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USE OF ACTIVATED CHARCOAL TO REDUCE INJURY TO SELECTED CUCURBITS BY ETHALFLURALIN OR PENDIMETHALIN

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

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June 1982

3060877

ACKNOWLEDGMENTS

The author wishes to express his sincere gratitude and appreciation to the following people without whose assistance this research and manuscript would not have been possible:

The Plant and Soil Science Department (Dr. Lloyd Seatz, Head) for providing financial assistance and necessary materials and equipment;

Dr. Larry Jeffery for serving as chairman of the graduate committee, for directing the preparation of this manuscript, and for guidance and encouragement;

Dr. James Caponetti, Dr. David Coffey, Dr. Wayne McLaurin, and Dr. Charles Pless who served on his graduate committee and gave advice and constructive criticism during the preparation of this manuscript;

Dr. Vernon Reich for assistance with the computer and statistical analysis;

Mrs. Carolyn Lunsford for typing the original manuscript;

Fellow graduate students for their fellowship and assistance throughout graduate work;

His parents, Mr. and Mrs. John Kennedy, and other relatives for their confidence and support during the course of this study.

CRANES CREST

ABSTRACT

The vining nature of cucurbit crops makes mechanical cultivation for weed control difficult. Most cucurbits are injured by many of the commonly used herbicides; therefore, very few are presently labeled for weed control. Activated charcoal has been shown to protect various crops from herbicide injury.

Comparisons of ethalfluralin [N-ethyl-N-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl)benzenamine] and pendimethalin [N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine] using two activated charcoal treatments were made on cucumbers (Cucumis sativus L.), summer squash (Cucurbita pepo L.), cantaloupes (Cucumis melo L.) and watermelon [Citrullus lanatus (Thunb.) Matsum and Nakai] in 1980 and 1981 at three locations in Tennessee. Ethalfluralin and pendimethalin were applied preplant incorporated at rates of 0.8 and 1.7 kg/ha. Activated charcoal was applied in a 2.5 cm band at a rate of 280 kg/ha, or as a seed coating. Data were collected on seedling stand, vigor reduction, weed control and fruit yield. In these studies activated charcoal reduced herbicide phytotoxicity to seedlings in most cases, resulting in greater plant survival and subsequent higher yields.

Cucumber, squash and watermelon cultivar trials were conducted in 1981. The chemical treatments were ethalfluralin applied at 1.4 kg/ha preemergence, and pendimethalin applied at 0.84 kg/ha preplant incorporated with no activated charcoal or an activated charcoal band applied at 280 kg/ha. Plants in ethalfluralin treated plots produced

fruit yields as high as those from the weed-free checks. Activated charcoal banding was effective in reducing crop injury by pendimethalin.

Six cucumber cultivars were grown on agar with several rates of pendimethalin or ethalfluralin. 'Sweet Slice' and '420 Green Pak' were the most sensitive, and 'Poinsett-76' and 'Ashley' were the most tolerant to the herbicides.

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CHAPTER I

INTRODUCTION

Most cucurbits are injured by many of the commonly used herbicides; therefore, very few herbicides have been labeled for weed control in them. Most of the labeled cucurbit herbicides do not provide adequate weed control.

Two of the most promising new herbicides for cucurbits which may be labeled in the near future are: pendimethalin [N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine] and ethalfluralin [N-ethyl-N-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl) benzenamine]. These herbicides control many grasses including seedling johnsongrass [Sorghum halepense (L.) Pers.] and some common annual broadleaf weeds such as the pigweeds (Amaranthus spp.) when applied preemergence or preplant incorporated. Tolerance of cucurbits to these herbicides is marginal.

Activated charcoal has been shown to reduce herbicide injury to emerging seedlings and transplants. The purpose of this study was to provide broad spectrum weed control in cucurbits while enhancing cucurbit herbicide tolerance with the use of activated charcoal.

CHAPTER II

LITERATURE REVIEW

Physical Properties of Dinitroaniline Herbicides

Trifluralin (a,a,a-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine) was introduced by Lilly/Elanco in 1960 (6). It was the first of the large class of dinitroaniline herbicides to which ethalfluralin and pendimethalin belong. Trifluralin is the most researched compound in this class (52).

Ethalfluralin has a water solubility of 0.21 ppm, and a vapor pressure of 8.2×10^{-5} mm Hg at 25 C (60,73).

Pendimethalin has a water solubility of 0.5 ppm and a vapor pressure of 3×10^{-5} at 25 C (55,73).

Behavior of Dinitroaniline Herbicides in Soils

Savage and Jordon (58) applied pendimethalin at 1.3 kg/ha on the surface of a Bosket silt loam soil. After three and eight days 59% and 47% of the herbicide remained on the soil surface, respectively. During a twelve day sampling period they found that two pseudo first order rate steps are involved in the dissipation of pendimethalin. During the first part of the sampling period the half-life of pendimethalin was determined to be four days. The latter portion of the sampling period was characterized by a much slower rate of dissipation with a half life of eighteen days.

Spencer and Claith (61) found that trifluralin volatilizes much more slowly when incorporated into the soil prior to planting. When

trifluralin was applied on the wet surface of a Gila silt loam soil at 1, 2 and 10 kg/ha there was no difference in the initial volatilization rates. The maximum volatilization rate for each surface treatment was approximately 4 kg/ha/day compared to 0.0157 kg/ha/day for the first 24 hours after soil incorporation.

Dissipation rates of the dinitroaniline herbicides are different (33,53,57,58). Three hours after surface application Kennedy and Talbert (33) recovered 95-100% of the fluchloralin [N-(2-chloroethyl)-2,6 dinitro-N-propyl-4-(trifluoromethyl)aniline], oryzalin (3,5-dinitro-N,N-dipropylsulfanilamide) and nitralin [4-(methylsulfonyl)-2,6-dinitro-N,N-dipropylaniline], 80-94% of the benefin (N-butyl-N-ethyl-a,a,a-trifluoro-2,6-dinitro-p-toluidine) and trifluralin and 66% of the profluralin [N-(cyclopropylmethyl)-a,a,a-trifluoro-2,6-dinitro-N-propyl-p-toluidine].

Parochetti et al. (53) reported similar results in a study with 11 dinitroaniline herbicides. Where all herbicides were applied on moist lakeland sand at 50 C, no vapor loss was detected after three hours for oryzalin, or nitralin. Vapor losses approached 25% for benefin, profluralin and trifluralin. Vapor losses of the other six herbicides ranged from 2 to 13%. Volatility of all the herbicides increased with increasing temperatures, but decreased as the soil moisture was increased beyond field capacity.

Kennedy and Talbert (32,33) found that trifluralin volatility is inversely related to soil moisture. Increasing the soil water content appears to block the active site for trifluralin adsorption on montmorillonite. The increased dilution in a wet soil yields a

lower aqueous herbicide concentration. On a percentage basis, the loss of trifluralin as a vapor is greater at lower concentrations which relates to the low water solubility of trifluralin and the effects of moisture on volatility. Therefore, increased vapor loss of trifluralin would be expected to occur with reduced barametric pressure, low relative humidity and increasing air movement (7,32).

The authors (32,33) found that volatilization of soil incorporated trifluralin is controlled more by the rate of herbicide movement to the soil surface than by the rate of air movement over the soil surface. The importance of soil water evaporation from the soil is that through capillary flow the surface water is replaced which concentrates the herbicide on the oustide of surface particles. The herbicide then attains a vapor pressure at which it volatilizes as fast as it arrives (32,33).

Kennedy and Talbert (32,33) incorporated several dinitroaniline herbicides at 0, 1, 3 and 7 days after surface application. Loss of herbicidal activity was determined by a grain sorghum (Sorghum bicolor L. Moench 'AKS-614') bioassay and by gas chromatography. They found that after a one day incorporation delay, oryzalin, nitralin, dinitramine (N,N-diethyl-a,a,a-trifluoro-3,5-dinitrotoluene-2,4-diamine), butralin [4-(1,1-dimethylethyl)-N-(1-methypropyl)-2,6-dinitrobenzenamine], fluchloralin and pendimethalin losses were within 5-12% of the control treatments which were incorporated immediately after application. Trifluralin, isopropalin (2,6-dinitro-N,N-diproplcumidine) and benefin were lost at a much greater rate under similar conditions. In this same test after three days on the soil surface only 10% of the oryzalin

was lost, while losses of nitralin, butralin, fluchloralin, dinitramine and pendimethalin losses ranged from 25-38%. This group of herbicides is considered to be moderately persistent. Trifluralin, isopropalin, and benefin were least persistent when left undisturbed on the soil surface for three days. Losses from this group ranged from 53-69%. After seven days on the soil surface the same trend of increasing herbicidal losses continued. Oryzalin was the most persistent losing only 19% of its activity while benefin lost 91% of its activity as compared to the incorporated control. With longer delays in soil incorporation there were increasing losses of the ten dinitroaniline herbicides tested. While these compounds have similar structures they have different vapor pressures thus different volatilization rates. Oryzalin has the lowest vapor pressure (1.4×10^{-6} mm Hg) as compared to benefin (3.9×10^{-5} mm Hg at 30 C) and trifluralin (1.99×10^{-4} mm Hg at 29.5 C). Vapor pressure is important in determining the volatility of a herbicide although other factors in the field also contribute to herbicide persistence in the field. Kennedy and Talbert (32,33) also compared effects of soil moisture on ten dinitroaniline herbicides. They found that dinitroaniline herbicides can be placed in three groups, (1) non-trifluro dinitroanilines (butralin, isopropalin, nitralin, pendimethalin and oryzalin), (2) trifluro-methyl diamines (dinitramine), and (3) trifluro-methyl dinitroanilines (benefin, fluchloralin, profluralin and trifluralin). The non-trifluro dinitroanilines were least affected by soil moisture. At 1% soil moisture by weight approximately 9% of the non-trifluro-methyl herbicides were lost after 24 hours at 30 C in ultra violet light. At 14, 26 and 33% soil moisture, 12, 18 and 13%

of the non-trifluro-methyl herbicides were lost respectively. Trifluro-methyl dinitroanilines were affected most by soil moisture. At 1, 14, 26 and 33% soil moisture by weight 15, 50, 72 and 84% of the herbicides in this group were lost (32,33).

Savage (57), in a moisture study evaluated the persistence of six dinitroaniline herbicides in two soil types. Using a hybrid grain sorghum 'DeKalk 57E' he found that trifluralin, butralin, profluralin, fluchloralin, dinitramine and pendimethalin were less toxic in a Sharkey clay than in a Bosket sandy loam when the herbicides were applied at a dosage of 8 μ moles/kg soil. Phytotoxic effects lasted longer in Bosket sandy loam than in Sharkey clay. Gas chromatographic analysis showed that the herbicides are more persistent in clay than in silt loam. Flooding Sharkey clay increased dissipation rates of trifluralin, profluralin, fluchloralin and pendimethalin as compared to clay maintained at near field capacity. Under flooded soil conditions the half life of pendimethalin was only 37 days, while at field capacity the half life of pendimethalin increased to 99 days (57). Rainfall also increases the dissipation rate of pendimethalin. After one day 65% of the pendimethalin remained, and after seven days less than 20% of the herbicide remained. Further studies with simulated rainfall at 0.6 cm showed the same dissipation trend. Rainfall on the first day reduced pendimethalin by 33% as compared to the control treatment with no rainfall and exposed to sunlight. Savage (57) concluded that initial losses were sufficient to discourage delayed incorporation of pendimethalin. Results indicate that rainfall may not be effective in incorporating pendimethalin and may result in increased herbicide loss.

These results are in contrast to Spencer and Cliath (61) who found that volatilization of trifluralin applied to a dry soil surface is extremely low and incorporation can be delayed.

Parochetti and Dec (54) found that under similar conditions pendimethalin decomposed faster when exposed to sunlight than held in the dark. Pendimethalin losses were 5.6-7.7% higher in the sunlight as compared to a dark control. Absorption by soil organic matter decreases the activity and dissipation rates of the dinitroaniline herbicides (17,59,61). Derr and Monaco (17) found increasing soil organic matter reduced the activity of ethalfluralin. When ethalfluralin at 1.25 lbs/A was applied on soils with three organic matter levels of 1, 3, and 9% control of barnyardgrass [Echinochloa crus-galli (L.) Beauv.] decreased correspondingly with increasing organic matter. Barnyardgrass control of 90% was achieved on a 1% organic matter soil, 75% control at 3% organic matter and only 55% control was achieved on a 9% organic matter soil.

Spencer and Cliath (61) found that trifluralin vapor density decreased as organic matter content increased. Vapor densities at 10 ug/g of trifluralin in three soils varying in organic matter content were 3.19, 1.73 and 0.62 ug/l in Imperial clay (.20% organic matter), Gila silt loam (.58% organic matter) and Kentwood sandy loam (1.62% organic matter), respectively. These results also indicate that clay plays a minor role in trifluralin adsorption.

These conclusions are further supported by Seagraves and others (59) who found that total carbon content was highly associated with the activity of both trifluralin and profluralin in 21 alluvial soils.

Herbicidal activity in each soil was assessed by determining the rate of herbicide required for 50% sorghum root inhibition. Soil carbon content accounted for 91% of the variability in trifluralin rate, while 55% of the variability in the trifluralin rate could be accounted for by soil clay content. Soil carbon content accounted for 84% of the variability in the profluralin rate, while 59% could be accounted for by the total clay content.

Mode of Action of Dinitroaniline Herbicides

Selective herbicidal activity was obtained by substitutions on the amino group of the 2,6-dinitroaniline molecule. Most of the selectivity of the dinitroaniline herbicides are directed toward pre-emergence grass control and usually prevent weeds from emerging through the soil surface. The herbicidal potency is modified by four-position substitutions in the order $CF_3 > CH_3 > Cl > H$ (30,52).

Injury symptoms caused by the dinitroaniline herbicides to dicots are a reduction in longation or stunting of the shoot, a leathery appearance of the cotyledons, swelling and brittleness of the hypocotyl and an intensification of green coloration (3,4,52). Root growth inhibition is accompanied by an increase in diameter of the root near the tip, and inhibition of secondary roots are common herbicidal symptoms (6,25,30, 46).

Lignowski and Scott (38) found that trifluralin inhibited mitosis in onion (Allium cepa L. 'Yellow Globe') and wheat (Triticum aestivium L.). Prophase was not affected by trifluralin. In metaphase the chromosomes were not arranged on an equatorial plate, but became scattered throughout the cytoplasm. In trifluralin treated species,

chromosomes of some arrested metaphases became very thickened and shortened and generally clumped to form micronuclei which fused to form amoeboid shaped nuclei. After 24 hours of treatment many cells were multinucleate and in some of the cells the chromosomes aggregated to form one polyploid nucleus. Chromosomal effects produced by trifluralin were similar in both onion and wheat root tips. After three hours the percent of metaphase figures increased from 10 to 40% while the percent of prophase figures did not change. The increase in metaphases was almost entirely due to a 50% decrease in anaphase and telophase figures. After 12 hours no anaphase figures and only a few telaphase figures were present and the percentage of metaphase figures rose to 83%. The percentage of prophase figures did not change. After three hours of trifluralin treatment centrifugation moved the chromosomes of the arrested metaphases which were spread throughout the cell. Control metaphase chromosomes stayed in the normal configuration on the equatorial plate presumably attached to the spindle apparatus. The centrifugation experiment gives further evidence that trifluralin is a mitotic agent and disrupts the spindle in a similar manner as colchicine.

Different tissues of cotton (Gossypium hisutum L.) roots respond differently to trifluralin (10,44). Bayer et al. (10) found that cells of the pericycle and endodermis are more sensitive to trifluralin than the cells in the root tip. Most of the tissues of trifluralin treated cotton roots developed normally. The pericycle cells were enlarged in the region opposite the protoxylem and the pericycle was one cell deep. Hayward (27) reported that the pericycle in cotton roots is two or three cells deep opposite the protoxylem. Bayer (10) concluded that

the observed enlargement of the cells of the pericycle is the result of blocking of one or more mitosis and cytokinesis with subsequent cell enlargement.

Gordon and Frans (24) ranked some of the dinitroaniline herbicides according to the extent they inhibited lateral root formation of treated plants. They found that trifluralin inhibited lateral root formation≥fluchloralin≥profluralin≥butralin≥pendimethalin. A trifluoro group was a common component of the ring structure for the most inhibitory herbicides and an amine group was a common component for the least inhibitory herbicides.

Cotton and soybean [Glycine max (L.) Merr.] root inhibition may be minimized by limiting the depth of incorporation of trifluralin. Incorporation of trifluralin improved weed control, but depths of incorporation greater than one inch caused injury to cotton and soybeans. Increasing the depth of incorporation decreased the number of lateral roots of cotton and soybeans (24,50,51,62,63). Approximately 0.75 ppmw of trifluralin was the threshold concentration for root growth retardation in soybeans (63). If the inhibitory effect is not sufficient to cause the death of the seedling the herbicidal effect may be overcome partially through production of more lateral roots in the non-treated zone of soil after the primary root has passed through the treated zone. The number of lateral roots increased below the treated zone with the greatest number of lateral roots in the one inch zone below the treated zone (31).

Anderson (3) found that stunting of cotton height was independent of root growth. When trifluralin was incorporated above the cotton

seed no root damage occurred while shoot damage was observed. Anderson (3) concluded that trifluralin enters the emerging cotton seedling through the hypocotyl, cotyledons and/or terminal bud. Apparently trifluralin is not translocated downward in the cotton seedling.

Derr and Monaco (17) found that both shoot and root uptake of ethalfluralin occur in cucumbers, and that root uptake was more important than shoot uptake. They concluded maxmimum crop safety to cucumbers would be attained using a preemergence rather than preplant incorporation of ethalfluralin.

Effect of Activated Charcoal on Herbicide Activity

Protection by activated charcoal depends on factors such as crop species, soil type, herbicide type and rate, brand of activated carbon and rate (1,12,13,14,35).

The use of activated charcoal to deactivate herbicides was introduced by Lucas and Hamner (42) in 1947. Early researchers (5,42) realized that equipment used to spray 2,4-D[(2,4-dichlorophenoxy)acetic acid] was difficult to adequately clean so injury often occurred when sensitive species such as tomatoes (Lycopersicon escalentum Mill.) were sprayed with the same equipment in which 2,4-D had been used. Lucas and Hamner (42) found that rinsing a sprayer used to apply a 2,4-D solution of 10,000 ppm with a 1% suspension of activated charcoal for two minutes made that sprayer safe to use on 2,4-D sensitive species.

Since this first report, many researchers (1,35,37,56) have devised different ways to use activated charcoal to reduce or eliminate herbicide injury to sensitive crops. Some researchers (2,35,56) use root dips to protect crops from herbicide injury. Ahrens (1) reported

an activated charcoal root dip is effective in protecting strawberry (Fragaria grandiflora Ehrh.) plants from simazine [2-chloro-4,6-bis (ethylamino)-s-triazine] applied at 2.0 or 3.0 lbs/A. He also reported activated charcoal reduced injury to transplanted cabbage (Brassica oleracea L.) and tomatoes by simazine at 1.5 and 3.0 lbs/A, respectively.

Activated charcoal banding at 28-56 kg/ha in the seed row also has been effective in protecting alfalfa (Medicago sativa L. 'Cayuga') from 1.7 kg/ha of G-36393 [2-esopropylamino-4-(3-methoxypropylamino)-6-methylthio-s-triazine] while 112 kg/ha of activated charcoal was necessary for protecting from 3.36 kg/ha G-36393. Activated charcoal did not protect alfalfa seedings from 1.7 kg/ha atrazine [2-chloro-4-(ethylamino)-6 isopropylamino)-s-triazine] (39).

Lee (37) found that banded activated charcoal at 336 kg/ha provided satisfactory protection to six species of lawn grasses when seeded in atrazine at 1.4 kg/ha, duiron [3-(3,4-dichlorophenyl)-1,1-dimethylurea] at 2.24, 2.8, and 3.6 kg/ha, simazine at 1.8 and 2.24 kg/ha and terbacil at 0.84 kg/ha. One grass species (Festuca arundinacea Schreb. 'Fawn') was injured by terbacil at 1.12 kg/ha with or without charcoal.

Banding activated charcoal in a 5% slurry is also effective in protecting lettuce (Lactuca sativa L.) from CDEC (2-chloroallyl diethyldithiocarbamate) at 9.0 kg/ha, benefin at 3.4 kg/ha and pronamide [3,5-dichloro(N-1,1-dimethyl-2-propynyl)benzamide] at 3.4 kg/ha (34). Banding activated charcoal at 281 kg/ha was effective in reducing watermelon injury from pendimethalin or ethalfluralin at 0.8 or 1.7 kg/ha (31).

Glaze et al. (22,23) developed a spot application system to apply activated charcoal with the watermelon seed as it is planted. This system is effective in preventing terbacil injury to watermelon, but is ineffective in preventing atrazine injury.

Kratky and Warren (36) reported that by placing activated charcoal in a hole over the seed, the activated charcoal became encrusted making tomato seedling emergence difficult. Kratky and others (34,36, 74,75) reported the addition of vermiculite along with activated charcoal prevented crusting in direct seeded tomatoes. This idea led to the development of a seed wafer. This wafer is made up of vermiculite and activated charcoal with tomato seeds inside. The wafer protected tomato seedlings from 0.56 kg/ha simazine and tended to raise the temperature around the seed (29).

Elstrom (18) used activated charcoal to absorb terbacil in the planting hills of direct seeded watermelons. Incorporated activated charcoal at 1008 kg/ha protected watermelon seedlings from terbacil at 1.12, 2.24 or 4.48 kg ai/A. Surface application of activated charcoal at 336 kg/ha did not provide as much protection as the incorporation of it at 1008 kg/ha.

Brenchley (13) compared two commercial brands of activated charcoal with nonactivated charcoal. Atrazine was applied at 3.36 and 6.72 kg a.i./ha to soils containing 224, 448 and 672 kg/ha of both brands of activated charcoal and 448, 896 and 1792 kg/ha of nonactivated charcoal. Comparing dry wrights of an oat (Avena Sativa L.) Brenchly (13) determined the effectiveness of the activated and nonactivated charcoal treatments. The activated charcoal brand Aqua Nuchar (R) was slightly

more active in absorbing atrazine than the active carbon brand Atlas Darco DM (R) which in turn was about three times more effective than non-activated charcoal.

Kratky and his coworkers (35) compared three brands of activated charcoal. They found that the activated charcoal brand Darco S-51 (R) when used as a strawberry root dip to prevent simazine injury, similar amounts treated almost twice as many plants as the activated charcoal brands Darco M (R) or Aqual Nuchar A (R). Brenchley (13) concluded that using non-activated charcoal is more cost-effective than using activated charcoal.

Burr (14) found that the use of the wetting agents X-77 (R) and Surfactant-WK (R) reduced the effectiveness of activated charcoal to inactivate diuron. Protection is apparently due to completion for adsorption sites on the charcoal rather than differences in the surface tension of the suspension.

Weed Control Practices in Cucurbits

Due to the vining nature of cucurbits, mechanical cultivation to remove weeds is limited during most of the growing season. Two approaches to seed bed preparation and seeding of cucurbits are currently used. The first approach is the stale seed bed method. This method requires that the seed bed be prepared, but seeding delayed for 12-14 days to allow weeds to germinate. After the weed seeds have germinated post emergence herbicides such as glyphosate [N-(phosphonomethyl) glycine] or paraquat (1,1'-dimethyl-4,4'-bipyridinium ion) can be used alone or in conjunction with other herbicides to kill the weeds. The

seed bed is then seeded disturbing the soil as little as possible (21, 46,47,48).

Glaze (25) found that in general the yield of the cucurbit crop is proportional to the weed control obtained, unless there was severe crop injury. He demonstrated the yield difference between the weedy checks and the handweeded checks with cucumbers was 2.6 times and watermelons was 5.8 times.

Friesen (20) conducted a weed competition test in cucumbers which showed a critical weed free period for cucumbers was between 12 and 36 days after cucumber seedling emergence. When the weeds were removed from these plots after 36 days the cucumbers showed little recovery. Friesen (20) suggested an allelopathic effect between cucumbers and common lambsquarters (Chenopodium album L.) since in 1976 in a previous study there was no difference between 95% and 50% control of common lambsquarters in cucumber yield.

Many researchers (11,63,64,65) report excellent weed control using ethalfluralin as a preemergence or as a preplant incorporated treatment. As a preemergence treatment 0.75 lbs/A ethalfluralin was required for acceptable weed control and as a preemergence treatment 2.25 lbs/A ethalfluralin was not phytotoxic to cucumbers. Crops recovered from any initial injury and there was no reduction in yield.

Teasdale (67) found that full season common lambsquarters control required at least 2.24 kg/ha ethalfluralin applied preemergence. In his studies treatment with 4.48 kg/ha ethalfluralin resulted in severe plant damage, reduced stand and vigor. Cucumber yield increased with common lanbsquarters control. Due to crop injury cucumber yield

declined when rates higher than 2.24 kg/ha ethalfluralin were used.

In Tennessee, Cordrey et al. (15) in a two year study found that ethalfluralin and pendimethalin applied preemergence at 1.25 kg/ha reduced the vigor and yield of cucumber, muskmelon and summer squash as compared to the weed-free check.

Talbert and co-workers (63,64,65) applied pendimethalin at 1.1 kg/ha and ethalfluralin at 0.8, 1.2 and 1.7 kg/ha as preemergence treatments to various cucurbits. In these studies neither compound reduced the yield of cucumbers (62,63). In 1978 (63) pendimethalin reduced the yield of cantaloupes 'Planter's Jumbo' and in 1979 (64) cantaloupe 'Hale's Best' yields were not reduced by either compound. Watermelon 'Crimson Sweet' was not injured by either compound from 1978-1980. Excellent control of crabgrass (Digitaria spp.), redroot pigweed (Amaranthus retroflexus L.) and goosegrass (Eleusine indica L.) was attained by both compounds (63,64,65).

Derr and Monaco (17) tested sixteen cucumber varieties with ethalfluralin at 1.25 lbs/A and found no difference in cultivar response to the herbicide.

Williamson and Beste (76) found that replanting cucumbers at 2, 4 or 8 weeks after applying ethalfluralin at 0.84, 1.25 and 2.52 kg/ha provided excellent weed control and cucumber tolerance with no yield reduction.

CHAPTER III

MATERIALS AND METHODS

Dinitroaniline Herbicides in Combination with Activated Charcoal on Cucurbits

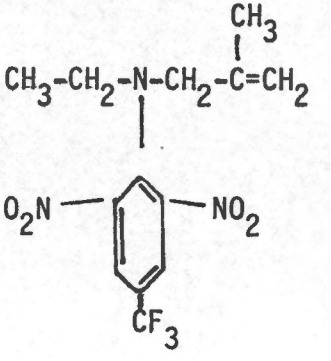
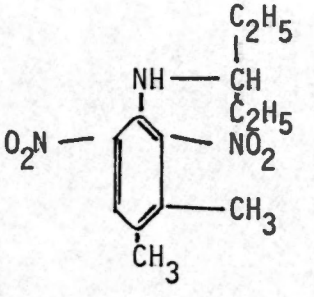
Experiments were conducted during 1980 and 1981 at three Tennessee locations: the West Tennessee Experiment Station at Jackson, the Plateau Experiment Station at Crossville, and the Plant Science Field Laboratory at Knoxville.

The common name, chemical name, and structures of both dinitroaniline herbicides used in this study are presented in Table 1.

These experiments were conducted to determine the susceptibility of cucurbits to preplant incorporated ethalfluralin or pendimethalin applied at 0.8 or 1.7 kg/ha. Activated charcoal was either applied in a band in the seed row at 280 kg/ha or applied as a coating on the seed as an attempt to reduce cucurbit herbicide injury. Activated charcoal was banded using a Plantet Jr. seeder.(R) Following the track left by the Plantet Jr.,(R) seeds were planted into the activated charcoal band. As a second treatment activated charcoal was applied to the cucurbit seeds. Wheat paste was applied to the seeds by rubbing the seeds in my hands which were coated with wheat paste. Seeds were allowed to fall into activated charcoal. Then the activated charcoal was sifted to separate the charcoal coated seeds.

Hereafter these two carbon treatments are referred to as CB and CC, respectively. These seed were then planted in the herbicide treated

Table 1. Dinitroaniline herbicides used in this study.

Common Name		
Ethalfluralin	N-ethyl-N-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl) benzenamine	
Pendimethalin	N-(1-ethylpropyl)-3,4-dimethyl-2,6 dinitrobenzenamine	

soil. Naptalam (N-1-naphthylphthalamic acid) herbicide presently labeled and recommended for weed control in cucurbits was also included in this study. Naptalam was applied preemergence at 6.7 kg/ha. Activated charcoal was not used. The checks were kept weed-free by hand hoeing throughout the growing season.

One row plots were arranged in a randomized complete block design. The plot size and number of replications at each location for each experiment are presented in Table 2.

A seed bed was prepared for planting by tillage operations commonly used at each location. Soil types, fertilization rates, cucurbit cultivators used at each location, planting dates and final cucurbit populations are presented in Table 3.

Ethalfluralin and pendimethalin were incorporated with a tilrovator into the top 5 cm of the seedbed at Jackson and Knoxville and a powered harrow was used for herbicide incorporation in Crossville.

Throughout the growing season, data were obtained on cucurbit injury expressed in terms of reduced crop vigor, using a rating scale ranging from 0 indicating no crop vigor reduction to 100, indicating a complete crop kill. Population data and yield data were also obtained. Grading standards used to determine marketable yields were from the U.S.D.A. Agricultural Marketing Service (68,69,70,61,72). Visual ratings on the basis of percent weed control were made on each experiment. In this rating scale, above 90% is considered as excellent, 75 to 90% as good, 60 to 75% as fair, and 60% or less as poor. Abbreviations for the weed species rated are presented in Table 4 (48).

The dates when data were collected for each location are shown

Table 2. Plot size and number of replications used at each location in the 1980 and 1981 dinitroaniline herbicides in combination with activated charcoal tests with selected cucurbits.

	Location					
	Crossville		Jackson		Knoxville	
	1980	1981	1980	1981	1980	1981
Number of Replications:						
Cucumbers	3	4	3	4	3	4
Summer Squash	4	4	4	4	4	4
Cantaloupes	3	4	-	4	3	4
Watermelons	4	4	3	4	3	4
Plot Size (all locations):						
Cucumbers	1.1 m x 3.0 m					
Summer Squash	1.2 m x 4.6 m					
Cantaloupes	2.1 m x 6.4 m					
Watermelons	2.1 m x 10.7 m					

Table 3. Soil types, cucurbit cultivars and cultural practices following in the 1980 and 198[illegible] dinitroaniline herbicides in combination with activated charcoal tests with selected cucurbits.

	Location					
	Crossville		Jackson		Knoxville	
Soil Type:	Hartsells Silt Loam		Collins Silt Loam		Etowah Silt Loam	
Fertilization (kg/ha):	24 N 111 P 117 K		45 N 104 P 110 K		24 N 111 P 117 K	
Cultivars:						
Cucumber	420 Green Pak		420 Green Pak		420 Green Pak	
Summer Squash						
1980	Zuchinni Elite		Dixie		Zuchinni Elite	
1981	Greyzinni		Greyzinni		Greyzinni	
Cantaloupe						
1980	Iroquois		-		Iroquois	
1981	Iroquois		Iroquois		Iroquois	
Watermelon	Crimson Sweet		Crimson Sweet		Crimson Sweet	
Planting Date:	1980	1981	1980	1981	1980	1981
Cucumber	6/5[a] 6/25[b]	6/17	5/26[a] 6/3[b] 6/10[c]	5/3	5/8[a] 6/27[b]	6/15
Summer Squash	6/5	6/17	5/26	5/3	5/8	6/15
Cantaloupe	6/5	6/17	-	5/3	5/8	6/15
Watermelon	6/5	6/17	5/20	5/3	5/8	6/15
Final Population/ha (all locations):						
Cucumber	215,200					
Summer Squash	26,900					
Cantaloupe	7,300					
Watermelon	4,390					

[a]First cucumber planting.

[b]Second cucumber planting.

[c]Third cucumber planting.

Table 4. Common name, scientific name and abbreviation of weeds rated for the effects of dinitroaniline herbicides in combination with activated charcoal studies on cucurbits.

Common Name	Scientific Name	Abbreviation[1]
Common lambsquarters	Chenopodium album L.	Colq
Common purslane	Portulaca oleracea L.	Copu
Common ragweed	Ambrosia artemisiifolia L.	Corw
Green foxtail	Setaria viridia (L.) Beauv	Grft
Goosegrass	Eleusine indica (L.) Gaertn.	Gogr
Large crabgrass	Digitaria sanguinalis L.	Lacq
Prickly sida	Sida spinosa L.	Prsi
Redroot pigweed	Amaranthus retroflexus L.	Rrpw
Tall morningglory	Ipomoea purpurea (L.)	Tamg

[1]Standard abbreviations as per North Central Weed Science Society (49).

in Table 5 for 1980 and in Table 6 for 1981.

Climatic data for each location were obtained from the official weather records for each experiment station (44,45).

Cucumber, Squash and Watermelon Cultivar Trials

In 1981, studies were initiated to determine if various cucurbit cultivars differ in their response to pendimethalin and ethalfluralin. The six cultivars of cucumbers and squash, and the five cultivars of watermelons used in these studies are listed in Table 7.

Pendimethalin was preplant incorporated at 0.84 kg/ha and ethalfluralin was applied preemergence at 1.12 kg/ha. As a third treatment, pendimethalin was preplant incorporated at 0.84 kg/ha and then an activated charcoal band was applied at a rate of 280 kg/ha in a 2.5 cm band on a treated area basis using a Plantet Jr.(R) The seeds were planted into the activated carbon band. Dates of herbicide application, planting and harvest are shown in Table 8.

The experimental design used for the cultivar evaluation study was a split-plot with four replications. The main plot treatments were herbicides and sub-plot treatments were cucurbit cultivars.

Cucumber Cultivar In Vitro Test

A 0.6% Bacto-Agar medium was prepared, with the pH of the distilled water adjusted to pH 6.3 with 1 N KOH. When the medium cooled to 55 C, an appropriate amount of pendimethalin or ethalfluralin was added to make solutions of 0.125, 0.250, 0.375, 0.500, and 0.625 ppmw. An untreated control was also prepared. A twenty ml. aliquot of each

Table 5. Dates in 1980 when various parameters were measured in the tests where selected cucurbits were grown in soil treated with dinitroaniline herbicides in combination with activated charcoal.

	Location		
	Crossville	Jackson	Knoxville
Vigor Reduction Ratings:			
Cucumber	6/25[a]	7/2[a], 7/2[b], 7/2[c]	6/24[a]
Summer Squash	-	7/2	6/1, 6/26
Cantaloupe	6/25	-	6/24
Watermelon	6/25	6/11	6/24
Population Counts:			
Cucumber	6/25[a]	6/3, 17, 25[a], 6/17, 25; 7/2[b], 7/2; 8/7[c]	6/6[a]. 7/14[b]
Summer Squash	6/25	6/3, 17, 25; 7/2	6/6
Canteloupe	6/25	-	6/24
Watermelon	6/25	6/11	6/24
Weed Control Ratings:			
Cucumber	8/13[b]	7/2[a], 7/2[b]	-
Summer Squash	-	-	6/26
Canteloupe	-	-	7/21
Watermelon	-	-	-
Harvest Dates:			
Cucumber	7/17a, 8/13b	8/7[c]	6/26[a], 8/15[b]
Summer Squash	7/18	-	6/26, 30; 7/7, 15
Canteloupe	8/13, 18, 22, 28	-	7/21, 25, 28, 31; 8/4
Watermelon	8/18, 22, 28; 9/3, 8	Continuous	8/4, 8, 14

[a]First cucumber planting.

[b]Second cucumber planting.

[c]Third cucumber planting.

Table 6. Dates in 1981 when various parameters were measured in the tests where selected cucurbits were grown in soil treated with dinitroaniline herbicides in combination with activated charcoal.

	Location		
	Crossville	Jackson	Knoxville
Vigor Reduction Ratings:			
Cucumber	7/16	6/23	7/14
Summer Squash	7/16	6/1	7/14
Cantaloupe	7/16	6/23	7/14
Watermelon	7/16	6/23	7/14
Population Counts:			
Cucumber	7/1	6/1	7/7
Summer Squash	7/1	6/1	7/7
Cantaloupe	7/1	6/23	7/7
Watermelon	7/1	6/23	7/8
Weed Control Ratings:			
Cucumber	-	6/23	-
Summer Squash	-	6/23	7/14
Cantaloupe	9/10	6/23	7/14
Watermelon	9/17	6/23	7/14
Harvest Dates:			
Cucumber	8/4	6/23	7/20
Summer Squash	7/21, 28; 8/4, 11, 19, 27	6/23, 30; 7/8, 13, 16, 30	7/17, 20, 23, 27, 31
Cantaloupe	9/10	7/27, 30; 8/4, 11	8/23, 28
Watermelon	9/17	8/14, 21	8/28

Table 7. Plot size and cultivars used in the cucurbit cultivar trials in Knoxville and Crossville.

	Cucurbit Crop		
	Cucumber	Squash	Watermelon
Plot Size:	1.2 m x 3.0 m	1.2 m x 4.6 m	1.5 m x 6.1 m
Cultivar:	'420 Green Pak'	'Warted Hubbard'	'Charleston Gray'
	'Ashley'	'Dixie'	'Black Diamond'
	'Carolina'	'Waltham Butternut'	'Seedless Hybrid'
	'Sweet Slice'	'Gold Rush'	'Sugar Baby'
	'Dasher'	'Early Prolific Straight Neck'	'Crimson Sweet'
	'Poinsett-76'	'Greyzinni'	

Table 8. Dates of planting, harvesting and herbicide application associated with the cucurbit cultivar trials at Knoxville and Crossville.

Crop	Herbicide Application	Planting	Harvest
Cucumber	6/15	6/15	7/24
Squash	6/15	6/15	Continuous
Watermelon			
at Knoxville	6/15	6/15	8/28, 9/9
at Crossville	6/17	6/17	9/17

medium was poured into individual 25 X 150 mm culture tubes. Each tube was capped with a plastic closure.

Seeds of hybrid cucumber cultivars '420 Green Pak,' 'Dasher,' 'Ashley,' 'Carolina,' 'Poinsett-76,' and 'Sweet Slice' were surface sterilized by soaking them for ten minutes in an aqueous solution containing 20% v/v chlorox and 1% w/v Alconox. The seeds were then rinsed three times with sterile water. Individual seeds were positioned horizontally on the surface of the solidified medium in the culture tubes.

The culture tubes were then placed in a culture room maintained at 25 C $\pm$ 2 C. A 16 hour light period each day was furnished by white fluorescent tubes and incandescent lamps at an intensity of 2600 lux at the level of the culture tubes. The culture tubes were arranged in a randomized complete block design with 12 tubes, each tube comprising a replicate.

After two to three days, when the primary root had emerged to a length of approximately 3 mm, the seeds were reoriented to an upright (root down) position and partially submerged with half of the seed in the medium.

After seven days in the herbicide treated medium the length of the primary root and the number of secondary roots of each seedling were recorded. The seedlings were transferred into untreated medium prepared as stated earlier. After ten days in the untreated medium the primary root length and the number of secondary roots were again recorded.

Duncan's multiple range test at the 5% level of significance was used to separate the treatment means in all tests.

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CHAPTER IV

RESULTS AND DISCUSSION

The purpose of this study was to reduce herbicide injury to cucurbits; therefore, vigor reduction ratings, population counts, marketable fruit yields, marketable fruit numbers and weed control ratings will be compared to the weed-free check.

Effects of Dinitroaniline Herbicides in Combination with Activated Charcoal on Cucumbers

No differences in 1980 vigor ratings were found between cucumbers in the weed-free check and cucumbers in the herbicide treated plots in Crossville and Jackson (Table 9). Neither of the activated charcoal treatments had an effect on these ratings. In 1980 and 1981 at Knoxville, cucumber seeds planted in an activated charcoal band were not injured by ethalfluralin at the 0.8 kg/ha rate; but were not protected by injury at the 1.7 kg/ha rate. An activated charcoal coating on the cucumber seeds did not prevent ethalfluralin injury at either rate. During 1981 at Crossville, ethalfluralin at 1.7 kg/ha reduced the vigor of the cucumbers which were not protected by activated charcoal. The 0.8 kg/ha rate of ethalfluralin did not reduce cucumber vigor except when the seeds were coated with activated charcoal. The 1.7 kg/ha rate of pendimethalin did not reduce cucumber vigor except when the seeds were coated with activated charcoal. During 1981, ethalfuralin, applied at both 0.8 and 1.7 kg/ha, injured cucumbers at Jackson. Neither a band treatment with activated charcoal nor an activated charcoal coating on the seed

Table 9. Percent cucumber vigor reduction in the dinitroaniline herbicides in combination with activated charcoal tests at three Tennessee locations.[a]

Treatment	Rate kg/ha	Charcoal	Crossville		Jackson				Knoxville	
			1980[b]	1981	1980[b]	1980[c]	1980[d]	1981	1980[b]	1981
Ethalfluralin	0.8	-	22 AB[e]	16 BCD	44 A	63 A	66 A	76 ABC	25 ABC	46 AD
		CC[f]	20 AB	30 BC	15 A	50 AB	43 A	70 ABC	33 AB	32 B-G
		CB[g]	29 AB	62 BCD	50 A	97 A	18 A	54 CDE	0 C	10 EFG
	1.7	-	30 A	77 A	71 A	68 A	65 A	92 AB	40 A	76 A
		CC	30 A	30 BC	66 A	99 A	37 A	97 A	13 ABC	60 AB
		CB	22 AB	11 BCD	72 A	80 A	53 A	90 AB	33 AB	54 ABC
Pendimethalin	0.8	-	22 AB	16 BCD	38 A	37 AB	35 A	12 F	3 C	26 C-G
		CC	5 AB	15 BCD	38 A	35 AB	27 A	27 EF	0 C	9 EFG
		CB	7 AB	7 BCD	20 A	50 AB	10 A	12 F	0 C	5 FG
	1.7	-	13 AB	12 BCD	48 A	70 A	47 A	54 CDE	8 BC	40 BE
		CC	3 B	31 B	25 A	95 A	80 A	47 CDE	0 C	17 D-G
		CB	15 AB	17 BCD	45 A	82 A	42 A	64 BCD	0 C	9 EFG
Naptalam		-	7 AB	5 CD	33 A	0 B	35 A	15 F	0 C	9 EFG
Weed-free check		-	5 AB	2 D	17 A	0 B	47 A[h]	25 EF[i]	3 C	9 EFG

[a] A 0 indicates no crop damage and 100 indicates a complete crop kill.

[b] First cucumber planting.

[c] Second cucumber planting.

[d] Third cucumber planting.

[e] Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's new multiple range test.

[f] CC = an activated charcoal coating applied to the seed at planting.

[g] CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

[h] Check plots were damaged by drought conditions.

[i] Check plots were damaged due to flooding.

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prevented this injury. The 1.7 kg/ha rate of pendimethalin did not reduce cucumber vigor except if the cucumber seeds were planted in an activated charcoal band.

None of the herbicide treatments reduced cucumber stands at Crossville in either 1980 and 1981, or in the first Knoxville planting in 1980 (Table 10). Neither of the activated charcoal treatments affected cucumber populations. In the second cucumber planting during 1980 and in 1981 at Knoxville, ethalfluralin at 1.7 kg/ha reduced cucumber populations. Pendimethalin did not reduce cucumber stands at either Crossville or Knoxville in either year.

When the initial population counts were made at Jackson, in all three cucumber plantings, none of the herbicide treatments influenced plant stand (Table 11). When population counts were repeated by June 25 in both the first and second plantings, the 1.7 kg/ha rate of ethalfluralin reduced cucumber stands. The 1.7 kg/ha rate of both ethalfluralin and pendimethalin reduced cucumber stands when counted by June 25 in the second planting. Neither a band treatment with activated charcoal or an activated charcoal coating on the seed prevented this injury. Both dinitroaniline herbicides reduced cucumber populations by June 2 when population counts were made in the second planting. Neither a band treatment with activated charcoal or an activated charcoal coating on the seed prevented this injury.

Cucumber populations in the second cucumber planting at Jackson reached their peak about June 25 in the dinitroaniline herbicide treated plots.

The probable death of the primary root meristem and the lack of

Table 10. Cucumber plants X 10/ha in the dinitroaniline herbicides in combination with activated charcoal tests at two Tennessee locations.

Treatment	Rate kg/ha	Charcoal	Crossville		Knoxville		
			1980[a]	1981	1980[a]	1980[b]	1981
Ethalfluralin	0.8	-	14162 AB[c]	10486 A	17327 AB	12907 AB	7852 A-E
		CC[d]	10517 AB	10126 A	21869 AB	22826 A	10311 ABC
		CB[e]	14699 AB	8517 A	18643 AB	15418 AB	11208 B
	1.7	-	18083 A	7170 A	16430 AB	6932 B	3855 E
		CC	7292 AB	8517 A	18162 AB	15894 AB	4573 DE
		CB	16254 AB	9767 A	20314 AB	12113 AB	6097 B-E
Pendimethalin	0.8	-	12608 AB	10041 A	15174 AB	24441 A	6545 A-E
		CC	13626 AB	8425 A	15894 AB	13338 AB	10759 AB
		CB	10157 AB	9230 A	20552 AB	17924 AB	9504 A-D
	1.7	-	14998 AB	9139 A	16668 AB	17028 AB	6007 B-E
		CC	5377 B	8157 A	27246 AB	12071 AB	9056 A-D
		CB	10395 AB	8334 A	29873 A	20796 A	5649 CDE
Naptalam	6.7	-	13028 AB	9230 A	8962 B	15893 AB	6814 A-E
Weed-free check			12907 AB	8425 A	12907 AB	20911 A	10490 ABC

[a]First cucumber planting.

[b]Second cucumber planting.

[c]Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[d]CC = an activated charcoal coating applied to the seed at planting.

[e]CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

Table 11. Cucumber plants X 10/ha in the dinitroaniline herbicides in combination with activated charcoal tests from three plantings at Jackson, Tennessee in 1980.

Treatment	Rate kg/ha	Charcoal	First Planting		Second Planting			Third Planting	
			6/12	6/25	6/17	6/25	7/2	7/2	8/1
Ethalfluralin	0.8	-	10992 A[a]	13803 A-D	1073 AB	1731 AB	1219 BCD	4780 A	1914 A
		CC[b]	10517 A	12431 A-D	835 B	835 B	1075 BCD	3944 A	957 A
		CB[c]	14577 A	13742 A-D	1073 AB	957 AB	360 CD	4304 A	3255 A
	1.7	-	7645 A	10041 CD	957 AB	896 B	238 D	4603 A	1317 A
		CC	7767 A	6694 D	835 AB	835 B	719 BCD	4304 A	2030 A
		CB	8243 A	18162 AB	1670 AB	1914 AB	1195 BCD	3944 A	957 A
Pendimethalin	0.8	-	12846 A	12846 A-D	658 B	1616 AB	1372 BCD	6097 A	3707 A
		CC	7645 A	10876 A-D	1317 AB	2512 A	1433 BCD	4182 A	2987 A
		CB	12309 A	17564 ABC	1670 AB	1555 AB	835 BCD	5853 A	3823 A
	1.7	-	11175 A	14339 ABC	597 B	896 B	536 CD	5139 A	3164 A
		CC	7407 A	10517 BCD	719 AB	957 AB	1195 BCD	4181 A	1195 A
		CB	10639 A	19716 A	1073 AB	1670 AB	1073 BCD	5615 A	2987 A
Naptalam	6.7	-	10279 A	16016 ABC	1914 A	2152 AB	2152 AB	4182 A	1433 A
Weed-free check	-	-	14443 A	19119 AB	1670 AB	2750 A	3463 A	3823 A	2268 A

[a]Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[b]CC = an activated charcoal coating applied to the seed at planting.

[c]CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

secondary root growth caused by the dinitroaliline herbicides may have been particularly lethal under dry soil conditions resulting in lower population counts by July 2.

In 1980, neither ethalfluralin or pendimethalin affected the marketable yield of cucumbers at Crossville, Jackson, or in the second planting of cucumbers in Knoxville and during 1981 no effect was found in Jackson (Table 12). At Crossville, 1.7 kg/ha of ethalfluralin reduced marketable cucumber yields. The activated charcoal treatments prevented this loss of yield. In Knoxville during 1981, both rates of ethalfluralin and pendimethalin reduced marketable cucumber yields. Activated charcoal applied as a seed coating reduced the loss of yield from pendimethalin applied at 0.8 kg/ha, and activated charcoal applied in a band reduced the yield losses caused by the low rate of either herbicide. Increased cucumber yield was observed when ethalfluralin (0.8 kg/ha) and pendimethalin (1.7 kg/ha) was used in combination with activated charcoal.

Both ethalfluralin and pendimethalin applied at equal rates gave comparable control of goosegrass, redroot pigweed, common purslane, green foxtail and common ragweed (Table 13). Neither activated charcoal treatment nor the lack of activated charcoal had an effect on these ratings.

Effects of Dinitroaniline Herbicides in Combination with Activated Charcoal on Summer Squash

At Crossville during 1980 and Jackson during 1981, both rates of ethalfluralin and pendimethalin reduced summer squash vigor (Table 14). None of the herbicide treatments reduced summer squash vigor

Table 12. Marketable cucumber yields (MT/ha) in the dinitroaniline herbicides in combination with activated charcoal tests at three Tennessee locations.

Treatment	Rate kg/ha	Charcoal	Crossville			Jackson		Knoxville	
			1980[a]	1980[b]	1981	1980[c]	1981	1980[a]	1981
Ethalfluralin	0.8	-	2.87 AB[d]	2.76 A	3.86 BC	0.47 AB	0 E	2.25 CD	0.69 BC
		CC[e]	1.46 B	2.38 AB	4.92 ABC	0.44 AB	0.08 DE	1.43 D	1.09 BC
		CB[f]	2.82 AB	2.32 AB	5.85 ABC	1.40 A	0.08 DE	4.86 A	1.46 ABC
	1.7	-	3.06 AB	1.46 B	0.65 D	1.16 B	0 E	2.00 D	0.49 C
		CC	1.08 B	1.90 AB	3.37 CD	0.22 AB	0 E	2.43 BCD	0.41 C
		CB	3.36 AB	1.68 AB	6.59 ABC	0.09 B	0 E	1.75 D	0.32 C
Pendimethalin	0.8	-	2.66 B	2.49 AB	4.31 ABC	0.49 AB	1.54 AB	2.86 BCD	1.26 BC
		CC	1.05 B	1.14 B	5.69 ABC	0.31 AB	1.34 ABC	3.91 ABC	1.46 ABC
		CB	2.49 B	1.30 B	7.32 A	1.10 AB	1.10 AD	3.00 BCD	2.11 ABC
	1.7	-	3.14 AB	2.22 AB	4.19 ABC	0.44 AB	0.36 CDE	2.22 CD	0.60 BC
		CC	0.97 B	2.93 A	4.01 ABC	0.39 AB	0.36 CDE	2.68 BCD	1.22 BC
		CB	1.95 B	2.17 AB	6.26 ABC	0.88 AB	0.12 DE	4.06 AB	0.81 BC
Naptalam	6.7	-	7.04 A	1.35 B	5.37 ABC	0.09 B	1.79 A	2.33 BCD	1.50 ABC
Weed-free check		-	2.22 B	2.06 AB	4.59 ABC	0.55 AB	0.48 B-E	2.12 CD	2.85 A

[a]First cucumber planting.

[b]Second cucumber planting.

[c]Third cucumber planting.

[d]Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[e]CC = an activated charcoal coating applied to the seed at planting.

[f]CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

Table 13. Percent weed control in the cucumber dinitroaniline herbicides in combination with activated charcoal tests at two Tennessee locations.

Treatment	Rate kg/ha	Charcoal	Jackson						Crossville	
			1980[a]			1980[b]	1981		1980[a]	
			Gagr	Rrpw	Copu	Gogr	Gogr	Copu	Grft	Corw
Ethalfluralin	0.8	-	63 A[c]	80 A	80 A	82 AB	100 A	96 A	97 A	100 A
		CC[d]	50 AB	100 A	100 A	97 AB	100 A	100 A	100 A	100 A
		CB[e]	97 A	100 A	100 A	93 AB	100 A	99 A	72 B	75 A
	1.7	-	68 A	100 A	100 A	83 AB	100 A	100 A	98 A	99 A
		CC	99 A	100 A	100 A	73 AB	100 A	100 A	100 A	100 A
		CB	80 A	100 A	100 A	73 AB	100 A	99 A	100 A	100 A
Pendimethalin	0.8	-	37 AB	83 A	83 A	55 AB	100 A	99 A	99 A	99 A
		CC	35 AB	100 A	95 A	73 AB	96 A	97 A	97 A	98 A
		CB	50 AB	100 A	100 A	67 AB	100 A	97 A	100 A	98 A
	1.7	-	70 A	100 A	100 A	80 AB	99 A	99 A	100 A	99 A
		CC	95 A	100 A	100 A	83 AB	100 A	100 A	100 A	100 A
		CB	82 A	100 A	100 A	100 A	100 A	99 A	98 A	100 A
Naptalam	6.7	-	0 B	66 AB	67 AB	63 AB	12 C	10 C	0 C	97 A
Weedy check		-	33 B	33 B	33 B	37 B	0 D	0 C	0 C	0 B
Weed-free check		-	100 A	100 A	100 A	70 AB	77 B	62 B	100 A	100 A

[a]Second cucumber planting.

[b]Third cucumber planting.

[c]Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[d]CC = an activated charcoal coating applied to the seed at planting.

[e]CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

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Table 14. Percent summer squash vigor reduction in the dinitroaniline herbicides in combination with activated charcoal tests at three Tennessee locations.[a]

Treatment	Rate kg/ha	Charcoal	Crossville 1980	Crossville 1981	Jackson 1980	Jackson 1981	Knoxville 1980	Knoxville 1981
Ethalfluralin	0.8	-	41 A-D[b]	32 A-D	91 A	86 AB	7 D	6 CD
		CC[c]	17 DE	39 A-D	91 A	52 CD	6 D	20 BCD
		CB[d]	10 E	9 CD	81 A	62 BC	0 CD	4 D
	1.7	-	58 A	35 A-D	98 A	97 A	15 CD	17 BCD
		CC	32 A-E	27 A-D	96 A	77 AB	17 BCD	24 BCD
		CB	22 CDE	40 ABC	94 A	84 AB	1 D	6 CD
Pendimethalin	0.8	-	49 ABC	22 A-D	89 A	92 A	25 ABC	42 B
		CC	25 B-E	9 CD	99 A	89 A	35 A	36 BC
		CB	17 DE	20 A-D	85 A	37 D	15 BCD	15 BCD
	1.7	-	52 AB	51 A	96 A	98 A	37 A	79 A
		CC	34 A-E	39 A-D	86 A	98 A	42 A	88 A
		CB	26 B-E	46 AB	94 A	90 A	36 AB	70 A
Naptalam	6.7	-	2 E	4 D	40 B	12 E	2 D	11 BCD
Weed-free check		-	2 E	14 BCD	2 C	0 E	0 D	6 CD

[a] A 0 indicates no crop damage and 100 indicates a complete crop kill.

[b] Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[c] CC = an activated charcoal coating applied to the seed at planting.

[d] CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

ratings in 1981 at Crossville except pendimethalin applied at 1.7 kg/ha. At Knoxville in 1980 and 1981, both rates of pendimethalin, and in 1980 at Jackson, ethalfluralin and pendimethalin at both rates reduced summer squash vigor. Neither activated charcoal treatment nor lack of activated charcoal had an effect on these ratings.

None of the herbicide treatments reduced summer squash stands at Crossville in 1981 or in Knoxville in 1981 (Table 15). When ethalfluralin was applied at 1.7 kg/ha and the seeds were protected with a charcoal band, an unexplained increase in plant stands occurred in Knoxville. Both rates of pendimethalin and the high rate of ethalfluralin reduced summer squash stands at Knoxville in 1980. Neither activated charcoal treatment reversed this reduction of the summer squash populations. When the initial population counts were made at Jackson, all the herbicide treatments reduced the summer squash stand. When a second population count was made June 25, the 1.7 kg/ha rate of ethalfluralin reduced summer squash stands. The band treatment with activated charcoal or the activated charcoal coating on the seed prevented stand reduction at Jackson during 1980.

At Crossville, during 1980 both ethalfluralin and pendimethalin reduced the marketable summer squash yields (Table 16). Neither activated charcoal treatment nor lack of activated charcoal prevented this loss of yield. During 1981 at Crossville and Jackson, both rates of pendimethalin and the high rate of ethalfluralin reduced summer squash yields. The activated charcoal treatments prevented this loss of yield in some cases. In Knoxville, the high rate of pendimethalin reduced the yields of summer squash in 1981. Neither activated charcoal

Table 15. Summer squash plants X10/ha in the dinitroaniline herbicides in combination with activated charcoal tests at three Tennessee locations.

Treatment	Rate kg/ha	Charcoal	Crossville 1981	Jackson 6/17/80	Jackson 6/25/80	Knoxville 1980	Knoxville 1981
Ethalfluralin	0.8	-	2463 A[a]	1164 C-F	3695 AB	2335 ABC	2372 BCD
		CC[b]	1256 B	939 C-G	2914 AB	1744 CDE	2103 BCD
		CB[c]	2061 AB	805 D-G	3585 AB	2658 AB	2061 BCD
	1.7	-	1750 AB	244 G	2396 B	1975 BCD	1701 BCD
		CC	1390 AB	719 EFG	3274 AB	1250 DE	1701 BCD
		CB	1835 AB	134 G	3134 AB	1933 BCD	3810 A
Pendimethalin	0.8	-	1475 AB	1274 B-F	2999 AB	1573 DE	2237 BCD
		CC	1835 AB	311 FG	538 C	1518 DE	1475 CD
		CB	1750 AB	1969 BC	3182 AB	2048 A-D	2914 AB
	1.7	-	1256 B	1616 B-E	3292 AB	1140 E	2646 BC
		CC	1030 B	2195 B	3762 AB	1024 E	1256 D
		CB	1567 AB	1884 BCD	3451 AB	1402 DE	2823 AB
Naptalam	6.7	-	2018 AB	1122 C-G	2375 B	2390 ABC	2597 BC
Weed-free check		-	1616 AB	3585 A	4438 A	2847 A	2237 BCD

[a]Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[b]CC = an activated charcoal coating applied to the seed at planting.

[c]CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

Table 16. Marketable summer squash yields (MT/ha) in the dinitroaniline herbicides in combination with activated charcoal tests at three Tennessee locations.

Treatment	Rate kg/ha	Charcoal	Crossville 1980	Crossville 1981	Jackson 1981	Knoxville 1980	Knoxville 1981
Ethalfluralin	0.8	-	2.34 BC[a]	9.75 ABC	23.05 AB	9.47 A	6.54 A
		CC[b]	3.95 AB	8.07 BC	16.26 A-D	10.93 A	4.63 AB
		CB[c]	2.14 BC	10.95 ABC	22.31 ABC	8.95 A	7.38 A
	1.7	-	1.25 C	8.54 BC	2.89 D	7.96 AB	7.15 A
		CC	1.73 BC	9.51 ABC	20.26 ABC	8.76 A	1.54 A
		CB	3.37 ABC	8.13 BC	17.69 A-D	7.61 AB	7.11 A
Pendimethalin	0.8	-	2.01 BC	8.41 BC	5.47 CD	7.04 AB	4.74 AB
		CC	3.00 ABC	11.20 ABC	8.83 CD	7.12 AB	3.13 BC
		CB	2.31 ABC	10.95 ABC	20.59 ABC	8.79 A	6.16 AB
	1.7	-	1.26 C	6.08 C	9.78 BCD	3.92 B	1.48 C
		CC	2.10 BC	7.66 BC	0.53 D	3.25 B	0.79 C
		CB	1.69 BC	8.19 BC	8.46 BCD	6.18 AB	3.23 BC
Naptalam		-	3.60 ABC	11.40 ABC	7.68 BCD	8.77 A	5.99 AB
Weed-free check		-	4.84 A	14.61 A	28.33 A	8.31 AB	6.97 B

[a]Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[b]CC = an activated charcoal coating applied to the seed at planting.

[c]CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

treatment presented the summer squash yield reduction in the plots treated with pendimethalin at 1.7 kg/ha. In 1980, neither ethalfluralin or pendimethalin affected the marketable yield of summer squash at Knoxville.

Ethalfluralin and pendimethalin applied at equal rates gave comparable control of goosegrass, common purslane, redroot pigweed and large crabgrass (Table 17). Neither activated charcoal treatment or the lack of activated charcoal has an effect on these ratings.

Effect of Dinitroaniline Herbicides in Combination with Activated Charcoal on Cantaloupes

No significant differences in 1980 vigor ratings were found between cantaloupes in the weed-free check and cantaloupes in the herbicide treated plots in Crossville (Table 18). Neither of the activated charcoal treatments had an effect on these ratings. In the 1981 experiment at Crossville, ethalfluralin at 1.7 kg/ha or pendimethalin at 0.8 kg/ha reduced the vigor of cantaloupes if they were not protected by activated charcoal. In 1981 at Jackson, the dinitroaniline herbicides reduced the vigor of cantaloupes. Neither activated charcoal treatment nor lack of activated charcoal had an effect on these ratings. At Knoxville in 1980, pendimethalin applied at 1.7 kg/ha reduced cantaloupe vigor. The activated charcoal treatments helped reduce pendimethalin injury. Ethalfluralin did not significantly reduce cantaloupe vigor. In 1981 at Knoxville, for an unexplained reason, an activated charcoal seed coating reduced cantaloupe vigor in plots treated with ethalfluralin at 1.7 kg/ha or pendimethalin applied at 0.8 kg/ha.

None of the herbicide treatments reduced cantaloupe stands

Table 17. Percent weed control in the summer squash dinitroaniline herbicides in combination with activated charcoal tests at two Tennessee locations.

Treatment	Rate kg/ha	Charcoal	Jackson 1981		Knoxville 1980		Knoxville 1981	
			Gogr	Copu	Gogr	Rrpw	Gogr	Lacg
Ethalfluralin	0.8	-	97 AB[a]	99 A	100 A	100 A	75 AB	74 AB
		CC[b]	98 AB	99 A	99 A	100 A	97 A	97 A
		CB[c]	100 A	100 A	100 A	100 A	96 A	99 A
	1.7	-	99 A	100 A	100 A	100 A	99 A	99 A
		CC	100 A	100 A	99 A	100 A	97 A	97 A
		CB	98 AB	100 A	100 A	100 A	96 A	100 A
Pendimethalin	0.8	-	97 AB	99 A	98 A	100 A	96 A	99 A
		CC	96 B	98 A	90 A	100 A	98 A	99 A
		CB	98 AB	100 A	100 A	100 A	99 A	99 A
	1.7	-	99 A	100 A	87 A	87 A	98 A	100 A
		CC	98 AB	100 A	99 A	100 A	97 A	97 A
		CB	100 A	99 A	100 A	100 A	100 A	100 A
Naptalam	6.7	-	0 C	0 B	50 B	50 B	50 B	50 B
Weedy check		-	0 C	0 B	25 B	25 B	0 C	0 C
Weed-free check		-	100 A	100 A	100 A	100 A	100 A	100 A

[a]Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[b]CC = an activated charcoal coating applied to the seed at planting.

[c]CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

Table 18. Percent cantaloupe vigor reduction in the dinitroaniline herbicides in combination with activated charcoal tests at three Tennessee locations.[a]

Treatment	Rate kg/ha	Charcoal	Crossville 1980	Crossville 1981	Jackson 1981	Knoxville 1980	Knoxville 1981
Ethalfluralin	0.8	-	30 A[b]	30 ABC	84 ABC	18 AB	24 BC
		CC[c]	3 A	60 A	25 DE	20 AB	20 BC
		CB[d]	35 A	67 A	54 BCD	0 B	6 C
	1.7	-	39 A	67 A	87 ABC	23 AB	24 B
		CC	18 A	39 ABC	85 ABC	13 AB	72 A
		CB	20 A	55 A	75 ABC	10 AB	12 BC
Pendimethalin	0.8	-	26 A	65 A	67 ABC	24 AB	7 C
		CC	3 A	52 AB	60 BC	27 AB	67 A
		CB	37 A	37 ABC	50 CD	7 B	6 C
	1.7	-	21 A	46 ABC	100 A	39 A	46 AB
		CC	25 A	64 A	79 ABC	27 AB	71 A
		CB	47 A	31 ABC	88 AB	0 B	59 A
Naptalam	6.7	-	13 A	9 C	10 E	23 AB	4 C
Weed-free check		-	3 A	12 BC	0 E	0 B	17 BC

[a] A 0 indicates no crop damage and 100 indicates a complete crop kill.

[b] Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[c] CC = an activated charcoal coating applied to the seed at planting.

[d] CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

either year at any location (Table 19). When ethalfluralin was applied at 0.8 kg/ha and the seeds were protected with an activated charcoal seed coating, an unexplained increase in plant stands occurred in 1980 at Crossville and Knoxville and in 1981 at Jackson. When either rate of pendimethalin was applied and the seeds were protected with a seed coating of activated charcoal, a decrease in plant stands occurred in Knoxville in 1981.

None of the herbicide treatments reduced the number (Table 20) or yield (Table 21) of marketable fruit produced at Crossville or Knoxville either year. At Jackson, the dinitroaniline herbicides reduced the marketable cantaloupe yield. The activated charcoal treatments partially prevented this loss of yield in some cases.

Both ethalfluralin and pendimethalin applied at equal rates gave comparable control of common lambsquarters, large crabgrass, redroot pigweed, goosegrass, common purslane, tall morningglory, prickly sida, and common ragweed (Tables 22, 23). Neither the addition of the activated charcoal treatments nor the lack of activated charcoal had an effect on these ratings.

Effects of Dinitroaniline Herbicides in Combination with Activated Charcoal on Watermelons

Neither of the herbicide treatments reduced the vigor of watermelons at Crossville either year (Table 24). Neither a band treatment with activated charcoal or an activated charcoal coating on the seed prevented this injury in 1980 at Jackson and Knoxville. At Knoxville in 1981 treatment with the high rate of ethalfluralin or both rates of pendimethalin reduced watermelon vigor. The activated charcoal

Table 19. Cantaloupe plants X 10/ha in the dinitroaniline herbicides in combination with activated charcoal tests at three Tennessee locations.

Treatment	Rate kg/ha	Charcoal	Crossville 1980	Crossville 1981	Knoxville 1980	Knoxville 1981	Jackson 1981
Ethalfluralin	0.8	-	817 AB[a]	457 ABC	1085 B-E	1573 A-D	421 B
		CC[b]	1049 A	439 ABC	1439 A	1427 B-E	1536 A
		CB[c]	707 AB	402 ABC	1244 ABC	1811 AB	695 B
	1.7	-	793 AB	293 C	890 DE	1427 B-E	219 B
		CC	805 AB	392 BC	1317 AB	2286 A	392 B
Pendimethalin	0.8	-	746 AB	493 ABC	951 CDE	1646 ABC	366 B
		CC	585 AB	530 ABC	756 EF	878 DE	951 AB
		CB	561 AB	512 ABC	1146 A-D	2030 AB	622 B
	1.7	-	700 AB	421 ABC	524 F	1555 A-D	183 B
		CC	476 B	384 ABC	786 DEF	1024 CDE	384 B
		CB	622 AB	695 AB	914 CDE	1573 A-D	146 B
Naptalam	6.7	-	561 AB	750 A	1292 AB	1774 ABC	695 B
Weed-free check		-	536 B	604 ABC	829 DEF	1865 AB	604 B

[a]Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[b]CC = an activated charcoal coating applied to the seed at planting.

[c]CB = an activated charcoal band was at 280 kg/ha in the seed row just before planting.

Table 20. Number of marketable cantaloupes produced X 10/ha in the dinitroaniline herbicides in combination with activated charcoal tests at two Tennessee locations.

Treatment	Rate kg/ha	Charcoal	Crossville 1980	Crossville 1981	Knoxville 1980	Knoxville 1981
Ethalfluralin	0.8	-	719 AB[a]	1079 AB	1920 AB	238 ABC
		CC[b]	975 A	768 AB	1957 AB	329 ABC
		CB[c]	536 AB	604 B	1616 AB	439 AB
	1.7	-	695 AB	530 B	1853 AB	274 ABC
		CC	341 B	1134 AB	1280 AB	91 BC
		CB	436 AB	567 B	1823 AB	201 BC
Pendimethalin	0.8	-	497 AB	1189 AB	1378 AB	366 ABC
		CC	658 AB	549 B	811 B	918 C
		CB	512 AB	860 AB	2426 AB	567 A
	1.7	-	606 AB	1079 AB	1274 AB	183 BC
		CC	695 AB	567 B	1414 AB	37 C
		CB	293 B	1152 AB	2932 A	1460 BC
Naptalam	6.7	-	390 AB	1518 A	1414 AB	329 ABC
Weed-free check		-	341 B	1061 AB	2091 AB	274 ABC

[a]Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[b]CC = an activated charcoal coating applied to the seed at planting.

[c]CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

Table 21. Cantaloupe marketable yield (MT/ha) in the dinitroaniline herbicides in combination with activated charcoal tests at three Tennessee locations.

Treatment	Rate kg/ha	Charcoal	Crossville 1980	Knoxville 1980	Knoxville 1981	Jackson 1981
Ethalfluralin	0.8	-	11.50 AB[a]	12.25 A	3.92 ABC	1.20 CB
		CC[b]	15.11 A	10.87 A	6.19 ABC	5.00 BC
		CB[c]	6.78 AB	9.63 A	7.28 AB	2.67 BCD
	1.7	-	11.48 AB	10.84 A	4.09 ABC	2.78 BCD
		CC	5.84 B	8.09 A	1.99 BC	3.91 BCD
		CB	7.30 AB	11.83 A	3.10 ABC	1.52 CD
Pendimethalin	0.8	-	6.54 B	8.03 A	6.23 ABC	0.33 D
		CC	8.87 AB	4.75 A	1.48 BC	2.66 BCD
		CB	8.20 AB	16.63 A	8.64 A	6.02 B
	1.7	-	8.67 AB	7.80 A	3.23 ABC	0.25 D
		CC	11.61 AB	8.27 A	0.70 C	1.54 CD
		CB	4.93 B	16.63 A	2.82 ABC	1.80 CD
Naptalam	6.7	-	5.34 B	8.97 A	4.55 ABC	1.38 CD
Weed-free check		-	5.44 B	6.18 A	4.56 ABC	11.37 A

[a]Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[b]CC = an activated charcoal coating applied to the seed at planting.

[c]CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

Table 22. Percent weed control in cantaloupe dinitroaniline herbicides in combination with activated charcoal tests at two Tennessee locations in 1981.

Treatment	Rate kg/ha	Charcoal	Crossville			Jackson		
			Colg	Lacg	Krpw	Gogr	Copu	Krpw
Ethalfluralin	0.8	-	99 A[a]	99 A	94 AB	97 A	96 A	100 A
		CC[b]	89 AB	99 A	92 AB	98 A	97 A	100 A
		CB[c]	91 AB	95 AB	98 AB	97 A	97 A	100 A
	1.7	-	97 A	99 A	100 A	100 A	99 A	100 A
		CC	99 A	100 A	100 A	100 A	100 A	100 A
		CB	64 ABC	75 ABC	74 AB	100 A	100 A	100 A
Pendimethalin	0.8	-	91 AB	92 AB	92 AB	92 A	94 A	96 A
		CC	46 BC	42 CD	69 ABC	95 A	97 A	100 A
		CB	43 BC	46 BCD	50 BC	96 A	97 A	100 A
	1.7	-	91 AB	92 AB	85 AB	98 A	99 A	99 A
		CC	92 AB	92 AB	87 AB	99 A	100 A	87 A
		CB	98 A	97 A	99 AB	99 A	100 A	100 A
Naptalam	6.7	-	45 BC	42 CD	67 ABC	25 B	25 B	25 B
Weed-free check		-	100 A	100 A	100 A	100 A	100 A	100 A

[a]Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[b]CC = an activated charcoal coating applied to the seed at planting.

[c]CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

Table 23. Percent weed control in the cantaloupe dinitroaniline herbicides in combination with activated charcoal tests at Knoxville, Tennessee.

Treatment	Rate kg/ha	Charcoal	Crossville 1980					Jackson 1981		
			Gogr	Tamg	Rrpw	Prsi	Corw	Gogr	Tamg	Lacq
Ethalfluralin	0.8	-	100 A[a]	48 AB	97 A	62 AB	95 A	74 AB	72 AB	75 A
		CC[b]	97 A	80 A	100 A	63 AB	98 A	94 AB	72 AB	97 A
		CB[c]	66 B	62 AB	90 A	62 AB	66 A	94 AB	87 AB	94 A
	1.7	-	100 A	99 A	98 A	89 A	97 A	100 A	81 AB	99 A
		CC	100 A	67 A	100 A	47 AB	100 A	98 AB	97 A	100 A
		CB	100 A	60 AB	97 A	78 A	97 A	96 AB	67 AB	96 A
Pendimethalin	0.8	-	98 A	58 AB	98 A	46 AB	99 A	99 A	57 AB	100 A
		CC	98 A	60 AB	97 A	63 AB	100 A	94 AB	76 AB	99 A
		CB	100 A	88 A	77 B	97 B	97 A	98 AB	74 AB	99 A
	1.7	-	97 A	91 A	97 A	87 A	64 A	98 AB	39 BC	100 A
		CC	100 A	97 A	95 A	66 AB	99 A	99 AB	69 AB	100 A
		CB	95 B	95 A	100 A	75 AB	100 A	98 AB	96 A	100 A
Naptalam	6.7	-	0 C	00 B	00 C	0 B	0 B	71 B	68 AB	72 A
Weedy check		-	0 B	0 B	0 C	0 B	0 B	0 C	0 C	0 B
Weed-free check		-	100 A	100 A	100 A	100 A	100 A	100 A	100 A	100 A

[a]Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[b]CC = an activated charcoal coating applied to the seed at planting.

[c]CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

Table 24. Percent watermelon vigor reduction in the dinitroaniline herbicides in combination with activated charcoal tests at three Tennessee locations.[a]

Treatment	Rate kg/ha	Charcoal	Crossville		Jackson		Knoxville	
			1980	1981	1980	1981	1980	1981
Ethalfluralin	0.8	-	19 BC[b]	26 A-D	38 BC	45 CD	55 A-F	31 C-F
		CC[c]	25 ABC	61 A	75 A	76 A	67 A-E	40 B-F
		CB[d]	42 ABC	29 A-D	12 CD	37 CDE	18 FG	11 F
	1.7	-	39 ABC	50 ABC	59 AB	100 A	87 AB	67 ABC
		CC	57 AB	31 A-D	60 AB	99 A	77 A-D	27 DEF
		CB	46 ABC	55 AB	55 ABC	90 AB	83 ABC	29 DEF
Pendimethalin	0.8	-	41 ABC	27 A-D	4 D	60 BC	53 B-F	64 A-D
		CC	42 ABC	29 A-D	5 D	12 EF	37 C-G	19 EF
		CB	44 A-C	15 B-D	3 D	15 DEF	23 EFG	14 F
	1.7	-	37 ABC	45 A-D	27 BCD	90 AB	88 A	94 A
		CC	25 ABC	55 AB	10 D	84 AB	77 A-D	71 AB
		CB	65 A	14 BCD	22 CD	82 AB	67 A-E	55 B-E
Naptalam	6.7	-	42 ABC	2 D	3 D	15 DEF	30 D-G	27 DEF
Weed-free check		-	5 C	4 CD	0 D	0 F	0 G	0 F

[a] A 0 indicates no crop damage and 100 indicates a complete crop kill.

[b] Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[c] CC = an activated charcoal coating applied to the seed at planting.

[d] CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

treatments prevented this injury in plots treated with the low rate of pendimethalin or the high rate of ethalfluralin.

In 1980 at Crossville and Jackson, and in 1981 at Crossville and Knoxville, neither ethalfluralin or pendimethalin reduced watermelon stands (Table 25). Neither activated charcoal treatment had an effect on watermelon stands except at Knoxville in 1981. An unexplained increase in plant stands occurred at Knoxville when pendimethalin was applied at 0.8 kg/ha and watermelon seeds were planted in an activated charcoal band. Both ethalfluralin and pendimethalin reduced plant stands at Jackson in 1981. Neither activated charcoal treatment nor the lack of activated charcoal prevented stand reduction. Ethalfluralin applied at 0.8 kg/ha and pendimethalin applied at 1.7 kg/ha reduced plant stands at Knoxville in 1980. Neither activated charcoal treatment nor lack of activated charcoal had an effect on plant stands.

According to Lorenz and Maynard (41) the minimum soil temperature for the germination of cantaloupes or watermelons is 16 C. Low soil temperatures in the 1981 Jackson cantaloupe (Table 19) and watermelon (Table 25) tests lowered plant populations particularly at the high rates of either dinitroaniline herbicide with no charcoal. The soil temperature on May 3 was 16 C; on May 8 the minimum soil temperature fell to 14 C and the minimum soil temperature did not reach 16 C again until May 19. Germination will normally start within three or four days after planting if moisture and temperature are adequate. During the four days just after planting the germination process probably began, but the low soil temperatures retarded germination so the seedlings remained in the treated soil for an extended period.

Table 25. Watermelon plants X10/ha in the dinitroaniline herbicides in combination with activated charcoal tests at three Tennessee locations.

Treatment	Rate kg/ha	Charcoal	Crossville 1980	Crossville 1981	Jackson 1980	Jackson 1981	Knoxville 1980	Knoxville 1981
Ethalfluralin	0.8	-	408 A[a]	483 AB	609 A	417 B-E	634 B	527 BCD
		CC[b]	439 A	307 B	417 A	252 C-F	646 AB	428 BCD
		CB[c]	469 A	417 AB	856 A	494 A-D	701 AB	615 ABC
	1.7	-	420 A	494 AB	640 A	0 F	701 AB	406 CD
		CC	305 A	439 AB	585 A	33 F	555 B	593 ABC
		CB	372 A	571 AB	856 A	186 DEF	543 B	604 ABC
Pendimethalin	0.8	-	402 A	384 AB	724 A	318 B-F	756 AB	494 BCD
		CC	341 A	362 AB	614 A	428 A-E	719 AB	560 BCD
		CB	354 A	646 AB	718 A	636 AB	646 AB	736 A
	1.7	-	402 A	472 AB	472 A	99 EF	573 B	385 D
		CC	372 A	318 AB	737 A	176 DEF	597 B	516 BCD
		CB	354 A	494 AB	614 A	176 DEF	543 B	671 AB
Naptalam	6.7	-	329 A	516 AB	761 A	560 ABC	835 AB	637 ABC
Weed-free check		-	537 A	714 A	702 A	757 A	939 A	516 BCD

[a]Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[b]CC = an activated charcoal coating applied to the seed at planting.

[c]CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

In 1980 at all three locations, and in 1981 at Crossville and Knoxville, neither ethalfluralin or pendimethalin reduced watermelon yields (Table 26). Both ethalfluralin and pendimethalin reduced watermelon yields in 1981 at Jackson. Neither activated charcoal treatment or lack of activated charcoal had an effect on watermelon yields when ethalfluralin was applied.

In 1980 at Crossville, and both years in Knoxville, neither ethalfluralin nor pendimethalin reduced the number of marketable watermelons (Table 27). Ethalfluralin applied at 0.8 kg/ha reduced the number of marketable fruit at Jackson. Neither activated charcoal treatment nor the lack of activated charcoal prevented this reduction. In 1981 ethalfluralin applied at 1.7 kg/ha reduced the number of marketable fruit at Crossville. Either a band of activated charcoal applied around the seed or an activated charcoal coating on the seed prevented this reduction.

Injured cucurbits (Table 24) many times produced higher marketable yields than expected (Table 27). At Jackson in 1980 watermelons treated with ethalfluralin at 1.7 kg/ha in combination with either activated charcoal treatment or no activated charcoal were damaged more than the plants in the weed-free check.

Both ethalfluralin and pendimethalin applied at equal rates gave excellent (90%) control of large crabgrass, common lambsquarters, redroot pigweed, and goosegrass in most cases (Table 28). They gave good (90%) to excellent control on common purslance and only fair to good (60-90%) control of tall morningglory. Neither activated charcoal treatment nor the lack of activated charcoal had an effect on these ratings.

Table 26. Marketable watermelon yield (MT/ha) in the dinitroaniline herbicides in combination with activated charcoal tests at three Tennessee locations.

Treatment	Rate kg/ha	Charcoal	Crossville 1980	Crossville 1981	Jackson 1980	Jackson 1981	Knoxville 1980	Knoxville 1981
Ethalfluralin	.08	-	13.54 A[a]	21.32 ABC	64.86 ABC	0.60 BC	8.22 A	3.39 A
		CC[b]	12.34 A	12.68 C	58.67 ABC	2.12 BC	0.79 A	5.01 A
		CB[c]	25.65 A	12.60 C	69.44 ABC	2.59 BC	7.27 A	8.49 A
	1.7	-	14.11 A	12.20 C	85.75 ABC	5.09 BC	3.99 A	3.67 A
		CC	7.39 A	14.77 ABC	56.24 ABC	0 C	4.48 A	6.33 A
		CB	12.13 A	17.45 ABC	87.59 ABC	1.69 BC	2.08 A	5.35 A
Pendimethalin	0.8	-	9.73 A	18.15 ABC	103.26 ABC	2.91 BC	2.31 A	4.99 A
		CC	7.39 A	16.30 ABC	113.12 ABC	11.42 AB	6.11 A	4.61 A
		CB	9.79 A	13.12 BC	120.36 AB	9.87 ABC	8.58 A	3.29 A
	1.7	-	13.19 A	17.90 ABC	73.50 ABC	1.99 BC	1.62 A	3.22 A
		CC	6.63 A	14.75 ABC	104.51 ABC	5.46 ABC	7.44 A	3.22 A
		CB	8.56 A	18.50 ABC	123.99 A	5.19 ABC	10.08 A	4.54 A
Naptalam	6.7	-	6.72 A	32.32 A	41.36 C	1.38 BC	0 A	4.46 A
Weed-free check		-	18.06 A	29.60 ABC	121.08 AB	14.74 A	10.37 A	3.99 A

[a]Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[b]CC = an activated charcoal coating applied to the seed at planting.

[c]CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

Table 27. Number of marketable watermelons X10/ha in the dinitroaniline herbicides in combination with activated charcoal tests at three Tennessee locations.

Treatment	Rate kg/ha	Charcoal	Crossville 1980	Crossville 1981	Jackson 1980	Knoxville 1980	Knoxville 1981
Ethalfluralin	0.8	-	140 A[a]	307 A-D	401 B	671 A	22 B
		CC[b]	177 A	176 CD	351 B	73 A	44 AB
		CB[c]	85 A	165 CD	483 AB	634 A	132 A
	1.7	-	158 A	154 D	539 AB	335 A	33 B
		CC	85 A	198 BCD	337 B	335 A	77 AB
		CB	122 A	209 BCD	271 AB	183 A	55 AB
Pendimethalin	0.8	-	116 A	242 A-D	551 AB	219 A	33 B
		CC	85 A	22 BCD	725 AB	518 B	44 AB
		CB	11 A	187 BCD	761 A	634 A	22 B
	1.7	-	146 A	209 BCD	676 AB	707 A	22 B
		CC	79 A	209 BCD	676 AB	707 A	22 B
		CB	85 A	22 BCD	776 A	890 A	44 AB
Naptalam	6.7	-	79 A	428 A	263 B	0 A	44 AB
Weed-free check		-	207 A	373 ABC	790 A	890 A	33 B

[a]Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[b]CC = an activated charcoal coating applied to the seed at planting.

[c]CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

Table 28. Percent weed control in the watermelon dinitroaniline herbicides in combination with activated charcoal tests at three Tennessee locations in 1981.

Treatment	Rate kg/ha	Charcoal	Crossville			Jackson		Knoxville	
			Lacg	Colq	Rrpw	Gogr	Copu	Rrpw	Tamg
Ethalfluralin	0.8	-	94 A[a]	92 AB	99 A	100 A	67 B	99 A	70 ABC
		CC[b]	96 A	92 AB	100 A	100 A	71 B	100 A	77 ABC
		CB[c]	94 A	91 AB	97 A	100 A	77 AB	97 A	75 ABC
	1.7	-	100 A	97 A	100 A	100 A	100 A	100 A	70 ABC
		CC	93 A	88 AB	96 A	100 A	100 A	100 A	79 ABC
		CB	100 A	94 AB	97 A	100 A	94 AB	97 A	86 AB
Pendimethalin	0.8	-	92 A	86 AB	97 A	100 A	82 A	99 A	65 ABC
		CC	75 A	66 AB	75 AB	97 AB	75 AB	100 A	74 ABC
		CB	91 A	87 AB	99 A	97 A	70 B	95 A	45 BCD
	1.7	-	97 A	92 AB	99 A	100 A	92 AB	100 A	72 ABC
		CC	96 A	95 AB	95 A	100 A	93 AB	75 AB	36 CD
		CB	70 A	61 B	72 AB	100 A	85 AB	100 A	74 ABC
Naptalam	6.7	-	22 B	25 C	50 B	0 B	0 C	50 B	12 D
Weedy check		-	0 C	0 C	0 C	0 B	0 C	0 C	0 D
Weed-free check		-	100 A	100 A	100 A	100 A	100 A	100 A	100 A

[a]Means followed by the same letter in the same column are not significantly different at the 5% level using Duncan's multiple range test.

[b]CC = an activated charcoal coating applied to the seed at planting.

[c]CB = an activated charcoal band was mixed at 280 kg/ha in the seed row just before planting.

Effect of the Dinitroaniline Herbicides in the Cucumber Cultivar Trials

No differences were found between the herbicide treatments and the weed-free checks for each cucumber hybrid (Table 29). The fruit yield of '420 Green Pak'≥'Carolina'≥'Poinsett 76'≥'Sweet Slice'≥'Dasher'≥ 'Ashley' in the weed-free check. The poor performance of Dasher and Ashley may have been due to premature harvesting.

Effect of the Dinitroaniline Herbicides in the Squash Cultivar Trials

No differences were found between the herbicide treatments and the weed-free checks for 'Greyzinni' and 'Dixie' summer squash cultivars (Table 30). Treatment with pendimethalin with a charcoal band or no charcoal reduced the yields of the winter squash cultivar 'Waltham Butternut' and the summer squash cultivar 'Gold Rush' when compared to their respective weed-free checks. The yield of the winter squash cultivar 'Warted Hubbard' was reduced when treated with ethalfluralin or pendimethalin with either a charcoal band or no charcoal when compared to its weed-free check.

Effect of the Dinitroaniline Herbicides in the Watermelon Cultivar Trials

In Knoxville no differences were found in the number of marketable watermelons produced in the herbicide treated plots and the weed-free check with 'Charleston Gray' and 'Crimson Sweet' (Table 31). Treatment of 'Black Diamond' with ethalfluralin resulted in more marketable watermelons than the weed-free check. Treatment of 'Sugar Baby' with pendimethalin with an activated charcoal band in the seed row or no activated charcoal resulted in fewer marketable watermelons than the weed-free check. 'Sugar Baby' watermelons produced more watermelons per plant

Table 29. Effect of dinitroaniline herbicides on the marketable fruit yields (MT/ha) from the cucumber cultivar trial conducted at Knoxville, Tennessee in 1981.

	Pendimethalin 0.84 PPI	Pendimethalin + CB[a] 0.84 PPI	Ethalfluralin 1.4 PRE	Weed-free check -
Cultivar				
420 Green Pak	4.49 C-I[b]	6.13 A-G	9.58 AB	8.47 A-D
Ashley	0 I	0.14 I	0.17 I	0.14 I
Carolina	4.04 C-I	6.86 A-F	10.24 A	7.74 A-E
Sweet Slice	1.81 GHI	2.26 F-I	3.76 D-I	3.17 E-I
Dasher	0.42 HI	0.38 HI	2.33 F-I	0.24 I
Poinsett-76	0 I	4.36 C-I	5.19 B-H	3.31 E-I

[a]CG = an activated charcoal band applied at 280 kg/ha just before planting.

[b]Means followed by the same letter within columns and rows are not significantly different at the 5% level using Duncan's multiple range test.

Table 30. Effect of dinitroaniline herbicides on the marketable fruit yields (MT/ha) from the squash cultivar trial conducted at Knoxville, Tennessee in 1981.

	Pendimethalin 0.84 PPI	Pendimethalin + CB[a] 0.84 PPI	Ethalfluralin 1.4 PRE	Weed-Free Check -
Cultivar				
Greyzinni	8.72 FG[b]	9.15 FG	15.58 C-G	17.12 B-F
Warted Hubbard	8.98 FG	5.69 G	7.52 G	21.75 ABC
Dixie	13.46 C-G	13.46 C-G	19.72 A-D	20.57 A-D
Waltham Butternut	12.07 D-G	10.47 F-G	18.80 A-E	23.58AB
Gold Rush	12.41 C-G	9.02 FG	19.31 A-E	26.53 A

[a]CB = activated charcoal band applied at 280 kg/ha just before planting.

[b]Means followed by the same letter within columns and rows are not significantly different at the 5% level using Duncan's multiple range test.

Table 31. Effect of dinitroaniline herbicides on the number of marketable fruit produced/ha from the watermelon cultivar trial conducted at Knoxville, Tennessee in 1981.

	Pendimethalin 0.84 PPI	Pendimethalin + CB[a] 0.84 PPI	Ethalfluralin 1.4 PRE	Weed-free check -
Cultivar				
Charleston Gray	270 EF[b]	810 DEF	540 DEF	1080 C-F
Crimson Sweet	810 DEF	1610 CD	540 DEF	540 DEF
Black Diamond	810 DEF	540 DEF	2150 C	810 DEF
Sugar Baby	1340 CDE	1080 CDE	8340 A	7800 A

[a]CB = activated charcoal band applied at 280 kg/ha just before planting.

[b]Means followed by the same letter within columns and rows are not significantly different at the 5% level using Duncan's multiple range test.

than the larger fruited watermelons which only produce a few fruit per plant.

No differences were found between the herbicide treatments and the weed-free checks for each watermelon cultivar when the marketable fruit yield was measured in Knoxville (Table 32) and Crossville (Table 33).

In Crossville treatment with pendimethalin with no activated charcoal resulted in fewer marketable fruit when compared to the weed-free check by 'Black Diamond' and 'Sugar Baby' (Table 34). No differences were found among the weed-free checks and the herbicide treatments with the other watermelon cultivars tested.

Cucumber Cultivar in Vitro Test

Large differences were found in the primary root growth of the cucumber cultivars in the in vitro studies (Table 35). After seven days under control conditions the primary root length was 'Sweet Slice'>'420 Green Pak'>'Carolina'>'Dasher'>'Poinsett-76'>'Ashley.' Treatment with either herbicide for seven days reduced the primary root length of the three most vigorous hybrids, 'Sweet Slice,' '420 Green Pak,' and 'Carolina.' The herbicides had no influence on the root growth of 'Ashley.' The length of the primary roots of the three most vigorous cultivars was greater when treated with either herbicide than was the length of the primary roots of 'Ashley' cucumbers in the non-herbicide treated control.

After 17 days the primary root length of 'Dasher'≥'420 Green Pak'≥'Carolina'≥'Sweet Slice'≥'Poinsett-76'≥'Ashley' in the control (Table 35). No differences were found among treatments when

Table 32. Effect of dinitroaniline herbicides on the marketable fruit yield (MT/ha) from the watermelon cultivar trial conducted at Knoxville, Tennessee in 1981.

	Pendimethalin 0.84 PPI	Pendimethalin + CB[a] 0.84 PPI	Ethalfluralin 1.4 PRE	Weed-free check -
Cultivar				
Charleston Gray	2.35 CD[b]	5.72 BCD	4.12 BCD	7.24 BCD
Crimson Sweet	6.16 BCD	10.45 A-D	3.89 BCD	4.94 BCD
Black Diamond	9.13 A-D	4.56 BCD	17.80 AB	7.38 BCD
Sugar Baby	3.46 BCD	1.46 D	21.68 A	16.31 ABC

[a]CB = activated charcoal band applied at 280 kg/ha just before planting.

[b]Means followed by the same letter within columns and rows are not significantly different at the 5% level using Duncan's multiple range test.

Table 33. Effect of dinitroaniline herbicides on the marketable fruit yield (MT/ha) produced from the watermelon cultivar trial conducted at Crossville, Tennessee in 1981.

	Pendimethalin 0.84 PPI	Pendimethalin + CB[a] 0.84 PPI	Ethalfluralin 1.4 PRE	Weed-free check
Cultivar				
Black Diamond	22.44 A[b]	14.09 A	9.81 A	10.30 A
Crimson Sweet	36.16 A	17.19 A	19.27 A	40.42 A
Seedless Hybrid	57.69 A	39.21 A	14.45 A	45.92 A
Charleston Gray	40.55 A	40.37 A	42.50 A	49.03 A
Sugar Baby	25.00 A	13.54 A	12.87 A	30.09 A

[a]CB = activated charcoal band applied at 280 kg/ha just before planting.

[b]Means followed by the same letter within columns and rows are not significantly different at the 5% level using Duncan's new multiple range test.

Table 34. Effect of dinitroaniline herbicides on the number of marketable fruit produced from the watermelon cultivar trial conducted at Crossville, Tennessee in 1981.

	Pendimethalin 0.84 PPI	Pendimethalin + CB[a] 0.84 PPI	Ethalfluralin 1.4 PRE	Weed-free check -
Cultivar				
Black Diamond	3230 C-E[b]	5110 A-E	9140 ABC	11030 A
Crimson Sweet	2420 DE	2420 DE	5650 A-E	5920 A-E
Seedless Hybrid	1340 E	3500 B-E	2420 DE	4030 B-E
Charleston Gray	810 E	540 E	1340 E	4840 B-E
Sugar Baby	1340 E	4840 B-E	9680 AB	8610 A-D

[a]CB = activated charcoal band applied at 280 kg/ha just before planting.

[b]Means followed by the same letter within columns and rows are not significantly different at the 5% level using Duncan's new multiple range test.

Table 35. Primary root length (cm) of cucumber cultivars after seven and seventeen days grown in *vitro* conditions.

		Sweeet Slice		Green Pak		Carolina		Poinsett-76		Dasher		Ashley	
	ppmw	7 days	17 days	7 days	17 days	7 days	17 days	7 days	17 days	7 days	17 days	7 days	17 days
Control	-	3.4 A[a]	5.7 C-H	2.9 B	7.9 A-D	2.0 C	6.7 B-E	0.7 K-R	1.2 NO	1.2 F-K	9.9 A	0.1 S	0.6 L-O
Ethalfluralin	.125	1.1 G-K	2.4 I-O	1.9 CDE	6.3 C-G	0.8 I-N	9.7 AB	0.2 P-S	0.4 L-O	0.9 H-N	4.9 D-J	0 S	0.2 NO
	.250	1.1 G-K	2.2 I-O	1.4 E-H	6.5 C-F	1.1 G-L	3.8 E-M	0.4 M-S	0.5 L-O	0.8 J-O	4.6 D-K	0 S	0.1 O
	.375	1.0 G-M	2.5 H-O	1.7 C-F	10.2 A	1.0 G-M	2.2 I-O	0.2 P-S	0.2 NO	0.8 K-O	4.6 D-K	0.1 S	0.2 NO
	.500	1.4 E-J	2.2 I-O	1.2 F-K	5.7 C-H	0.8 K-O	3.9 E-L	0.2 P-S	0.2 NO	1.1 G-L	2.5 H-O	0 S	0.3 NO
	.625	0.8 I-N	2.2 I-O	1.0 G-M	4.8 D-J	0.8 I-N	1.7 J-O	0.3 N-S	1.4 MNO	0.5 L-S	2.3 I-O	0 S	0.2 NO
Pendimethalin	.125	0.9 H-N	2.9 G-O	1.5 C-G	8.9 ABC	1.1 F-K	9.5 AB	0.5 L-S	0.6 L-O	0.8 J-O	5.4 D-I	0 S	0.2 NO
	.250	1.0 G-M	2.4 I-O	1.3 F-K	1.9 I-O	0.8 J-N	5.2 D-I	0.5 L-S	0.4 L-O	0.8 J-N	2.8 G-O	0 S	0.2 NO
	.375	0.9 G-M	1.6 J-O	1.0 G-M	1.5 J-O	1.0 G-M	2.4 I-O	0.3 N-S	0.4 NO	0.7 K-P	3.4 F-O	0 S	0.2 NO
	.500	1.9 CD	3.5 E-N	1.5 E-G	4.4 D-L	1.0 G-M	6.8 B-E	0.2 QRS	0.4 NO	1.0 G-M	2.5 H-O	0 S	0.2 NO
	.625	1.1 G-K	2.8 H-O	1.2 F-K	3.0 F-O	0.7 K-Q	2.2 I-O	0.1 RS	0.2 NO	0.7 K-Q	1.2 L-O	0 S	0.2 NO

[a]Means of each observation date within columns and rows followed by the same letter are not significantly different at the 5% level of Duncan's multiple range test.

'Poinsett-76' and 'Ashley' were treated with either herbicide and '420 Green Pak' treated with ethalfluralin when compared to their respective controls. Treatment with either herbicide reduced the primary root length of 'Dasher.' No differences were found among treatments or among hybrids when comparing 'Ashley' and 'Poinsett-76' seedlings treated with either herbicide or their controls or with 'Sweet Slice' treated with ethalfluralin.

'Sweet Slice' and '420 Green Pak' under the control conditions were the only cultivars to produce secondary roots in seven days (Table 36).

After seventeen days under control conditions the production of secondary roots was: 'Sweet Slice'$\geq$'Dasher'$\geq$'420 Green Pak'$\geq$'Carolina'$\geq$ 'Poinsett 76'$\geq$'Ashley,' 'Sweet Slice,' '420 Green Pak' and 'Dasher' in the control produced more secondary roots than their respective counterparts in the herbicide treated agar (Table 36). 'Carolina' cucumbers produced more secondary roots in the control and on agar media containing 0.125 ppmw of either herbicide than when grown on agar media contraining higher concentrations of either herbicide.

When the average primary root lengths and average number of secondary roots were combined for each herbicide at seven days none of the cucumber hybrids responded differently to pendimethalin or ethalfluralin in any of the measured parameters (Tables 37, 38).

Ethalfluralin inhibited '420 Green Pak' less than pendimethalin in both measured parameters when observed at seventeen days (Tables 37, 38). 'Sweet Slice' was the only cultivar to show damage by both herbicides in all the measured parameters when compared to its control.

Table 36. Average number of secondary roots per seedling of cucumber cultivars after seven and seventeen days grown in vitro conditions.

	ppmw	Sweet Slice		420 Green Pak		Carolina		Poinsett-76		Dasher		Ashley	
		7 days	17 days	7 days	17 days	7 days	17 days	7 days	17 days	7 days	17 days	7 days	17 days
Control		4 A[a]	20 A	3 A	18 AB	0 B	11 CDE	0 B	1 KLM	0 B	19 A	0 B	1 KLM
Ethalfluralin	.125	0 B	7 E-H	0 B	5 E-M	0 B	11 CDE	0 B	1 J-M	0 B	5 E-M	0 B	0 M
	.250	0 B	5 E-M	0 B	6 E-M	0 B	2 H-M	0 B	1 J-M	0 B	6 E-L	0 B	0 M
	.375	0 B	9 C-G	0 B	7 E-H	0 B	1 J-M	0 B	0 M	0 B	3 G-M	0 B	0 M
	.500	0 B	5 E-M	0 B	6 E-M	0 B	2 H-M	0 B	0 M	0 B	2 H-L	0 B	0 M
	.625	0 B	6 D-J	0 B	6 D-L	0 B	2 H-M	0 B	0 M	0 B	1 I-M	0 B	0 M
Pendimethalin	.125	0 B	9 C-F	0 B	4 F-M	0 B	11 CD	0 B	1 LM	0 B	7 D-I	0 B	0 M
	.250	0 B	6 E-L	0 B	1 J-M	0 B	4 F-M	0 B	0 M	0 B	2 H-M	0 B	0 M
	.375	0 B	4 G-M	0 B	0 M	0 B	1 F-M	0 B	0 M	0 B	3 H-M	0 B	0 M
	.500	0 B	13 BC	0 B	2 H-M	0 B	6 D-K	0 B	2 H-M	0 B	0 M	0 B	0 M
	.625	0 B	10 CDE	0 B	2 H-M	0 B	2 H-M	0 B	0 M	0 B	0 M	0 B	0 M

[a]Means of each observation date within columns and rows followed by the same letter are not significantly different at the 5% level of Duncan's multiple range test.

Table 37. Average primary root length (cm) per seedling in the cucumber cultivar in vitro test after seven and seventeen days.[a]

Treatment	Hybrid											
	Sweet Slice		420 Green Pak		Carolina		Poinsett-76		Dasher		Ashley	
	7 Days	17 Days	7 Days	17 Days	7 Days	17 Days	7 Days	17 Days	7 Days	17 Days	7 Days	17 Days
Control	3.4 A	5.7 BC	2.9 B	7.9 AB	2.0 C	6.7 B	0.6 GH	1.2 FG	1.2 DEF	9.9 A	0.1 IJ	0.6 FG
Ethalfluralin	1.1 EF	2.3 F	1.4 D	6.8 B	0.9 FG	4.3 CD	0.3 HI	0.3 G	0.8 FG	3.8 CDE	0 J	0.2 G
Pendimethalin	1.2 EF	2.6 EF	1.3 DE	3.9 CDE	0.9 FG	5.2 BC	0.3 HI	0.4 G	0.8 FG	3.0 DEF	0 J	0.2 G

[a]Data for all rates of each herbicide were combined.

[b]Means of each observation date within columns and rows followed by the same letter are not significantly different at the 5% level of Duncan's multiple range test.

Table 38. Average number of secondary roots per seedling in the cucumber in vitro test after seven and seventeen days.[a]

	Sweeet Slice		420 Green Pak		Carolina		Poinsett-76		Dasher		Ashley	
	7 days	17 days	7 days	17 days	7 days	17 days	7 days	17 days	7 days	17 days	7 days	17 days
Control	3 A[b]	20 A	3 A	18 A	0 B	11 B	0 B	1 FG	0 B	19 A	0 B	1 FG
Ethalfluralin	0 B	6 CD	0 B	6 DE	0 B	4 EF	0 B	0 G	0 B	4 EF	0 B	0 G
Pendimethalin	0 B	8 BC	0 B	2 FG	0 B	.5 DE	0 B	0 G	0 B	2 FG	0 B	0 C

[a]Data for all rates of each herbicide were combined.

[b]Means of each observation Date within columns or rows followed by the same letter are not significantly different at the 5% level of Duncan's multiple range test.

Treatment with either herbicide reduced the primary root length of 'Sweet Slice,' '420 Green Pak' and 'Carolina' after seven days.

After 17 days ethalfluralin treated seedlings of 'Sweet Slice,' 'Carolina' and 'Dasher' cucumbers showed reduced primary root lengths when compared to the control (Table 38). Ethalfluralin treated seedlings of 'Sweet Slice,' '420 Green Pak,' 'Carolina,' and 'Dasher' had fewer secondary roots when compared to seedlings of their respective controls. Pendimethalin treated seedlings of 'Sweet Slice,' '420 Green Pak' and 'Dasher' had shorter roots than their respective controls. Fewer secondary roots were produced by pendimethalin treated 'Sweet Slice,' '420 Green Pak,' 'Carolina,' and 'Dasher' cucumbers when compared to their respective controls. Figures 1 and 2 illustrate the differences in the root growth of 'Sweet Slice,' one of the most vigorous cultivars tested, and 'Ashley,' the least vigorous cultivar tested.

Although no primary root growth differences were detected between 'Poinsett 76' and 'Ashley' between the herbicide treated plants and those plants in the control, the low plant vigor of these cultivars may cause the germinating seedlings to stay in the treated zone for an extended time so the root meristem would gradually be lost. Without secondary root development there probably would be inadequate water or nutrient uptake for continued plant survival under field conditions.

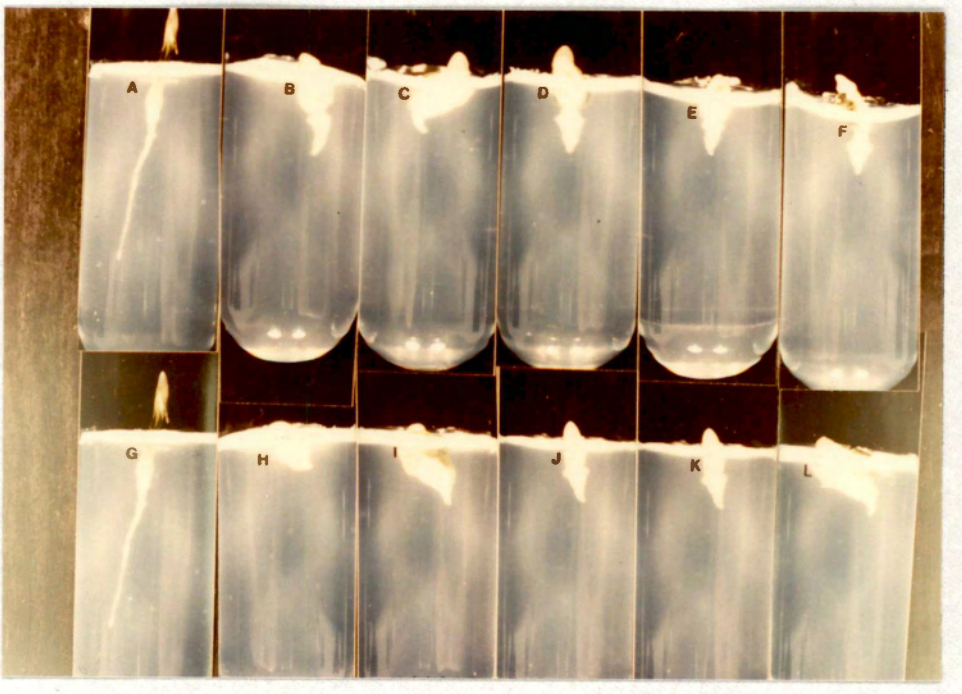


Figure 1. Effect of ethalfluralin or pendimethalin on cucumber 'Ashley' seedling roots in vitro (A, control; B, .125 ppmw ethalfluralin; C, .250 ppmw ethalfluralin; D, .375 ppmw ethalfluralin; E, .500 ppmw ethalfluralin; F, .625 ppmw ethalfluralin; G, control; H, .125 ppmw pendimethalin; I, .250 ppmw pendimethalin; J, .375 ppmw pendimethalin; K, .500 ppmw pendimethalin; L, .625 ppmw pendimethalin).

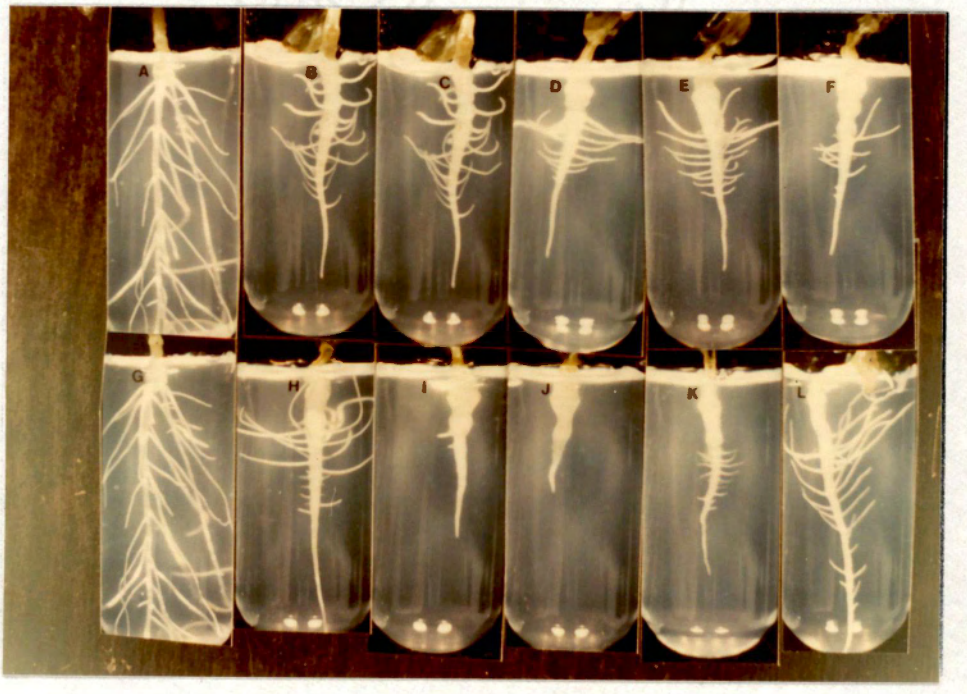


Figure 2. Effect of ethalfluralin or pendimethalin on cucumber 'Sweet Slice' seedling roots in vitro (A, control; B, .125 ppmw ethalfluralin; C, .250 ppmw ethalfluralin; D, .375 ppmw ethalfluralin; E, .500 ppmw ethalfluralin; F, .625 ppmw ethalfluralin; G, control; H, .125 ppmw pendimethalin; I, .250 ppmw pendimethalin; J, .375 ppmw pendimethalin; K, .500 ppmw pendimethalin; L, .625 ppmw pendimethalin).

CHAPTER V

SUMMARY

The above ground symptoms of dinitroaniline herbicide injury on cucurbits during seedling stages of growth are an inhibition of shoot growth, a leathery appearance of the cotyledon, a swelling of the hypocotyl and an intensification of green coloration (3,4,50), and reduced plant populations.

Throughout this series of experiments, charcoal banding or coating seed with charcoal reduced crop injury and improved cucurbit seed emergency through the dinitroaniline treated soil. Charcoal banding tended to be more effective in protecting seedlings than did charcoal coating the seeds. Ethalfluralin or pendimethalin applied at 1.7 kg/ha with no charcoal caused moderate to severe seedling vigor reduction in most cases. Charcoal coating the seed coat probably helped protect the emerging seedling by absorbing some of the herbicide around the cotyledons and apical meristem. A charcoal seed coat does not protect the hypocotyl or the radicle which are primary sites of action of the dinitroanilines (3,6,50). The band of activated charcoal which was mixed in soil as the seed was planted should absorb some of the herbicide in the germination zone thereby partially protecting emerging seedlings. The effectiveness of charcoal banding over a charcoal seed coat may be due to protection of the primary root as it grows through the treated soil.

An activated charcoal seed coat or activated charcoal banding

tended to increase the yield of the cucurbit crops over their respective dinitroaniline treated plots with no activated charcoal. Plants treated with the low rate of the dinitroaniline herbicides usually produced higher fruit yields than plants treated with the high rate of either dinitroaniline herbicide.

No advantage was found using the higher dinitroaniline herbicide rate to enhance weed control since both rates provides the same degree of weed control. Usually good to excellent weed control was obtained by using either dinitroaniline herbicide. No weed control was observed in the 1980 Crossville cantaloupe and watermelon tests. Poor herbicide incorporation by a powered harrow, combined with low rainfall, may have contributed to inactivation of the herbicides.

Excellent results were obtained using ethalfluralin applied preemergence in the cucurbit cultivar trials. Applying ethalfluralin as a preemergence treatment reduced herbicide-seedling contact in the soil during germination as compared with preplant incorporated ethalfluralin. Cucurbit cultivars in the ethalfluralin treated plots consistently produced as much marketable fruit as cucurbits in the weed-free checks. Activated charcoal banding in the seed row was effective in reducing cucurbit crop injury from preplant incorporated pendimethalin although fruit yield from cucurbits in these plots were not as high as cucurbits in the weed-free checks.

The cucumber in <u>vitro</u> test demonstrated cultivar vigor may be critical in the tolerance of cucumbers to ethalfluralin or pendimethalin The more vigorous cultivars, '420 Green Pak,' 'Carolina,' 'Sweet Slice,' and 'Dasher' in the herbicide treated agar still produced more root

growth than the less vigorous cucumber cultivars, 'Poinsett-76' and 'Ashley' in the non-herbicide treated agar. Cucumber cultivars exhibiting low seedling vigor may cause the roots to stay in the treated zone for an extended time so the root meristem would gradually be lost. Without secondary root development there would be inadequate water or nutrient uptake for continued plant survival under field conditions. A cucurbit cultivar which shows good seedling vigor should be able to grow through the herbicide treated zone quickly, minimizing herbicide injury.

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