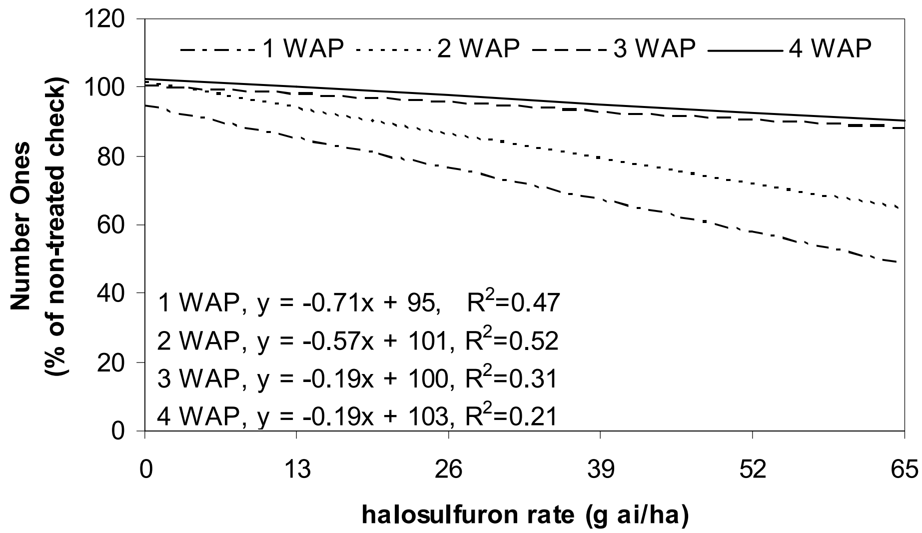

Figure 2. Sweetpotato yield of number ones by halosulfuron rate for the 1, 2, 3 and 4 WAP timings combined across year (2 and 4 WAP timings), site and cultivar.

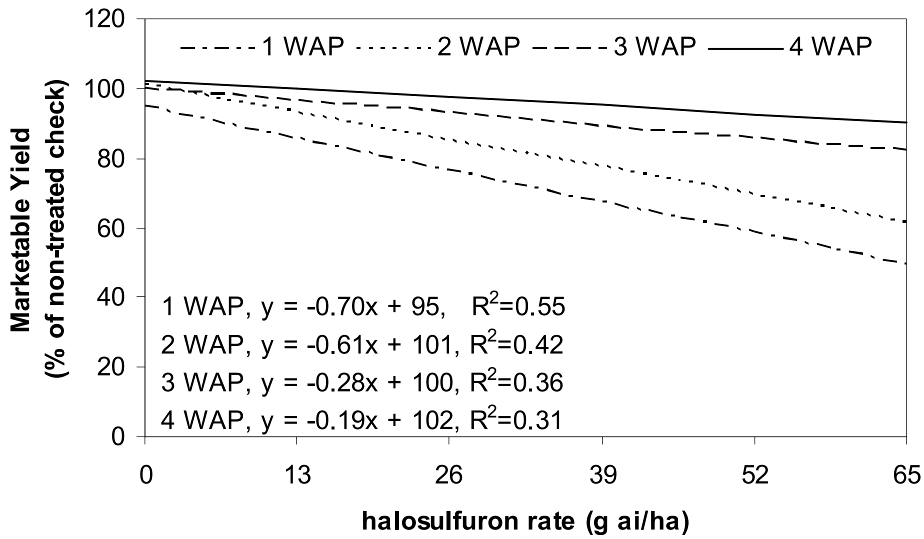

Figure 3. Sweetpotato marketable yield by halosulfuron rate for the 1, 2, 3 and 4 WAP timings combined across year (2 and 4 WAP timings), site and cultivar.

Sweetpotato (*Ipomoea batatas*) Tolerance to Thifensulfuron POST[5]

ANDREW W. MACRAE, DAVID W. MONKS, ROGER B. BATTS, and ALAN C. THORNTON[6]

Abstract: Trials were conducted at two locations in each of 2003 and 2004 to determine the timing and rate of thifensulfuron that are safe to sweetpotato. Thifensulfuron was applied 1, 2, and 4 weeks after transplanting (WAP) in 2003 and 4, 6, and 8 WAP in 2004. Within each timing, thifensulfuron treatments were 1.1, 2.1, 3.2, 4.3, and 8.5 g ai/ha plus a non-treated weed-free check. The 1 and 2 WAP timings of thifensulfuron reduced yield of number one and marketable roots greater than 25 %. The 4, 6, and 8 WAP timings had less than 15 % reduction in yield with the 6 WAP timing reducing yield of number one and marketable roots 5 and 7 %, respectively. The 4 WAP timing had yield loss of number one and marketable roots of less than 10 % for the 1.1 g/ha rate of thifensulfuron increasing to 52 % for the 8.5 g/ha rate. The 6 and 8 WAP timings had sporadic yield reduction with no rate response being observed. Application of 4.5 g/ha of thifensulfuron at 6 or 8 wks after transplant would allow for control of problematic weed species while only having a risk of yield loss of 10 %. This yield loss may in fact be a

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delay in crop maturity that could be recovered if the sweetpotato harvest was delayed to allow the optimal amount of number one grade roots to form.

Nomenclature: thifensulfuron; sweetpotato, *Ipomoea batatas* (L.) Lam.

Additional Index Words: injury, yield, timing, rate.

Abbreviations: WAP, weeks after planting.

INTRODUCTION

Weed escapes are common place in North Carolina sweetpotato [*Ipomoea batatas* (L.) Lam.] production fields. The PRE herbicides registered in sweetpotato do not provide season long control of many broadleaf weed species including pigweeds (*Amaranthus* sp.). With no POST products registered for control of broadleaf weeds in sweetpotato, growers often have to depend on hand removal to prevent any yield reduction.

High yielding cultivars such as 'Beauregard' have been found to be poor competitors with weeds, with yields being reduced significantly with heavy weed infestations (La Bonte et al. 1996). 'Beauregard' is the most commonly planted cultivar of sweetpotato in North Carolina. Seem et al. (2003) observed that season long weed interference in 'Beauregard' sweetpotato would result in 85 % yield reduction. Weeds that emerged 6 weeks after transplant did not affect yield while removal of weeds before 2 weeks after transplant prevented any yield loss. This critical weed-free period (2 to 6 weeks after transplant) for sweetpotato would be the optimal time for application of a postemergence herbicide to remove weeds from the crop row.

Palmer amaranth (*Amaranthus palmeri* S. Wats.) is one of the most troublesome weeds in North Carolina sweetpotato production fields. Brill (2005) conducted a recent survey in 25 sweetpotato production fields (260 on-farm sample sites) in North Carolina and observed that pigweed species, including Palmer amaranth, are the most common weeds in North Carolina sweetpotato fields. Palmer amaranth is a dioecious summer annual herb with branched erect stems often exceeding 100 cm tall. It grows up through the sweetpotato crop canopy and is capable of growing 6.25 cm per day making it highly competitive with sweetpotato (Monks, personal communication). The inflorescence is an open panicle with a terminal branch up to 50 cm tall (Lorenzi and Jeffery 1987). The allelopathic effects of Palmer amaranth have also been documented (Menges 1987 and 1988). Menges (1987) observed a reduction in growth of 49 and 68 % for carrot (*Daucus carota* L.) and onion (*Allium cepa* L.), respectively, with Palmer amaranth biomasses of 5.1 and 8.5 kg/ m^2. Menges (1988) reported that sorghum [*Sorghum bicolor* (L.) Moench.] root growth was inhibited a minimum of 17, 24, and 29 % with the 4, 8, and 16 thousand ppm concentrations of Palmer amaranth in soil, respectively. One cabbage (*Brassica oleracea* L.) cultivar was found to have root inhibition of a minimum 19, 32, and 38 % with the 4, 8, and 16 thousand ppm concentrations of Palmer amaranth, respectively (Menges 1988). The 16,000 ppm concentration of Palmer amaranth is approximately 50 % of the maximum concentrations encountered under field conditions (Menges 1987). Palmer amaranth can reduce yield of sweetpotato over 50 % (Monks, personal communication). Thifensulfuron POST is effective at controlling Palmer amaranth. Mayo et al. (1995) observed thifensulfuron POST at 4 g ai/ha providing 87 % or greater control of Palmer amaranth in soybean [*Glycine max* (L.) Merr].

Thifensulfuron also controls other *Amaranthus* species found in Southeastern sweetpotato production fields. Mayo et al. (1995) observed 98 % or greater control of common waterhemp (*Amaranthus rudis* Sauer), redroot pigweed (*Amaranthus retroflexus* L.), and tumble pigweed (*Amaranthus albus* L.) with thifensulfuron POST at 4 g/ha in soybean. Sweat et al. (1998) observed similar results with thifensulfuron POST at 4.5 g/ha providing 89 % or greater control of redroot pigweed and tumble pigweed in soybean. Simpson and Stoller (1995) observed 95 % control of smooth pigweed (*Amaranthus hybridus* L.) with thifensulfuron POST at 4.4 g/ha in soybean. Manley et al. (1996) observed 82 to 95 % control of 13 to 25 cm tall smooth pigweed with thifensulfuron POST at 4 g/ha.

Common lambsquarters (*Chenopodium album* L.) and common cocklebur (*Xanthium strumarium* L.) are also troublesome weeds in North Carolina sweetpotato production fields (Brill 2005). They ranked sixth and eighth, respectively, for the most common weeds observed in a recent survey of North Carolina sweetpotato fields (Brill 2005). Common lambsquarters and common cocklebur were controlled 88 and 80 %, respectively, with thifensulfuron POST at 4.4 g/ha (Simpson and Stoller 1995). Parks et al. (1995) observed 94 % or greater control of common lambsquarters 12 weeks after planting corn (*Zea mays* L.) with thifensulfuron POST at 3 or 4 g/ha. This control reduced common lambsquarters density and biomass a minimum of 87 and 97 %, respectively. Thus, thifensulfuron POST has great potential for control of the common broadleaf weeds found in North Carolina sweetpotato fields. The objective of this study was to evaluate the sweetpotato tolerance to thifensulfuron POST and to determine the least injurious timing and rate that would minimize injury and/or yield loss.

MATERIALS AND METHODS

Four trials were conducted, two in Clinton and Turkey, North Carolina in 2003 and two in Clinton and Dunn in 2004. The Clinton site was planted on June 25, 2003 and May 19, 2004 with 'Beauregard' and 'Hernandez' in two row plots (105 cm row spacing) 5.5 m long on an Orangeburg loamy sand (Fine-loamy, kaolinitic, thermic Typic Kandiudults) with pH 5.8 (2003) and 5.9 (2004) and less than 2 % OM. The Turkey and Dunn sites were planted on June 4, 2003 and May 26, 2004, respectively, with 'Beauregard' at Turkey and 'Hernandez' at Dunn, in two row plots (105 cm row spacing) 4.5 m long on an Autryville loamy sand (Loamy, siliceous, subactive, thermic Arenic Paleudults) with pH 5.6 (2003) and 6.0 (2004) and less than 2 % OM.

The experiment was a factorial design with thifensulfuron timing as the main effect and thifensulfuron rate as the secondary effect. In 2003, the Clinton and Turkey sites had thifensulfuron POST at 1, 2, and 4 weeks after transplant (WAP). Treatments within each timing were thifensulfuron at 1.1, 2.1, 3.2, 4.3, and 8.5 g ai/ha plus a non-treated weed-free check. Thifensulfuron treatments included a non-ionic surfactant[7] at 0.25% v/v. Thifensulfuron treatments were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 187 L/ha using 8003XR[4] tips at 152 kPa. The application dates at the Clinton site were July 4, 2003, July 13, 2003, and July 26, 2003 for the 1, 2, and 4

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[7] Induce, a mixture of alkyl aryl polyoxylkane ethers, free fatty acids, and dimothyl polysiloxane. Helena Chemical Company, 225 Schilling Boulevard, Suite 300, Collierville, TN 38017.

WAP timings, respectively. The application dates at the Turkey site were June 13, 2003, June 20, 2003, and July 9, 2003 for the 1, 2, and 4 WAP timings, respectively. In 2004, the Clinton and Dunn sites had thifensulfuron POST at 4, 6, and 8 WAP. Treatments within each timing were thifensulfuron at 1.1, 2.1, 3.2, 4.3, and 8.5 g/ha plus a non-treated weed-free check. Thifensulfuron treatments included a non-ionic surfactant[3] at 0.25% v/v. Thifensulfuron treatments were applied using a tractor mounted CO_2 pressurized sprayer calibrated to deliver 187 L/ha using 11003XR[8] tips at 145 kPa. The application dates at the Clinton site were June 17, 2004, July 1, 2004, and July 15, 2004 for the 4, 6, and 8 WAP timings, respectively. At the Dunn site the application dates were June 26, 2004, July 10, 2004, and July 24, 2004 for the 4, 6, and 8 WAP timings, respectively.

In 2003, plots were maintained weed-free with hand removal clomazone at 0.63 kg/ha plus napropamide at 2.2 kg/ha PRE. Sethoxydim POST at 0.21 kg/ha plus crop oil at 1% v/v was also used to remove grasses from the test plots. In 2004, plots were maintained weed-free with hand removal and clomazone at 0.63 kg/ha plus metolachlor at 0.80 kg/ha PRE. Clethodim POST at 0.14 kg/ha plus crop oil at 1% v/v was also used for grass control.

Data taken were visual stunting (0 = no crop injury, 100 = complete crop death) and yield by weight. Sweetpotato yield data was graded at three levels, jumbos (greater that 8.8 cm in width), ones (greater than 4.4 cm but less that 8.8 cm), and canners (greater than 1.9 cm but less than 4.4 cm) (Anonymous 2005). Marketable yield was determined

[8] Spraying Systems Co., P.O. Box 7900, Wheaton, IL 61089-7900.

by combining the jumbo and number one grade roots. Data was subjected to analysis of variance at a significance level of p=0.05 and means separated using Fisher's protected LSD (SAS 2005). Where possible, data was regressed using the proc glm function in SAS (SAS 2005).

RESULTS AND DISCUSSION

Thifensulfuron Timing. No year by site by timing by rate by cultivar interaction was observed so data was pooled over years, sites, rates and cultivars. Number one roots and marketable yield were found to have a quadratic relationship for thifensulfuron timing (Figure 1). Number ones and marketable yield had similar curves with thifensulfuron applied 1 WAP reducing yield of ones and marketable roots 38 and 40 %, respectively, compared to the non-treated weed-free check. Thifensulfuron applied 2 WAP reduced yield of number one and marketable roots greater than 25 %. The 4, 6, and 8 WAP had less than 15 % reduction in number ones and marketable yield. Sweetpotato treated with thifensulfuron 6 WAP had yield of number one and marketable roots equaling 95 and 93 %, respectively, of the non treated check

Thifensulfuron Rate. No year by site by rate by cultivar interaction was observed so data was pooled over years, sites, and cultivars. A quadratic relationship was fit to the visual stunting data for each of the five timings tested (Figure 2). The 8 WAP timing had the greatest level of stunting when the sweetpotato vines were visually rated for stunting 12 wks after transplant (Figure 2). Injury increased from 2.8 to 23.5 % from the 1.1 to the 8.5 g ai/ha rate of thifensulfuron applied 8 WAP. The sweetpotato plants in the 8 WAP treatments had less time to recover than the earlier application timings before the time of rating. The 4 and 6 WAP timings showed levels of injury increasing from approximately 1 to 10 % for the 1.1 and 8.5 g/ha rates of thifensulfuron, respectively (Figure 2). The 1 and 2 WAP timings of thifensulfuron showed greater injury levels than the 4 and 6 WAP timings. Thifensulfuron at 2.1, 3.2, and 4.3 g/ha applied 1 WAP showed approximately 5 % more stunting than the 4 and 6 WAP timings (Figure 2). The 2 WAP timing of thifensulfuron showed levels of stunting in excess of 10 % for the 3.2, 4.3, and 8.5 g/ha of thifensulfuron (Figure 2). The 1 and 2 WAP timing treatments had the most time to recover before rating, however they showed more injury than the 4 and 6 WAP timings. This result shows that the level of stunting of the vines was severe after application of the 1 and 2 WAP timings.

The 1, 2, and 4 WAP timings were found to have a quadratic relationship for yield of number one and marketable roots. The 1 WAP timing treatment had number one and marketable roots yield reduction of 23 % (Figure 3) and 24% (Figure 4),respectively compared to the non-treated weed-free check, for the 1.1 g/ha rate of thifensulfuron. This increased to 56 % for the projected thifensulfuron rate of 7 g/ha (Figures 3 and 4). The maximum rate of thifensulfuron tested, 8.5 g/ha, applied 1 WAP caused a 52 % reduction in yield of number one and marketable roots (Figures 3 and 4). Thifensulfuron applied 2 and 4 WAP showed similar levels of yield reduction to one another with the 1.1 g/ha rate reducing yield of number one and marketable roots less than 10 % and increasing to approximately 30 % for the 8.5 g/ha rate of thifensulfuron (Figures 3 and 4). A curve could not be fit to the 6 and 8 WAP timings data for either number one roots or marketable yield. The 2.1, 3.2, and 8.5 g/ha rates of thifensulfuron reduced yield of number one roots when applied 6 WAP, however the 1.1 and 4.3 g/ha rates did not. The 1.1, 2.1, 3.2, and 8.5 g/ha rates of thifensulfuron reduced yield of marketable roots when applied 6 WAP, however the 4.3 g/ha rate did not. Similar results were seen with the 8 WAP timing with the 2.1 and 8.5 g/ha rates of thifensulfuron reducing yield of number one roots while the 1.1, 2.1, and 4.3 g/ha rates did not. The 2.1 and 8.5 g/ha rates of thifensulfuron reduced yield of marketable roots when applied 8 WAP, however the 1.1, 3.2, and 4.3 g/ha rates did not.

The reductions in yield of number one and marketable roots observed with the 6 and 8 WAP timings and the 1.1 g/ha rate of thifensulfuron for the 4 WAP timing may be due to a delay in crop maturity. If harvest was delayed the crop may have time to recover and produce and optimal number of number one and marketable roots. Thifensulfuron at 4 to 4.5 g/ha has been shown to provide 87 % or greater control of pigweed species including Palmer amaranth (Mayo et al. 1995; Simpson and Stoller 1995; Sweat et al 1998). Pigweed species are problematic in sweetpotato production fields. With yield loss in excess of 50 % being expected with a moderate density of these weeds (Monks, personal communication), an application of thifensulfuron at 4 to 4.5 g/ha 6 to 8 wks after transplant would provide control of these weeds with only the possibility of a 10 % yield reduction. Further study is needed to determine if yield reduction from thifensulfuron can be eliminated by delaying harvest to further the crop's maturity.

Acknowledgements

We thank Dr. Cavell Brownie, Department of Statistics, North Carolina State University, for her expert statistical assistance. We also appreciate the assistance of the Clinton Horticultural Crops Research Station personnel and the grower Mr. Roger Lane for the use of his production fields to conduct this research.

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Table 1. Sweetpotato yield in 2003 and 2004 by thifensulfuron for the 6 and 8 WAP timings combined across site and cultivar.

Thifensulfuron rate	Sweetpotato yield			
	6 WAP		8 WAP	
	Ones	Marketable	Ones	Marketable
g ai/ha	——————— t/ha ———————			
0	23.2	26.5	19.5	22.1
1.1	20.5	21.8	18.8	20.2
2.1	17.4	19.5	16.5	18.6
3.2	18.8	21.6	19.2	20.0
4.3	22.0	23.8	18.7	19.8
8.5	17.3	18.4	15.6	16.6
LSD ($p<0.05$)	3.0	2.8	2.6	2.8

[a] WAP = weeks after planting.

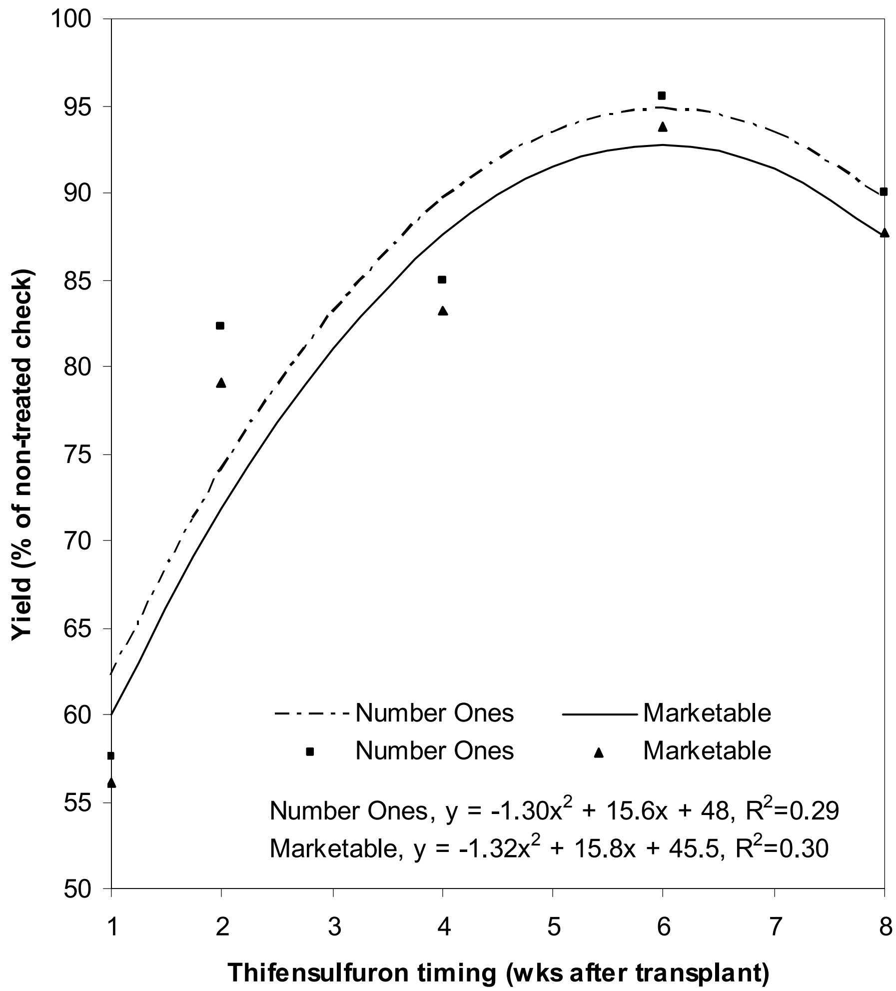


Figure 1. Number one roots and marketable yield by thifensulfuron timing pooled over year, site, rate, and cultivar.

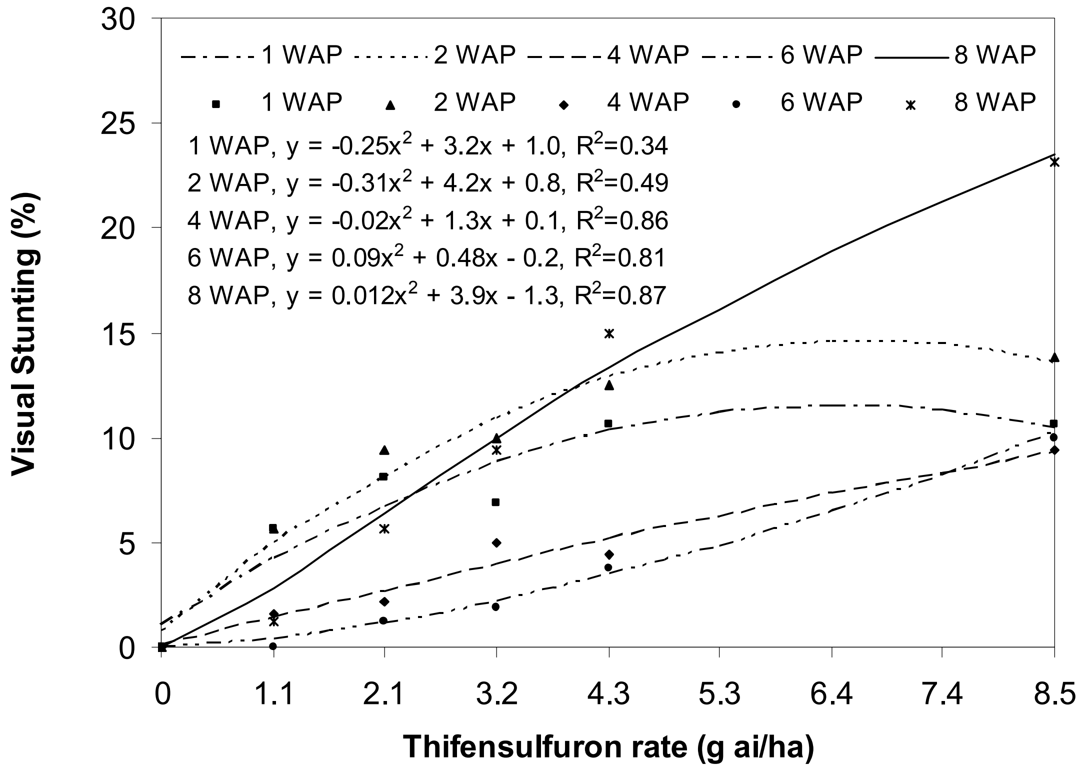


Figure 2. Visual stunting by thifensulfuron rate for the 1, 2, 4, 6, and 8 WAP timings pooled over year, site, and cultivar. Visual stunting (0 = no stunting, 100 = crop death) data recorded 12 wks after transplanting.

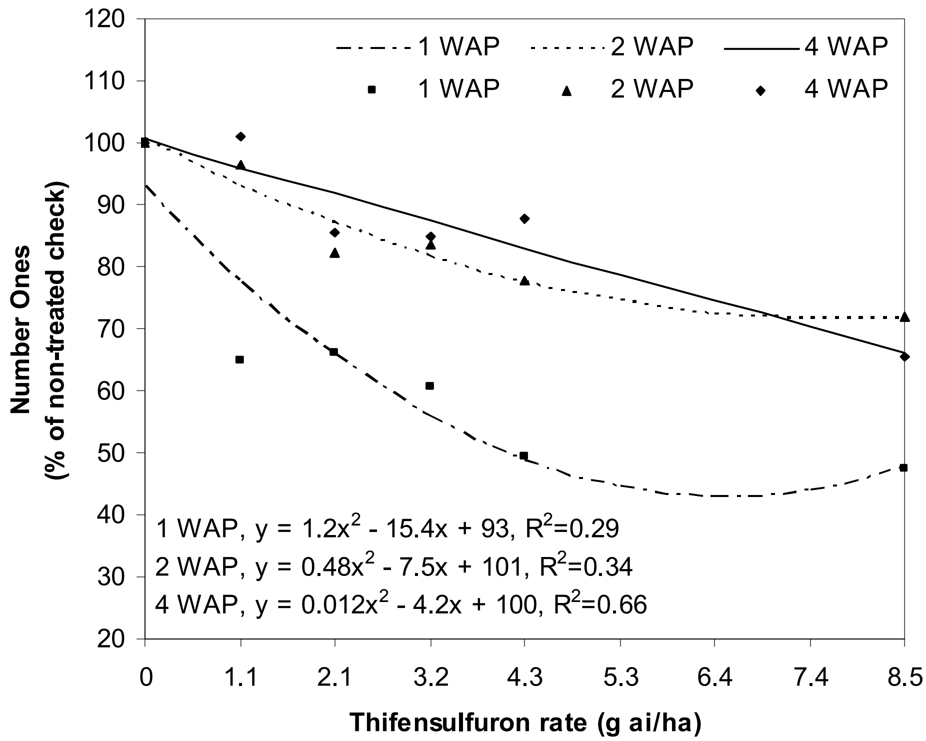
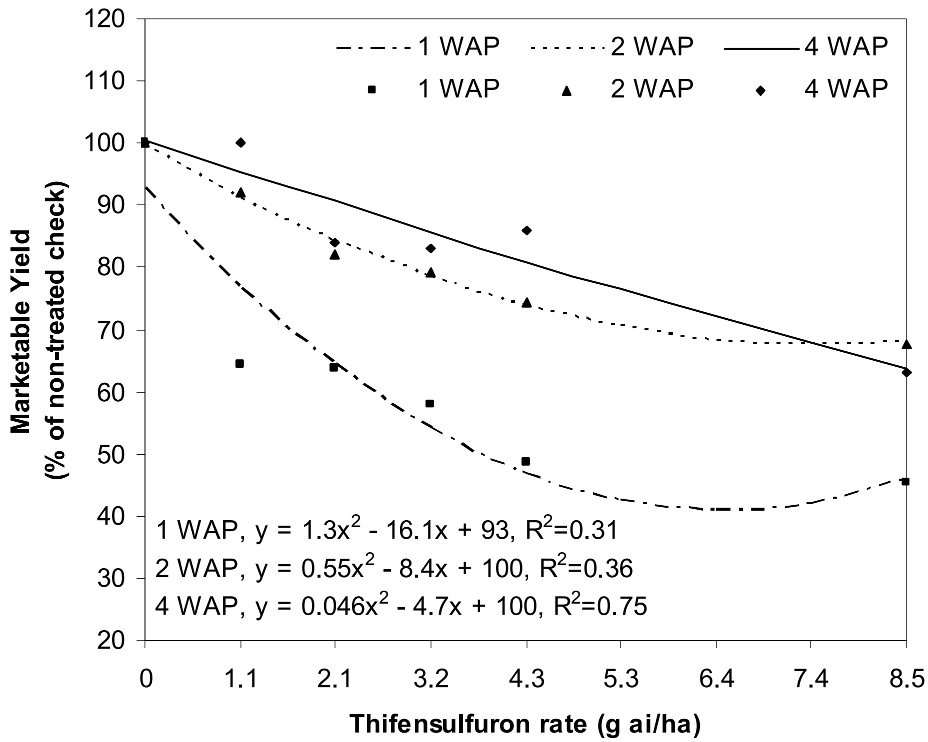


Figure 3. Yield of number one roots by thifensulfuron rate for the 1, 2, and 4 WAP timings pooled over year, site, and cultivar.



igure 4. Marketable yield by thifensulfuron rate for the 1, 2, and 4 WAP timings pooled over year, site, and cultivar.

Sweetpotato (*Ipomoea batatas*) Tolerance to Trifloxysulfuron POST[9]

ANDREW W. MACRAE, DAVID W. MONKS, ROGER B. BATTS, ALAN C. THORNTON, JOHN W. WILCUT, and DAVID L. JORDAN[10]

Abstract: Trials were conducted in 2003 and 2004 to determine the timing and rate of trifloxysulfuron that was the least injurious and caused the least amount of yield reduction in sweetpotato. In 2003 the timings of trifloxysulfuron were 1, 2, and 4 weeks after planting (WAP). Due to the injury and yield reduction observed for the 1 and 2 WAP timings, in 2004 the timings were 4, 6, and 8 WAP. Within each timing, the trifloxysulfuron rates were 1.1, 2.1, 3.2, 4.3, and 8.5 g ai/ha plus a weed-free check. The 1 and 2 WAP timings of trifloxysulfuron reduced yield of number one and marketable roots greater than 50 %. The 4 WAP timing reduced number one roots and marketable yield approximately 15 % while the 6 and 8 WAP timings did not reduce yield of any grade of sweetpotato. Using the quadratic relationship found for trifloxysulfuron timing, application at 5 WAP would only reduce marketable yield two percent. Trifloxysulfuron applied 4 WAP at 2.1 g/ha reduced yield of number one and marketable roots 12 %. These results may be due to a delay in crop maturity caused by trifloxysulfuron application, this delay may be recovered by delaying harvest until an optimal number of

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number one roots are produced. Trifloxysulfuron is safe to apply to sweetpotatoes at six and eight wks after transplant and according to our predictive curve for trifloxysulfuron timing, it is safe to apply 5 wks after transplant.

Nomenclature: trifloxysulfuron; sweetpotato, *Ipomoea batatas* (L.) Lam.

Additional Index Words: injury, yield.

Abbreviations: WAP, weeks after planting.

INTRODUCTION

Sweetpotato [*Ipomoea batatas* (L.) Lam.] production relies on PRE herbicides and cultivation for control of broadleaf weeds. While POST herbicides are available for the control of annual grasses, there are currently no POST herbicides available for control of broadleaf weeds. Currently registered PRE herbicides do not provide season long control of broadleaf weeds (Monks, personal communication). This lack of control has resulted in some growers avoiding herbicide use and relying on cultivation for weed control in sweetpotato production fields. A survey conducted by Toth et al. (1997) revealed that of those growers who responded, 30 % of North Carolina sweetpotato growers do not apply herbicides while 97 % use cultivation an average of 3.4 times during the growing season. Weeds that escape herbicides and cultivation are managed by mowing or hand removal. Mowing is not highly effective since the mower must be maintained at a height above the crop canopy allowing for regrowth of the weeds. Removing weeds by hand is costly with growers often spending 200 dollars per hectare or more to control escaped weeds (Thornton, personal communication).

Brill (2005) recently conducted a survey in 25 sweetpotato production fields (260 on-farm sample sites) in North Carolina and beginning first with the most common weed species found pigweed species (*Amaranthus* sp.), nutsedge species, large crabgrass [*Digitaria sanguinalis* (L.) Scop.], tropic croton (*Croton glandulosus* var. septentrionalis Muell.-Arg.), Florida pusley (*Richardia scabra* L.), common cocklebur (*Xanthium strumarium* L.), common ragweed (*Ambrosia artemisiifolia* L.), common lambsquarters (*Chenopodium album* L.), prickly sida (*Sida spinosa* L.), smartweed species (*Polygonum* sp.), groundcherry species (*Physalis* sp.), morningglory species (*Ipomoea* sp.), eastern black nightshade (*Solanum ptycanthum* Dun.), annual sedge (*Cyperus compressus* L.), common bermudagrass [*Cynodon dactylon* (L.) Pers.], and horsenettle (*Solanum carolinense* L.) as being the most common weed species reported.

'Beauregard' is the most commonly planted cultivar of sweetpotato in North Carolina. High yielding cultivars of sweetpotato have been found to be poor competitors with weeds as yields are reduced significantly with heavy weed infestation. (La Bonte et al. 1996). Heavy weed infestations can cause a 85 % reduction in the yield of 'Beauregard' (Seem 2003). Seem (2003) found that the critical weed-free period for 'Beauregard' sweetpotato was two to six weeks after transplanting. Weeds that emerged after six weeks from transplant did not reduce yield. The two to six week critical weed-free interval would be the optimum time to control emerged broadleaf weeds using cultivation or a POSt herbicide.

Trifloxysulfuron, trade name Envoke, is currently registered for POST application in cotton, sugarcane, and transplanted tomato (Florida only) (Anonymous 2005). If proven safe on sweetpotatoes it could provide effective control of many troublesome weeds in North Carolina production fields. Trifloxysulfuron POST at 7.5 g/ha was found to provide 97 and 88 % control of common ragweed and sicklepod [*Senna obtusifolia* (L.) Irwin and Barnaby] (Porterfield et al. 2002a). Richardson et al. (2004) observed 87 % control of common ragweed and 96 % or greater control of smooth pigweed (*Amaranthus hybridus* L.), common lambsquarters, and common cocklebur with 7.5 g/ha of trifloxysulfuron POST.

Morningglory (*Ipomoea* sp.) can be problematic in North Carolina sweetpotato production since they are genetically related to sweetpotatoes (*Ipomoea batatas*) and have a similar vining growth habit. Siebert et al. (2004) observed 97 % control of red morningglory (*Ipomoea coccinea* L.) 14 days after treatment with trifloxysulfuron POST at 20 g ai/ha. Porterfield et al. (2002) observed 96, 90, and 80 % control of entireleaf morningglory (*Ipomoea hederacea* var. *integriuscula* Gray), tall morningglory [*Ipomoea purpurea* (L.) Roth], and pitted morningglory (*Ipomoea lacunosa* L.) with trifloxysulfuron POST at 7.5 g/ha. Similar results were observed by Richardson et al. (2004) with 7.5 g/ha of trifloxysulfuron POST providing over 90 % of a mixture of ivyleaf, pitted, and tall morningglory. With limited POST options in sweetpotato, our objective was to evaluate the sweetpotato tolerance to trifloxysulfuron POST and to determine the least injurious timing and rate that would minimize injury and/or yield loss.

MATERIALS AND METHODS

Four trials were conducted in Clinton and Turkey, North Carolina in 2003 and 2004.

The Clinton site was planted on June 25, 2003 and May 19, 2004 with two cultivars (‘Beauregard’ and ‘Hernandez’) in two row plots (105 cm row spacing) 5.5 m long on an Orangeburg loamy sand (Fine-loamy, kaolinitic, thermic Typic Kandiudults) with pH 5.8 (2003) and 5.9 (2004) and 0.7 and 0.8 % humic matter, respectively. The Turkey sites were planted on June 4, 2003 and June 22, 2004, respectively, with one cultivar (‘Beauregard’) on two row plots (105 cm row spacing) 4.5 m long. Soil in 2003 was an Autryville loamy sand (Loamy, siliceous, subactive, thermic Arenic Paleudults) with pH 5.6 and in 2004 a Norfolk loamy sand (Fine-loamy, kaolinitic, thermic Typic Kandiudults) with pH 5.9 both with 0.8 % humic matter.

The experiment was a factorial design with trifloxysulfuron timing as the main effect and trifloxysulfuron rate as the secondary effect. In 2003, trifloxysulfuron was applied POST at 1, 2, and 4 weeks after sweetpotato transplant (WAP). Treatments within each timing were trifloxysulfuron at 1.1, 2.1, 3.2, 4.3, and 8.5 g ai/ha plus a weed-free check. All trifloxysulfuron treatments included a non-ionic surfactant[11] at 0.25% v/v. Applications were made using a CO_2 pressurized backpack sprayer calibrated to deliver 187 L/ha using 8003XR[12] tips at 152 kPa. The application dates at the Clinton site were July 4, 2003, July 13, 2003, and July 26, 2003 for the 1, 2, and 4 WAP timings, respectively. At the Turkey site the application dates were June 13, 2003, June 20, 2003, and July 9, 2003 for the 1, 2, and 4 WAP timings, respectively. In 2004, trifloxysulfuron

[11] Induce, a mixture of alkyl aryl polyoxylkane ethers, free fatty acids, and dimothyl polysiloxane. Helena Chemical Company, 225 Schilling Boulevard, Suite 300, Collierville, TN 38017.

[12] Spraying Systems Co., P.O. Box 7900, Wheaton, IL 61089-7900.

was applied POST at 4, 6, and 8 weeks after sweetpotato transplant (WAP). Treatments within each timing were trifloxysulfuron at 1.1, 2.1, 3.2, 4.3, and 8.5 g/ha plus a weed-free check. All applications of trifloxysulfuron included a non-ionic surfactant[3] at 0.25% v/v. Applications were made using a tractor mounted CO_2 pressurized sprayer calibrated to deliver 187 L/ha using 11003XR[4] tips at 145 kPa. The application dates at the Clinton site were June 17, 2004, July 1, 2004, and July 15, 2004 for the 4, 6, and 8 WAP timings, respectively. At the Turkey site the application dates were July 20, 2004, August 3, 2004, and August 19, 2004 for the 4, 6, and 8 WAP timings, respectively.

In 2003, plots were maintained weed-free with hand removal and a PRE application of clomazone at 0.63 kg/ha plus napropamide at 2.2 kg/ha. Sethoxydim POST at 0.21 kg/ha plus crop oil at 1% v/v was also used to remove grasses from the test plots. In 2004, plots were maintained weed-free with hand removal and a PRE application of clomazone at 0.63 kg/ha plus metolachlor at 0.80 kg/ha. Clethodim POST at 0.14 kg/ha plus crop oil at 1% v/v was also used for grass control.

Data taken were visual stunting (0 = no crop injury, 100 = complete crop death) and yield by weight. Sweetpotato yield data was graded at three levels, jumbos (greater that 3.5 inches in width), ones (greater than 1.75 inches but less that 3.5 inches), and canners (greater than 0.75 inches but less than 1.75 inches) (Anonymous 2005b). Marketable yield was determined by combining jumbo and number one grades. Data was subjected to analysis of variance at a significance level of p=0.05 and means separated using Fisher's protected LSD (SAS 2005). Where possible, data was regressed using the proc glm function in SAS (SAS 2005).

RESULTS AND DISCUSSION

Trifloxysulfuron Timing. No year by site by timing by rate by cultivar interaction was observed so data was pooled over years, sites, rates, and cultivars. A quadratic relationship was discovered for number one roots and marketable yield plotted against trifloxysulfuron timing (Figure 1). Number one and marketable yield both had similar curves with the 1 WAP timing predicting yields less than 30 % of the non-treated check. The 2 WAP timing showed a predicted yield of approximately 50 % of the non-treated check for both number one roots and marketable yield. The 4 WAP timing had a great increase in predicted yield of number one roots and marketable yield with both approximately 85 % of the non-treated check. The 6 and 8 WAP timings of trifloxysulfuron has yield of number one and marketable roots in excess of 100 % of the non-treated check. With the critical weed-free period for 'Beauregard' having been observed by Seem et al. (2003) to be 2 to 6 wks after transplant, the 6 and 8 WAP timings may not provide control of the weeds in time to prevent any yield loss. The 4 WAP timing of trifloxysulfuron predicts a yield loss of 15 % compared to the non-treated weed-free check. Using the model in Figure 1, application of trifloxysulfuron five wks after transplant would result in a yield loss of marketable roots of only two percent. Removal of weeds five wks after transplant would prevent any loss due to weed interference. Currently, any weeds that escape control by the PRE herbicides currently used are often removed by hand. This is a costly process often exceeding 200 dollars per hectare (Thorton, personal communication).

Trifloxysulfuron Rate. No year by site by rate by cultivar interaction was observed so data was pooled over years, sites, and cultivars. Visual stunting data recorded 12 wks after transplant was fitted to quadratic curves for the 1, 2, and 4 WAP timings of trifloxysulfuron and a linear relationship was fitted to the 8 WAP timing data (Figure 2). No visual stunting was observed for the 6 WAP timing of trifloxysulfuron (data not shown). The 1 and 2 WAP timings of trifloxysulfuron have curves that show high levels injury (20 % or greater) for rates of trifloxysulfuron 2.1 g ai/ha or greater. This despite the 11 and 10 weeks, respectively, of recovery time from application until the time of rating. The relationships for the 4 and 8 WAP timings show injury did not exceed 10 % for any rate of trifloxysulfuron applied.

Yield of number one and marketable roots were shown to have a quadratic relationship for 1, 2, and 4 WAP timings of trifloxysulfuron (Figure 3 and 4) while no relationship could be determined for 6 and 8 WAP (Table 1). The 1 WAP timing curve shows a 80 % reduction in number one roots, compared to the non-treated weed-free check, once the rate of trifloxysulfuron is equal to or greater than 3.2 g/ha (Figure 3). This is also true for marketable yield (Figure 4). The lowest rate of trifloxysulfuron (1.1 g/ha) applied 1 WAP would still reduce yield of number one and marketable roots 40 % (Figures 3 and 4, respectively). The 2 WAP timing of trifloxysulfuron shows less yield loss than the 1 WAP timing with all rates tested reducing yield of number one roots 20 to 60 % (Figure 3). The 2 WAP timing reduced marketable yield 20 to 70 % for all rates tested (Figure 4). The 4 WAP timing reduced yield a maximum 20 % for both number one roots and marketable yield (Figures 3 and 4, respectively). Trifloxysulfuron at 2.1 g/ha applied 4 WAP would reduce yield of number one and marketable roots 12 % (Figures 3 and 4, respectively). This yield reduction may be a delay in crop maturity that could be recovered by delaying harvest until an optimal number of number one grade roots are produced. Further testing is needed to determine if a delay in crop maturity is the cause of the lower yields. The 6 and 8 WAP timings of trifloxysulfuron did not reduce number one roots or marketable yield (Table 1).

Porterfield et al. (2002b) observed no reductions in cotton (*Gossypium hirsutum* L.) lint yield for any cultivar tested when trifloxysulfuron was applied POST. Our results are similar with safety on sweetpotatoes observed when trifloxysulfuron is applied to sweetpotatoes six and eight wks after transplanting at rates ranging from 1.2 to 8.5 g/ha. With the use of the predictive curve in Figure 1 it is likely that trifloxysulfuron applied 5 wks after transplant is safe to sweetpotato. With a proposed rate of 7.5 g/ha of trifloxysulfuron applied at 5 WAP and using the weed efficacy data of Porterfield et al. (2002a), if trifloxysulfuron is registered, crop safety and control of several troublesome broadleaf species in North Carolina sweetpotato production fields would be expected.

Acknowledgements

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Table 1. Sweetpotato yield in 2003 and 2004 by trifloxysulfuron rate for the 6 and 8 WAP timings combined across site and cultivar.

Trifloxysulfuron rate	Sweetpotato yield			
	6 WAP[a]		8 WAP	
	Ones	Marketable	Ones	Marketable
g ai/ha	———— t/ha ————			
0	25.8	33.1	24.2	31.0
1.1	25.9	33.8	27.0	33.0
2.1	28.2	35.1	27.5	33.9
3.2	25.5	31.9	26.7	33.8
4.3	24.6	33.8	25.3	32.0
8.5	27.3	33.0	27.0	31.8
LSD ($p<0.05$)	NS	NS	NS	NS

[a] WAP = weeks after planting

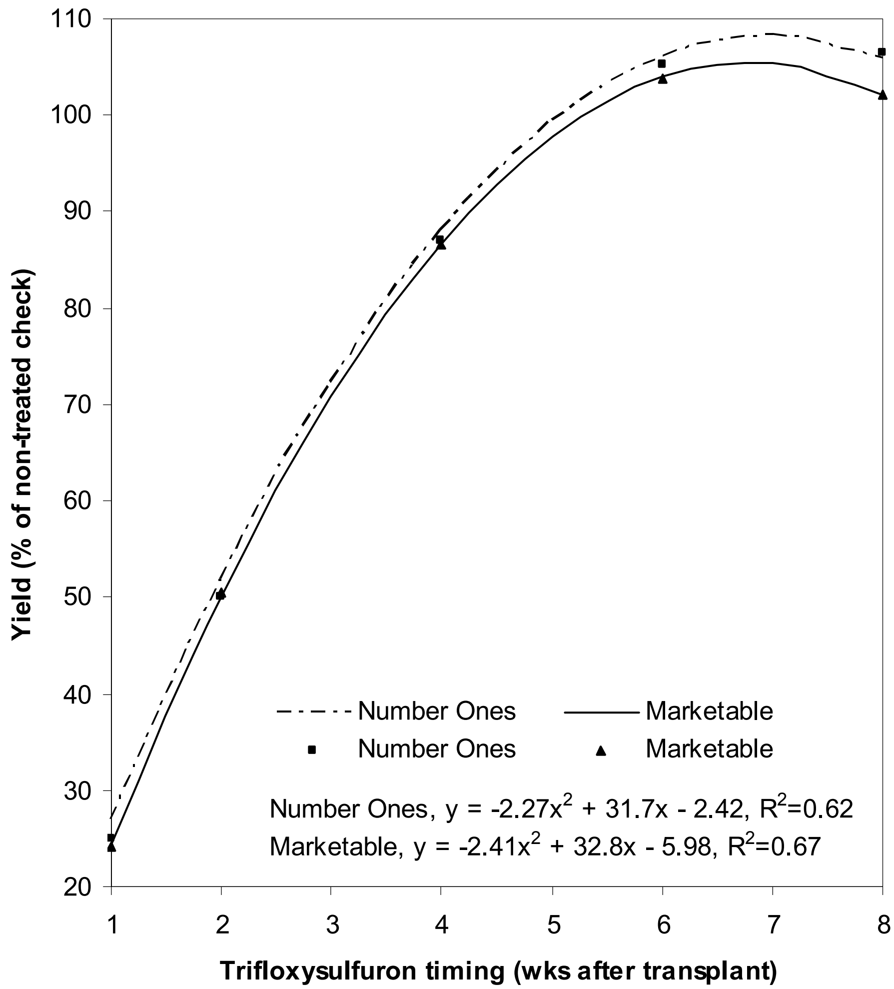

Figure 1. Number one roots and marketable yield by trifloxysulfuron timing pooled over year, site, rate, and cultivar.

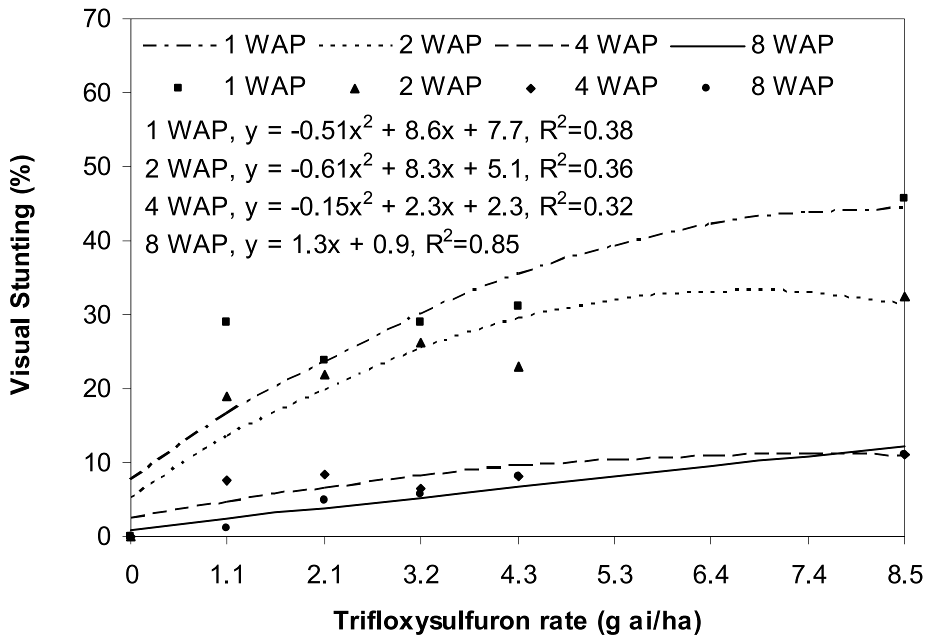

Figure 2. Visual stunting by trifloxysulfuron rate for the 1, 2, 4, and 8 WAP timings pooled over year, site, and cultivar. Visual stunting (0 = no stunting, 100 = crop death) data recorded 12 wks after transplant. No visual stunting was observed for any rate at the 6 WAP timing.

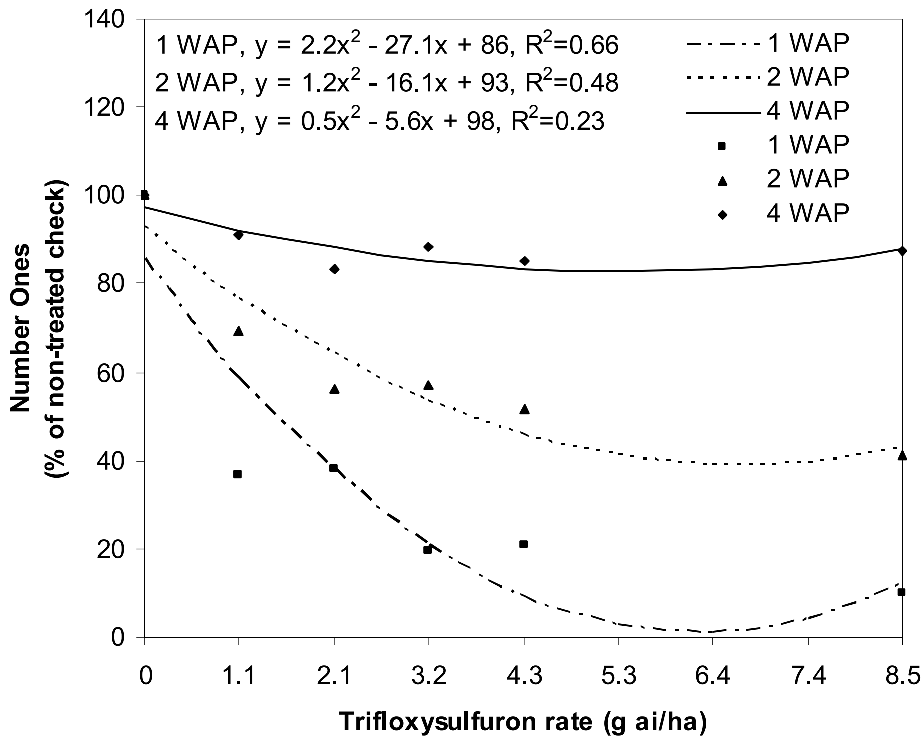

Figure 3. Yield of number one roots by trifloxysulfuron rate for the 1, 2, and 4 WAP timings pooled over year, site, and cultivar.

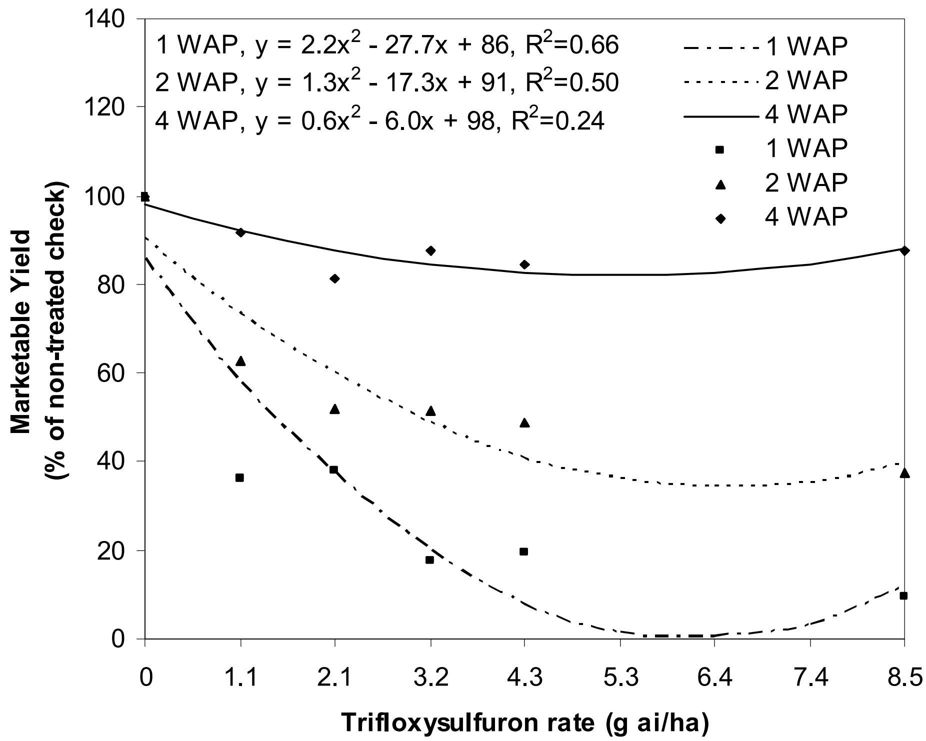

Figure 4. Marketable yield by trifloxysulfuron rate for the 1, 2, and 4 WAP timings pooled over year, site, and cultivar.

Tolerance of Six Sweetpotato (*Ipomoea batatas*) Cultivars to Halosulfuron POST [13]

ANDREW W. MACRAE, DAVID W. MONKS, ROGER B. BATTS, and ALAN C. THORNTON[14]

Abstract: Studies were conducted in 2003 and 2004 in Clinton, NC to determine the safety of halosulfuron POST to the six sweetpotato cultivars ‘Beauregard’, ‘Covington’, ‘Diane’, ‘Jewel’, ‘O’Henry’, and ‘Poinatta’. Halosulfuron was applied 2 and 4 weeks after transplant (WAP). Treatments within each timing were halosulfuron at 13, 26, 39, 52, and 65 g ai/ha plus a non-treated weed-free check. ‘Diane’ was found to have reduced yield of ones and marketable yield (91 and 90 % of the weed-free check, respectively) when halosulfuron was applied 2 WAP. Number one roots and marketable yield of ‘Beauregard’, ‘Covington’, ‘Jewel’, ‘O’Henry’, and ‘Poinatta’ were similar when treated with halsulfuron applied 2 and 4 WAP. When halosulfuron was applied 4 WAP, there was no reduction in yield found for any cultivar tested and for any rate of halosulfuron tested, compared to the weed-free check. These results suggest that halosulfuron timing may be more important than halosulfuron rate in determining the tolerance of a sweetpotato cultivar to halosulfuron POST. Our results show that halosulfuron may be applied to the cultivars tested 4 WAP without a reduction in yield.

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Nomenclature: halosulfuron; sweetpotato, *Ipomoea batatas* (L.) Lam.

Additional Index Words: Timing, rate, yield, Beauregard, Covington, Diane, Jewel, O'Henry, Poinatta.

Abbreviations: WAP, weeks after planting.

INTRODUCTION

North Carolina sweetpotato [*Ipomoea batatas* (L.) Lam.] production reached 17,000 ha in 2003 (NCDA & CS 2005). This hectarage was 45 % of the US production of 37,500 ha that was valued at 305 million dollars. Sweetpotato is considered a minor crop due to the limited amount of hectares produced and as such, herbicide registrations are limited.

Sweetpotato weed control programs include preemergence herbicides and cultivation. The PRE herbicides most commonly used, except napropamide, have a half life of 16 days or less (Vencill 2002). Napropamide has a half life of 70 days, however it is water soluble and in a sandy loam soil it was reported to move 20 cm when 20 cm of water was applied (Vencill 2002). These herbicides often miss the most troublesome weeds in North Carolina sweetpotato production fields. The lack of season long weed control and limited control of the weed spectrum often leads to growers not applying herbicides. A survey conducted by Toth et al. (1997) revealed that of those who responded, 30 % of North Carolina sweetpotato growers do not apply herbicides while 97 % use cultivation an average of 3.4 times during the growing season. When broadleaf weeds escape control from the PRE herbicides and cultivation, mowing and hand removal are utilized. Mowing is not highly effective since the mower must be maintained at a height above the crop canopy allowing for regrowth of the weeds. Removing weeds by hand is costly with growers often spending 200 dollars per hectare or more to control escaped weeds (Thornton, personal communication).

Certain sweetpotato cultivars such as 'Beauregard' are less competitive with weeds and significant yield loss can occur at heavy weed infestations (La Bonte et al. 1996). Season long weed interference in 'Beauregard' sweetpotato has been found to reduce yield 85 % (Seem et al. 2003). In a recent survey of 25 field locations (260 on-farm sample sites) in North Carolina beginning with the most common weed species, pigweed species (*Amaranthus* sp.), nutsedge species, large crabgrass [*Digitaria sanguinalis* (L.) Scop.], tropic croton (*Croton glandulosus* var. septentrionalis Muell.-Arg.), Florida pusley (*Richardia scabra* L.), common cocklebur (*Xanthium strumarium* L.), common ragweed (*Ambrosia artemisiifolia* L.), common lambsquarters (*Chenopodium album* L.), prickly sida (*Sida spinosa* L.), smartweed species (*Polygonum* sp.), groundcherry species (*Physalis* sp.), morningglory species (*Ipomoea* sp.), eastern black nightshade (*Solanum ptycanthum* Dun.), annual sedge (*Cyperus compressus* L.), common bermudagrass [*Cynodon dactylon* (L.) Pers.], and horsenettle (*Solanum carolinense* L.) were the most common weed species reported (Brill 2005).

Seem et al (2003) found that a critical weed-free period of two to six weeks after transplant exists with 'Beauregard' sweetpotato. This interval of 2 to 6 weeks after transplanting would be the optimal time for application of a POST herbicide to remove weeds from the crop row. Currently no POST herbicides are registered in sweetpotato that will control broadleaf weeds. Application of halosulfuron at 39 g ai/ha four wks after transplant has been shown to be safe on ‘Beauregard’ sweetpotato transplants (MacRae, data not published).

Halosulfuron controlled purple and yellow nutsedge in previous studies (Ackley et al. 1996; Blum et al. 2000; Earl et al. 2004; Ferrel et al. 2004; Grichar et al. 2003; Molin et al. 1999; Nelson and Renner 2002; Rao and Reddy 1999; Vencill et al. 1995). Halosulfuron has also been reported to control common cocklebur, common lambsquarters, common ragweed, jimsonweed (*Datura stramonium* L.), Pennsylvania smartweed (*Polygonum pensylvanicum* L.), redroot pigweed (*Amaranthus retroflexus* L.), tall morningglory [*Ipomoea purpurea* (L.) Roth], and velvetleaf (*Abutilon theophrasti* Medicus) (Brown and Masiunas 2002; Isaacs et al. 2002; Sprague et al. 1997).

Horticultural crops have shown a cultivar response to various herbicides including those herbicides in the sulfonylurea herbicide family. Robinson et al. (1993, 1994) and Burton et al. (1994) reported that sweet corn (*Zea mays* L.) cultivars varied in their response to primisulfuron and nicosulfuron. Other researchers (O’Sullivan and Sikkema 2002; O’Sullivan et al. 2000) have also reported similar responses in sweet corn with the primisulfuron and nicosulfuron. The objective of this study was to determine the effect of halosulfuron timing and rate on six sweetpotato cultivars.

MATERIALS AND METHODS

Studies were conducted in 2003 and 2004 near Clinton, North Carolina on an Orangeburg loamy sand (fine-loamy, kaolinitic, thermic Typic Kandiudults) with pH 5.7 (2003) and 5.9 (2004) and 0.7 % humic matter. Plots consisted of six rows 5.5 m long with a row spacing of 105 cm. Each row was transplanted with one of the six cultivars 'Beauregard', 'Covington', 'Diane', 'Jewel', 'O'Henry', and 'Poinatta' on July 11, 2003 and May 26, 2004.

The experiment was a factorial design with halosulfuron timing as the main effect and halosulfuron rate as the secondary effect. Halosulfuron was applied 2 and 4 weeks after transplanting (WAP). Treatments within each timing were halosulfuron at 13, 26, 39, 52, and 65 g ai/ha plus a non-treated weed-free check. All applications of halosulfuron included a non-ionic surfactant[15] at 0.25% v/v. In 2003 applications were made using a CO_2 backpack sprayer calibrated to deliver 187 L/ha using 8003XR[16] tips at 152 kPa. Application dates for halosulfuron in 2003 were July 26, 2003 and August 9, 2003 for the 2 and 4 WAP timings, respectively. In 2004 applications were made using a tractor mounted CO_2 sprayer calibrated to deliver 187 L/ha using 11003XR[4] tips at 145 kPa. Application dates for halosulfuron in 2004 were June 11, 2004 and June 25, 2004 for the 2 and 4 WAP timings, respectively.

In 2003, plots were maintained weed-free with hand removal and clomazone at 0.63 kg/ha plus napropamide at 2.2 kg/ha PRE. Sethoxydim POST at 0.21 kg/ha plus crop oil at 1% v/v was also used to control grasses in the study In 2004, plots were maintained weed-free with hand removal and clomazone at 0.63 kg/ha plus metolachlor at 0.80 kg/ha

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[15] Induce, a mixture of alkyl aryl polyoxylkane ethers, free fatty acids, and dimothyl polysiloxane. Helena Chemical Company, 225 Schilling Boulevard, Suite 300, Collierville, TN 38017.

[16] Spraying Systems Co., P.O. Box 7900, Wheaton, IL 61089-7900.

PRE. Clethodim POST at 0.14 kg/ha plus crop oil at 1% v/v was also used for grass control.

Data recorded were visual stunting (0 = no crop injury, 100 = complete crop death) and yield by weight. Sweetpotato storage roots were graded into jumbo (greater that 8.8 cm in width), one (greater than 4.4 cm but less that 8.8 cm), and canner (greater than 1.9 cm but less than 4.4 cm) roots (Anonymous 2005). Marketable yield was determined by combining the jumbo and number one grades. Data was subjected to analysis of variance at a significance level of $p=0.05$ and means separated using Fisher's protected LSD (SAS 2005).

RESULTS AND DISCUSSION

Halosulfuron Timing. No year by timing by rate by cultivar interaction was observed so data was pooled over years and rates. 'Diane' was found to have reduced yield of ones and marketable yield (91 and 90 % of the weed-free check, respectively) when halosulfuron was applied 2 WAP (Table 1). Number one roots and marketable yield of 'Beauregard', 'Covington', 'Jewel', 'O'Henry', and 'Poinatta' were similar when treated with halsulfuron applied 2 and 4 WAP (Table 1). When halosulfuron was applied 4 WAP no reduction in yield was found for any cultivar tested, for any rate of halosulfuron tested, compared to the weed-free check.

Halosulfuron Rate. No year by timing by rate by cultivar interaction was observed so data was pooled over years and timings. No reduction in yield was found for any cultivar tested, for any rate of halosulfuron tested, compared to the weed-free check (Table 2).

‘Diane’ had reduced yields with halosulfuron applied 2 WAP, however, no yield reduction was observed with the 4 WAP timing. These results suggest that halosulfuron timing may be more important than halosulfuron rate in determining the tolerance of a sweetpotato cultivar to a POST application of halosulfuron. No cultivar showed sensitivity to halosulfuron when applied 4 WAP. Other sulfonyurea herbicides have shown similar results. Porterfield et al. (2002) observed no cotton (*Gossypium hirsutum* L.) cultivar sensitivity to trifloxysulfuron when applied POST. Likewise, Robinson et al. (1993, 1994) and O’Sullivan and Sikkema (2002) reported sweet corn cultivars varied in their sensitivity to the sulfonylurea herbicides nicosulfuron and primisulfuron. Our results show that halosulfuron at a rate from 13 to 65 g/ha 4 WAP may be applied to the cultivars tested without a reduction in yield.

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Table 1. Sweetpotato yield by halosulfuron timing and cultivar combined across years and rates.

Halosulfuron timing	Sweetpotato yield											
	'Beauregard'		'Covington'		'Diane'		'Jewel'		'O'Henry'		'Poinatta'	
	One	Market	One	Market	One	Market	One	Market	One	Market	One	Market
WAP[a]	------------------ % of the weed-free check ------------------											
2	108	106	103	104	91	90	152	148	102	98	92	92
4	108	108	100	107	120	121	147	146	116	117	96	99
LSD	NS	NS	NS	NS	17	18	NS	NS	NS	NS	NS	NS
check (t/ha)	13.1	21.9	15.2	23.2	11	15.9	10.8	18.8	7.4	12.3	12.7	21.2

[a] WAP = weeks after planting.

Table 2. Sweetpotato yield by halosulfuron rate and cultivar combined across years and timings.

Halosulfuron rate	Sweetpotato yield											
	'Beauregard'		'Covington'		'Diane'		'Jewel'		'O'Henry'		'Poinatta'	
	One	Market	One	Market	One	Market	One	Market	One	Market	One	Market
g ai/ha	-- % of the weed-free check --											
0	100	100	100	100	100	100	100	100	100	100	100	100
13	104	105	101	102	109	108	155	144	110	104	79	82
26	109	104	92	90	103	102	133	134	110	106	105	107
39	108	108	103	110	111	109	151	149	95	91	97	95
52	111	110	118	127	103	105	169	164	107	106	102	100
65	106	108	94	98	103	103	140	142	123	130	89	95
LSD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
check (t/ha)	13.1	21.9	15.2	23.2	10.8	15.9	10.8	18.8	7.4	12.3	12.7	21.2

Sweetpotato (*Ipomoea batatas*) Tolerance to Halosulfuron and Trifloxysulfuron Pre-transplant[17]

ANDREW W. MACRAE, DAVID W. MONKS, ROGER B. BATTS, ALAN C. THORNTON[18]

Abstract: Two studies were conducted at each of two sites in Clinton and Turkey, NC in 2004. In both studies, herbicides were applied pre-transplant 1, 3, and 7 days before transplanting (DBP). One study had trifloxysulfuron applied within each timing at 1.1, 2.1, 3.2, 4.3, and 8.5 g ai/ha plus a weed-free check while the other study had halosulfuron applied within each timing at 13, 26, 39, 52, and 65 g ai/ha plus a non-treated weed-free check. No visual injury was observed from halosulfuron or trifloxysulfuron. Sweetpotato treated 7 DBP with halosulfuron was found to have lower marketable yield (21 t/ha) than sweetpotato treated 1 or 3 DBP (23.5 and 24 t/ha, respectively) with halosulfuron. These differences may be attributed to the rainfall received between the application date and the planting date. The Clinton and Turkey sites received 2.9 and 2.3 cm, respectively of rainfall between the 7 and 3 DBP timings of halosulfuron application. Both sites did not receive any rainfall after the 3 DBP timing until 2 days after transplanting when both sites received more than 2.5 cm. Halosulfuron

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may have leached into the root zone of the transplants which may have delayed storage root production causing a reduction in yield. These same rainfall events occurred with the trifloxysulfuron applications, however, no differences in jumbo, one or marketable yield was observed with trifloxysulfuron at any timing. Our results show that trifloxysulfuron at a maximum rate of 8.5 g/ha pre-transplant is safe on sweetpotato. Halosulfuron pre-transplant is safe on sweetpotato if no rainfall occurs until two days after transplant.

Nomenclature: trifloxysulfuron; sweetpotato, *Ipomoea batatas* (L.) Lam.

Additional Index Words: injury, yield.

Abbreviations: WAP, wks after planting.

INTRODUCTION

Sweetpotato [*Ipomoea batatas* (L.) Lam.] production in the United States in 2003 reached 37,500 ha worth 305 million dollars (NCDA & CS 2005). North Carolina production was 45 % of the total US production. Sweetpotato is a minor crop and as such, there are limited weed control options with few new registrations being pursued. The limited options often result in hand removal for the troublesome weeds found in North Carolina sweetpotato production fields.

Preemergence herbicides are currently the only options for chemical broadleaf weed control. Weed control from the registered PRE herbicides do not provide season long control and they also have limited efficacy on some of the troublesome weeds in North Carolina sweetpotato fields. These limitations often lead to a dependency on cultivation for removal of the difficult to control species with some growers opting not to use herbicides at all. A survey conducted by Toth et al. (1997) revealed that of those who responded, 30 % of North Carolina sweetpotato growers do not apply herbicides while 97 % use cultivation an average of 3.4 times during the growing season.

High yielding cultivars of sweetpotato such as 'Beauregard' have been found to be poor competitors with weeds, with yields being reduced significantly with heavy weed infestations (La Bonte et al. 1996). Seem et al. (2003) observed that season long weed interference in 'Beauregard' sweetpotato would result in 85 % yield reduction. Weeds that emerged 6 wks after transplant did not affect yield while removal of weeds before 2 wks after transplant prevented any yield loss. This critical weed-free period (2 to 6 wks after transplant) for sweetpotato would require the PRE herbicide to control the troublesome weeds in NC sweetpotato fields through six wks after transplanting.

Sweetpotatoes have been shown to exhibit tolerance to halosulfuron applied POST four wks after transplanting (MacRae, data not published). However, the broadleaf weeds may exceed the size that halosulfuron POST is effective if treatment is delayed until 4 wks after transplant. A PRE application of halosulfuron may extend the window of a POST application and provide greater control of some of these troublesome weed species.

Halosulfuron PRE has given excellent purple (*Cyperus rotundus* L.) and yellow (*Cyperus esculentus* L.) nutsedge control. Grichar et al. (2003) observed that halosulfuron PRE at 66 g/ha controlled purple nutsedge 95 % or greater. Vencill et al. (1995) reported that at 60 days after treatment with halosulfuron PRE at 106 g/ha reduced purple nutsedge shoot number and weight 100 %, reduced shoot regrowth 80 %, and root-tuber dry weight 73 %. At 60 days after treatment, halosulfuron PRE at 106 g/ha reduced yellow nutsedge shoot number and shoot weight 100 % , reduced shoot regrowth 51 %, and root-tuber dry weight 62 % (Vencill et al. 1995).

Halosulfuron PRE has also provided control of other troublesome weeds commonly present in North Carolina sweetpotato fields. A PRE application of halosulfuron at 110 g/ha gave greater than 95 % control of redroot pigweed (*Amaranthus retroflexus* L.), velvetleaf (*Abutilon theophrasti* Medicus), and common lambsquarters, (*Chenopodium album* L.) 45 days after treatment (Brown and Masiunas 2002). Halosulfuron PRE at 84 g/ha provided 92 % or greater control of common lambsquarters, Pennsylvania smartweed (*Polygonum pensylvanicum* L.), velvetleaf, common cocklebur (*Xanthium strumarium* L.), tall morningglory [*Ipomoea purpurea* (L.) Roth], and jimsonweed (*Datura stramonium* L.) (Sprague et al. 1997).

Sweetpotato has tolerance to trifloxysulfuron applied POST six to eight wks after transplanting (MacRae, data not published). If sweetpotato is found to have tolerance to trifloxysulfuron PRE, growers may be able to control weeds through the critical weed-free period reported by Seem et al (2003). Although no information is currently available for weed efficacy of trifloxysulfuron applied PRE, POST applications controls some of the troublesome weeds in NC sweetpotato fields. Trifloxysulfuron POST at 7.5 g/ha was found to provide 97 and 88 % control of common ragweed *(Ambrosia artemisiifolia* L.) and sicklepod [*Senna obtusifolia* (L.) Irwin and Barnaby] (Porterfield et al. 2002). Richardson et al. (2004) observed 87 % control of common ragweed with trifloxysulfuron POST at 7.5 g/ha. Richardson et al. (2004) also observed 96 % or greater control of smooth pigweed (*Amaranthus hybridus* L.), common lambsquarters, and common cocklebur (*Xanthium strumarium* L.) with 7.5 g/ha of trifloxysulfuron POST.

Morningglory species (*Ipomoea* sp.) can be problematic in North Carolina sweetpotato production since they are genetically related to sweetpotato (*Ipomoea batatas*) and have a similar vining growth habit. Siebert et al. (2004) observed 97 % control of red morningglory (*Ipomoea coccinea* L.) 14 days after treatment with trifloxysulfuron POST at 20 g ai/ha. Porterfield et al. (2002) observed 96, 90, and 80 % control of entireleaf morningglory (*Ipomoea hederacea* var. *integriuscula* Gray), tall morningglory [*Ipomoea purpurea* (L.) Roth], and pitted morningglory (*Ipomoea lacunosa* L.) with trifloxysulfuron POST at 7.5 g/ha. Similar results were observed by Richardson et al. (2004) with 7.5 g/ha of trifloxysulfuron POST providing 91 and 93 % control (for 1999 and 2000, respectively) of a complex of morningglory species consisting of ivyleaf, pitted, and tall morningglory.

A PRE application of halosulfuron or trifloxysulfuron would expand the weed spectrum that may be controlled in sweetpotato production fields. The objective of these trials was to determine the tolerance of sweetpotato to PRE applications of halosulfuron and trifloxysulfuron over several rates and timings.

MATERIALS AND METHODS

Four studies were conducted at Clinton and Turkey, NC in 2004. The Clinton site was planted on May 28, 2004 with two cultivars (‘Beauregard’ and ‘Hernandez’) in two row plots (105 cm row spacing) 5.5 m long on an Orangeburg loamy sand (fine-loamy, kaolinitic, thermic Typic Kandiudults) with pH 5.8 and 0.7 % humic matter. The Turkey site were planted on June 22, 2004 with one cultivar (‘Beauregard’) in two row plots (105 cm row spacing) 4.5 m long on a Norfolk loamy sand (fine-loamy, kaolinitic, thermic Typic Kandiudults) with pH 5.9 and 0.8 % humic matter. Both experiments were factorial designs with herbicide timing as the main effect and herbicide rate as the secondary effect. In both trials, the herbicide was applied pre-transplant at 1, 3, and 7 days before transplant (DBP). The trifloxysulfuron studies’ treatments within each timing were trifloxysulfuron at 1.1, 2.1, 3.2, 4.3, and 8.5 g ai/ha plus a weed-free check. The halosulfuron studies’ treatments within each timing were halosulfuron at 13, 26, 39, 52, and 65 g ai/ha plus a non-treated weed-free check. Herbicide applications were made using a tractor mounted CO_2 pressurized sprayer calibrated to deliver 187 L/ha using 11003XR[19] tips at 145 kPa. The application dates at the Clinton site were May 19, 2004, May 25, 2004, and May 27, 2004 for the 1, 3, and 7 DBP timings, respectively. At the Turkey site the application dates were June 15, 2004, June 19, 2004, and June 21, 2004 for the 1, 3, and 7 DBP timings, respectively.

Plots were maintained weed-free with hand removal and clomazone at 0.63 kg/ha plus metolachlor at 0.80 kg/ha PRE. Clethodim POST at 0.14 kg/ha plus crop oil at 1% v/v was also used for grass control.

[19] Spraying Systems Co., P.O. Box 7900, Wheaton, IL 61089-7900.

Data taken were visual stunting (0 = no crop injury, 100 = complete crop death) and yield. Sweetpotato yield data was graded into jumbo (greater that 3.5 inches in width), one (greater than 1.75 inches but less that 3.5 inches), and canner (greater than 0.75 inches but less than 1.75 inches) roots (Anonymous 2005). Marketable yield was determined by combining the jumbo and one grades. Data was subjected to analysis of variance at a significance level of p=0.05 and means separated using Fisher's protected LSD (SAS 2005).

RESULTS AND DISCUSSION

Herbicide Timing. No site by timing by rate by cultivar interaction was observed so data was pooled over sites, rates, and cultivars. No visual injury resulted from halosulfuron or trifloxysulfuron (data not shown). Sweetpotato treated 7 DBP with halosulfuron was found to have lower marketable yield (21 t/ha) than when treated 1 or 3 DBP (23.5 and 24 t/ha, respectively) (Table 1). Sweetpotato treated 7 DBP with halosulfuron was also found to have lower jumbo grade root yield than if treated 1 DBP. These differences may be attributed to the rainfall received between the application date and the planting date. The Clinton site received 2.9 cm of rainfall between the 7 and 3 DBP timings of halosulfuron application. The Turkey site received 2.3 cm between the 7 and 3 DBP timings. Both sites did not receive any rainfall after the 3 DBP timing until 2 days after transplanting when both sites received more than 2.5 cm. Leaching of halosulfuron into the root zone of the transplants may have occurred, which delayed storage root development and reduced yield. Further study is needed to better understand the role of rainfall and halosulfuron on sweetpotato yield loss. These same rainfall events occurred with the trifloxysulfuron applications, however, no difference in jumbo, one or marketable root yield was found with any timing of trifloxysulfuron (Table 1).

Herbicide Rate. No site by rate by cultivar interaction was observed so data was pooled over sites, and cultivars. No differences were found for any sweetpotato root grade for any rate of halosulfuron applied 1 DBP (Table 2). Halosulfuron at 65 g ai/ha applied 3 DBP reduced ones and marketable yield when compared to the weed-free check (Table 2). A rate response was observed for ones and marketable yield when halosulfuron was applied 7 DBP. Yield of ones were reduced with halosulfuron at 39 g/ha and greater (7 DBP) while marketable yield was reduced with halosulfuron at 26 g/ha and greater (7DBP) (Table 2). No difference was found for any grade of sweetpotato for any rate of trifloxysulfuron applied at the 1, 3, and 7 DBP timings (Table 3).

Further study is needed to determine the level of weed efficacy with trifloxysulfuron PRE. Our results show that sweetpotato is tolerant to trifloxysulfuron applied pre-transplant to a maximum rate of 8.5 g/ha even when there is rainfall 3 cm or less. Grichar et al. (2003) found that 66 g/ha of halosulfuron PRE would provide control of purple nutsedge. Our results show that halosulfuron may leach into the transplants' roots zone with rainfall greater than 2.2 cm. However, halosulfuron pre-transplant is safe on sweetpotato up to a maximum rate of 65 g/ha if no rainfall occurs until two days after transplant.

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Table 1. Sweetpotato yield by halosulfuron and trifloxysulfuron timing combined across site and cultivar.

Herbicide timing	Sweetpotato yield							
	Halosulfuron				Trifloxysulfuron			
	Jumbos	Ones	Canners	Marketable	Jumbos	Ones	Canners	Marketable
DBP[a]	——— t/ha ———							
1	6.7	16.7	6.4	23.5	5.5	20.5	6.1	26.0
3	6.4	17.6	6.3	24.0	5.2	18.9	7.1	24.1
7	5.0	16.0	7.5	21.0	5.3	20.0	6.5	25.3
LSD ($p<0.05$)	1.5	NS	0.8	2.2	NS	NS	0.8	NS

[a] DBP = days before planting.

Table 2. Sweetpotato yield by halosulfuron rate combined across site and cultivar.

Halosulfuron rate	Sweetpotato yield											
	1 DBP[a]				3 DBP				7 DBP			
	Jumbo	One	Canner	Marketable	Jumbo	One	Canner	Marketable	Jumbo	One	Canner	Marketable
g ai/ha	t/ha											
0	5.6	20.7	5.5	26.3	7.4	21.5	5.1	28.8	5.8	22.3	6.9	28.1
13	4.8	19.2	7.5	24.0	5.4	18.3	7.7	23.7	8.3	16.9	6.6	25.2
26	6.1	16.6	6.4	22.7	8.0	17.7	5.1	25.7	3.4	19.0	9.0	22.4
39	9.4	15.7	6.6	25.1	5.9	18.3	6.2	24.3	3.7	15.5	7.6	19.1
52	7.4	15.9	5.3	23.3	6.5	19.2	5.8	25.8	5.8	14.5	6.5	20.3
65	5.9	16.3	6.3	22.2	6.1	14.2	6.5	20.3	4.0	14.1	8.0	18.1
LSD ($p<0.05$)	NS	NS	NS	NS	NS	3.7	1.6	4.3	3.0	3.9	1.7	5.4

[a] DBP = days before planting.

Table 3. Sweetpotato yield by trifloxysulfuron rate combined across site and cultivar.

Trifloxysulfuron rate	Sweetpotato yield											
	1 DBP[a]				3 DBP				7 DBP			
	Jumbo	One	Canner	Marketable	Jumbo	One	Canner	Marketable	Jumbo	One	Canner	Marketable
g ai/ha	t/ha											
0	7.6	20.4	5.5	28.1	5.3	19.7	6.8	25.0	6.4	21.0	6.2	27.5
1.1	5.6	19.6	6.4	25.2	5.5	19.1	6.7	24.6	4.8	19.7	6.2	24.5
2.1	5.6	20.1	5.2	25.7	5.4	20.0	7.4	25.4	6.3	19.2	5.8	25.5
3.2	5.6	20.1	6.8	25.7	6.2	17.0	6.2	23.2	4.7	20.5	6.7	25.2
4.3	5.8	21.1	5.9	26.9	2.9	18.2	8.6	21.1	4.9	18.9	6.7	23.8
8.5	4.9	21.6	6.0	26.5	5.8	20.2	6.6	26.0	5.9	21.8	7.4	27.8
LSD ($p<0.05$)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[a] DBP = days before planting.

Evaluation of ALS Inhibiting Herbicide Screening Trials in the Lab and the Field for Sweetpotato (*Ipomoea batatas*)[20]

ANDREW W. MACRAE, DAVID W. MONKS, JAMES D. BURTON, and GOUYING MA[21]

Abstract: Laboratory experiments were conducted to determine if a ratio can be established between the I50 of a herbicide and their field application rate, that would accurately rank their potential to reduce yield in sweetpotato. 'Beauregard' sweetpotato was used to compared the inhibition of the acetolactate synthase (ALS) enzyme by halosulfuron, nicosulfuron, primisulfuron, and trifloxysulfuron. Halosulfuron was found to have the smallest I50 with a concentration of 2 nM and the largest risk ratio with a value of 19.5. Primisulfuron was observed to have an I50 of 15 nM and a potential risk ratio of 2.7. Trifloxysulfuron was to found to have an I50 of 16 nM and a potential risk ratio of 0.27. Nicosulfuron was found to have an I50 of 305 and a potential risk ratio of 0.11. The potential risk ratio calculated by dividing the field use rate by the I50 actually provided the same ranking as that seen by the I50 values alone. If our ratio is accurate, nicosulfuron should have the lowest risk of reducing yields in sweetpotato. However, we know from previous sweetpotato tolerance data that halosulfuron at 39 g ai/ha is safe to

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apply to sweetpotato four wks after transplant with only a 7 % yield loss expected while the same amount of yield loss was discovered with trifloxysulfuron at 1 g/ha when applied 4 wks after transplant. These numbers would suggest that trifloxysulfuron is more injurious to sweetpotato than halosulfuron and thus the use of our lab screening process and risk ratio to determine the safety of chemicals in the field is flawed and does not provide us with an accurate picture of the processes going on the field.

Nomenclature: halosulfuron; nicosulfuron; primisulfuron; trifloxysulfuron; sweetpotato, *Ipomoea batatas* (L.) Lam.

Additional Index Words: ALS, acetolactate synthase, I50.

Abbreviations: ALS, acetolactate synthase; DTT, dithiothreitol; FAD, flavin adenine dinucleotide; PVPP, polyvinylpolypyrrolidone; TPP, thiamine pyrophosphate

INTRODUCTION

Herbicide screening trials require time and space to perform in the field with the result on yield not being discovered until the end of the growing season. Lab analysis of herbicides tend to not determine a true result of crop tolerance due to absorbance, translocation, and metabolism effects that are not easily studied under controlled conditions. If a compromise between these two methods could be discovered, the reduction in time spent evaluating a herbicide in the field would be beneficial to the researcher.

Research has been conducted on the safety of halosulfuron and trifloxysulfuron on sweetpotato [Ipomoea batatas (L.) Lam.] in North Carolina. Results have shown that halosulfuron at 39 g ai/ha applied four weeks after transplanting does not reduce marketable yield and is effective at controlling troublesome weeds in NC sweetpotato production fields (data not published). Trifloxysulfuron at 4.3 g ai/ha was found to be safe on sweetpotato when applied six weeks after transplanting (data not published). Similar results were seen in cotton (*Gossypium hirsutum* L.) with no reductions in lint yield being observed for any cultivar tested when trifloxysulfuron was applied postemergence (Porterfield et al. 2002). When the two herbicides are compared, trifloxysulfuron is found to be more injurious to sweetpotato four weeks after transplanting than halosulfuron (Monks, personal communication). These herbicides are both ALS inhibiting herbicides and many other chemicals in this class may also be found to be safe to apply sweetpotato.

The ability to determine safety of chemicals in the lab would reduce the amount of time spent in the field and allow for faster registration of herbicides in minor crops. The objective of this trial is to determine if a ratio can be established between the I50 of a herbicide and their field application rate, that would accurately rank their potential to reduce yield in sweetpotato.

MATERIALS AND METHODS

'Beauregard' sweetpotato roots were planted in harvest lugs containing a soil:vermiculite:peat (2:1:1 by volume) mixture. Flats were placed in a greenhouse with temperature maintained between 12 and 37 C utilizing natural light presence. Leaf tissue was harvested from the end of the sweetpotato vines, selecting the most recently formed leaf and cutting at the top of the petiole. Shoot tissue was harvested until 45 g of material was obtained.

Modified protocols from previously published methods (Ray 1984, Singh et al. 1988, Sunderland et al. 1995) for protein extraction and determination of ALS activity were utilized. Leaf tissue was homogenized in 180 mL of buffer solution for 10 minutes in a prechilled mortar and pestle. Homogenization buffer consisted of 100 mM KH_2PO_4, 10 mM pyruvate, 5 mM $MgCl_2$, 10 % glycerol (v/v), 5 mM DTT, and 5 % PVPP (w/v) at pH 7.5. To facilitate the process, two grams of sea sand was included. The homogenate was filtered through six layers of cheese cloth and the filtrate was centrifuged under refrigerated conditions (4 C) at 25,000 x g for 20 minutes. The supernatant was then precipitated with 29.1 g of ammonium sulfate being added per 100 mL of supernatant and the solution being stirred for 20 minutes. The solution was then centrifuged under refrigerated conditions (4 C) at 25,000 x g for 20 minutes. The liquid was poured off and the precipitate placed in a freezer at -30 C until required for assay. The precipitate was resuspended in 12 mL of buffer consisting of 100 mM KH_2PO_4, 1 mM EDTA, and 100mM NaCl adjusted to pH 7.5.

Protein extracts were assayed with halosulfuron at 0, 0.05, 0.1, 1, 10, and 100 nM, nicosulfuron at 0, 50, 100, 200, 400, and 800 nM, primisulfuron at 0, 10, 50, 100, 200, and 500 nM, and trifloxysulfuron at 0, 1, 10, 25, 50, and 100 nM. Protein extracts were placed in culture tubes (0.2 mL per tube) containing 0.05 mL of herbicide and 0.25 mL of buffer consisting of 100 mM KH_2PO_4, 100 mM pyruvate, 10 mM MgCl, 1 mM TPP, and

0.01 mM FAD. Samples were placed in a water bath at 37 C for 1 h. Reactions were stopped with 0.05 mL of 6 N H_2SO_4. Samples were then place in a 60 C water bath for 15 minutes. Creatin (0.5 % w/v) and 1-napthol (5 % w/v) solutions were added each at a volume of 0.5 mL. The samples were placed in a 60 C water bath for 15 minutes at which time they were removed and allowed to sit at room temperature for 15 minutes. Absorbance values at 520 nm were determined using spectrophotometry. Treatments were duplicated and the experiment repeated.

Data was subjected to curve fitting using general linear procedures (SAS 2005). Ratios were created using the I_{50} values and the registered herbicide rate to produce a scale to possibly determine the relative safety of the chemicals on sweetpotato.

RESULTS AND DISCUSSION

Protein assay data was plotted and the I_{50} for each of the herbicides were determined. Halosulfuron was found to have the smallest I_{50} with a concentration of 2 nM (Figure 1). Halosulfuron was also found to have the largest potential risk ratio with a value of 19.5 (Table 1). This would suggest that halosulfuron would have the highest risk of reducing yields of the herbicides assayed. This is contradicted by the safety observed with POST applications of halosulfuron applied to North Carolina sweetpotato (data not published). The potential risk ratio calculated by dividing the field use rate by the I_{50} actually provided the same ranking as that seen by the I_{50} values alone. Primisulfuron was observed to have an I_{50} of 15 nM (Figure 3) and a potential risk ratio of 2.7 (Table 1). Trifloxysulfuron was to found to have an I_{50} of 16 nM (Figure 4) and a potential risk ratio of 0.27. Nicosulfuron was found to have an I50 of 305 (Figure 2) and a potential risk ratio of 0.11 (Table 1). If our ratio is accurate, nicosulfuron should have the lowest risk of reducing yields in sweetpotato. However, we know from previous sweetpotato tolerance data that halosulfuron at 39 g ai/ha is safe to apply to sweetpotato four wks after transplant with only a 7 % yield loss expected while the same amount of yield loss was discovered with trifloxysulfuron at 1 g/ha when applied 4 wks after transplant (data not published). These numbers would suggest that trifloxysulfuron is more injurious to sweetpotato than halosulfuron and thus the use of our lab screening process and risk ratio to determine the safety of chemicals in the field is flawed and does not provide us with an accurate picture of the processes going on the field.

Askew and Wilcut (2002) studied the absorption, translocation, and metabolism of trifloxysulfuron in sicklepod (*Cassia obtusifolia* L.) and jimsonweed (*Datura stramonium* L.) to determine their differing control while Richardson et al. (2003) did the same for spurred anoda [*Anoda cristata* (L.) Schlecht.] and smooth pigweed (*Amaranthus hybridus* L.). Jimsonweed, sicklepod, spurred anoda, and smooth pigweed absorbed 53, 42, 42, and 55 % of the applied chemical. Askew and Wilcut (2002) found the half-life of trifloxysulfuron in jimsonweed was estimated at 1.9 days while sicklepod was estimated at 4 days. The longer half-life in sicklepod would lead to a greater exposure time in the meristems. Along with a shorter half-life, jimsonweed also has increased acropetal translocation allowing the plant to sequester or compartmentalize large portions of the absorbed trifloxysulfuron and then resprout after large portions of the meristematic tissue have died. Richardson et al. (2003) concluded that the tolerance of spurred anoda was most likely due to limited translocation of the trifloxysulfuron while smooth pigweed had high rates of symplastic translocation and a slow metabolism of the herbicide most likely causing its susceptibility. Translocation of trifloxysulfuron may be greater in sweetpotato than halosulfuron or halosulfuron may be metabolized quicker than trifloxysulfuron. Dubelman et al. (1997) found that halosulfuron is rapidly metabolized in corn and wheat thus reducing the amount of the parent material left to cause injury to the crop. Without the knowledge of the absorbance and translocation of the herbicides tested in the sweetpotato plants we are unable to determine safety in the field with lab screenings.

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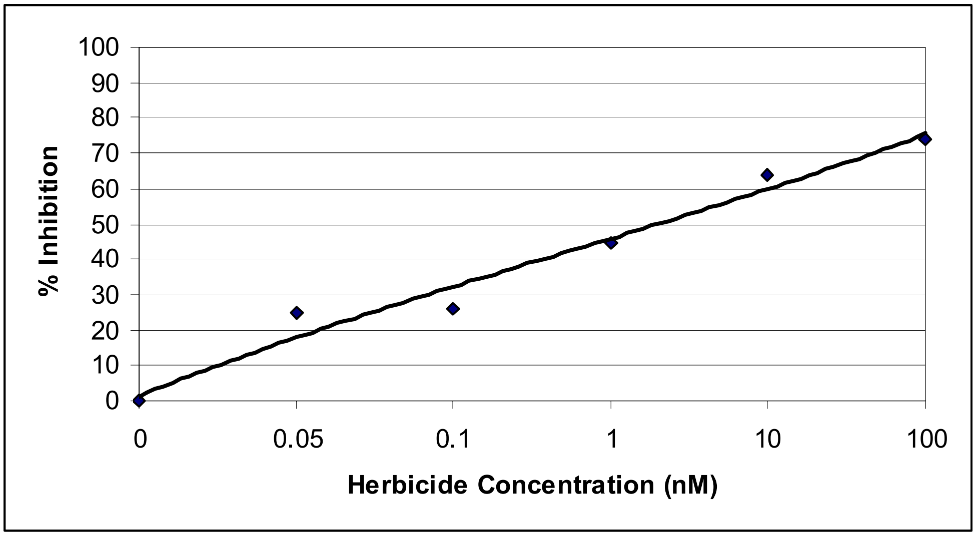

Figure 1. Halosulfuron concentration by percent inhibition of the ALS enzyme in sweetpotato (R^2=0.92). Herbicide concentration was transformed to a log 10 value.

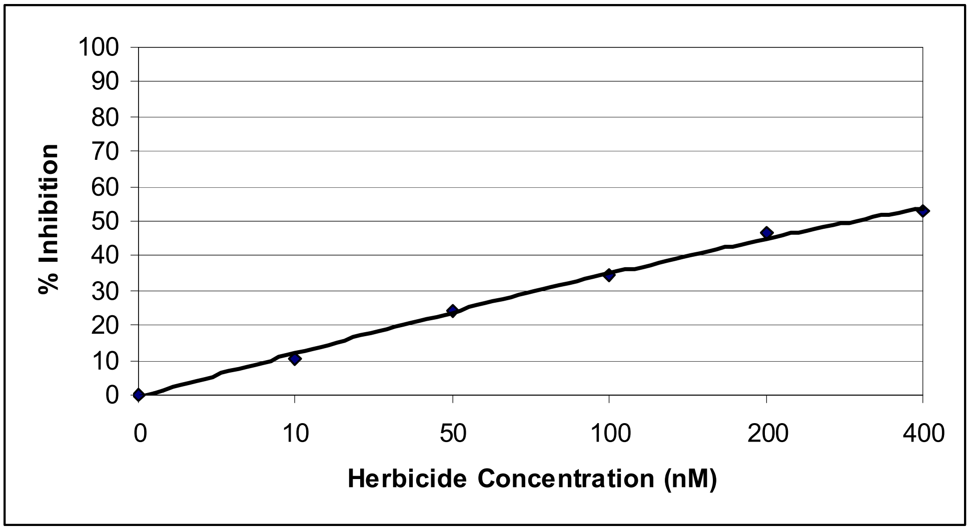

Figure 2. Nicosulfuron concentration by percent inhibition of the ALS enzyme in sweetpotato (R^2=0.98). Herbicide concentration was transformed to a log 10 value.

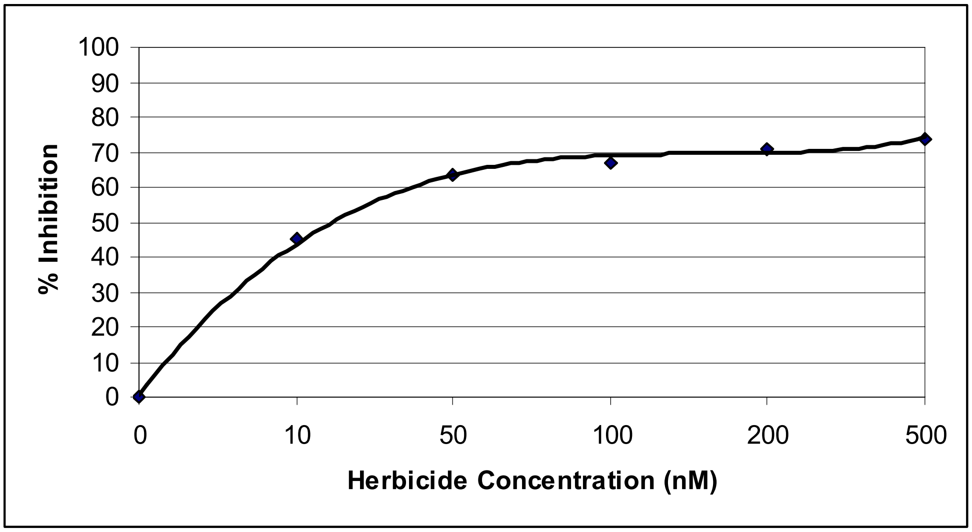

Figure 3. Primisulfuron concentration by percent inhibition of the ALS enzyme in sweetpotato (R^2=0.94). Herbicide concentration was transformed to a log 10 value.

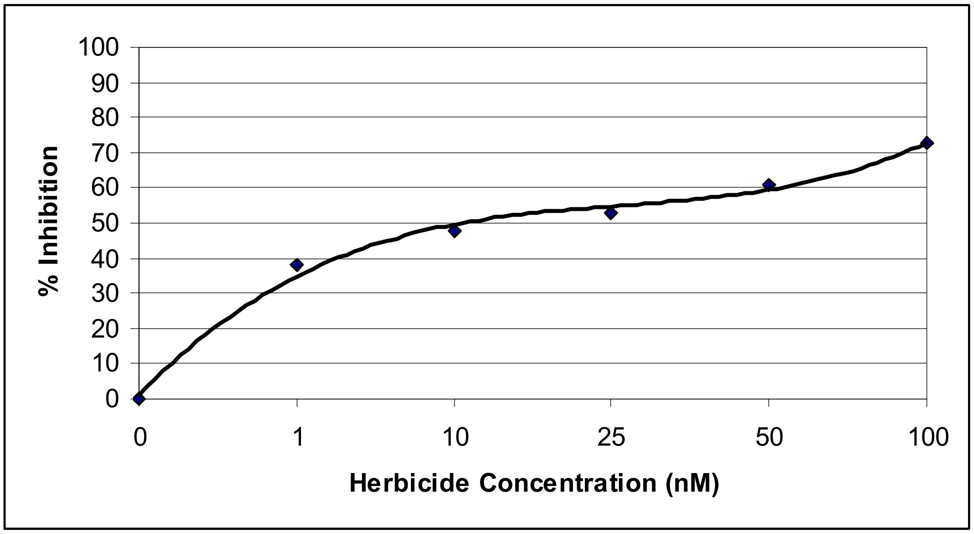

Figure 4. Trifloxysulfuron concentration by percent inhibition of the ALS enzyme in sweetpotato (R^2=0.84). Herbicide concentration was transformed to a log 10 value.

Table 1. Determination of a potential risk ratio for herbicide application to sweetpotato.

Herbicide	Field use rate	Calculated I50	Potential Risk Ratio
	g ai/ha	nM	(g ai/ha)/(nM)
Halosulfuron	39	2	19.5
Primisulfuron	40	15	2.7
Trifloxysulfuron	4.3	16	0.27
Nicosulfuron	35	305	0.11