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MISA and DPX-PE350 effects on cotton development, yield and quality

Mark W. Shankle

To the Graduate Council:

I am submitting herewith a thesis written by Mark W. Shankle entitled "MISA and DPX-PE350 effects on cotton development, yield and quality." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Plant, Soil and Environmental Sciences.

Thomas C. Mueller, Major Professor

We have read this thesis and recommend its acceptance:

Thomas C. Mueller, Robert M. Hayes

Accepted for the Council:
Carolyn R. Hodges

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I am submitting herewith a thesis written by Mark Wayne Shankle entitled " MSMA and DPX-PE350 Effects on Cotton Development, Yield and Quality." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Plant and Soil Science.

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MSMA AND DPX-PE350 EFFECTS ON COTTON DEVELOPMENT, YIELD AND QUALITY

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Mark Wayne Shankle

December 1993

DEDICATION

To my parents, Gerald Wayne and Joyce Ann Shankle, whose support, prayers and advice continue to influence my decisions every day, I dedicate this thesis.

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ABSTRACT[1]

Field research was conducted at Jackson in 1991 and Milan in 1992 to compare the effect of MSMA and DPX-PE350 on cotton development, yield and quality. "Deltapine 50" cotton was planted in rows spaced 1 m apart. Individual plots were four rows by 9 m in length. Treatments were replicated four times in a randomized complete block design. MSMA at 2.24 kg ai ha $^{-1}$ and DPX-PE350 at 0.14 kg ai ha^{-1} were applied to 15 to 25 cm (early) and 45 to 55 cm (late) cotton. Early treatments coincided with first square, while late applications were just prior to first flower. An untreated check was included for comparison. Experiments were hand-hoed to maintain weedfree conditions. Plant growth regulators and harvest aids were not used in these experiments to prevent interactive effects. A plant mapping procedure developed by Jenkins et al. 1990 was used to describe plant development. Terms include: 1. monopodium - vegetative branch; 2. sympodium - fruiting branch; 3. node - place on the main stem where sympodia or monopodia arise, nodes begin with the cotyledonary node as zero; 4. position - refers to the order in which fruit is produced on a sympodium branch; 5. fruiting site - any specific node and

[1] To be submitted for publication in Weed Science. Authors: Mark W. Shankle, Thomas C. Mueller, Robert M. Hayes and Vernon H. Reich. Former Grad. Res. Asst., Asst. Prof., Prof., and Prof., respectively, Dept. of Plant and Soil Sci., Unvi. of Tennessee, Knoxville, TN 37901.

position combination. Plants were mapped at 5 weeks after treatment (WAT)[2], 12 WAT and at harvest. Mapping data measured plant internode, height, number of sympodia, number of open bolls / closed bolls and yield by fruiting site. Data was collected from seven consecutive plants in 1 m of a middle row. Two center rows of each plot were machine harvested. A 1.14 kg sample of seed cotton from each plot was composited by treatment and ginned. Generally, DPX-PE350 did not affect development, yield and quality of cotton. However at 5 WAT, DPX-PE350-late increased square production and decreased boll production for sympodia position two, which could cause delayed plant development under extreme adverse growing conditions. MSMA decreased cotton plant internode length and height at 5 WAT for both years. However, only MSMA-late decreased plant height in 1992 and further observations revealed that no other plant characteristics were different for the 1992 growing season which could be a result of more favorable growing conditions. In 1991, MSMA generally increased squares and decreased blooms and bolls for monopodia and sympodia position one and two which suggests a delay in plant development. However, the delayed plant development response was more pronounced for MSMA-late which was still prevalent late season. At 12 WAT, MSMA-late reduced plant height, number of sympodia and number of open bolls, while increasing number of closed bolls. In 1991, mechanical harvest and plant mapping lint yields were decreased by MSMA-late. Mechanical harvest lint yields were decreased by MSMA at first harvest while increasing lint yields second harvest.

[2] WAT; weeks after treatment

However, only MSMA-late decreased total harvest lint yield. Plant mapping data determined that the yield decrease was a result of decreased yields at sympodia positions one and two. A trend developed for sympodia 8,9,10 and 11 where yield at positions one and two were generally decreased and position three was increased. This coincides with late applications made during sympodia 8 development. Fiber properties: length, strength and % trash were not different but, micronaire readings were decreased by MSMA-late in both years. Cotton seed arsenic analysis in 1991 indicates that MSMA-late increased arsenic levels for sympodia at position one and two compared to the untreated check, while position two contained the highest level. Therefore, arsenic movement in the plant may follow a source to sink relationship. In summary, DPX-PE350 had no measurable adverse affects on development, yield and quality of cotton. MSMA-late decreased plant internode and height, number of sympodia, number of open bolls, yield, and micronaire. MSMA-late also increased arsenic levels in cotton seed for sympodia at positions one and two.

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PART I

GENERAL INTRODUCTION

AND

LITERATURE REVIEW

CHAPTER 1

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) production profits are influenced by weed management. Prior to herbicide development middle row cultivation and hand hoeing were used to control weeds. Herbicides were first used in cotton in the 1950's to minimize large amounts of hand labor. Cotton is a warm season perennial which is usually planted in cool soil during early spring. Cotton germination and seedling growth can be slower than weed emergence and growth. Therefore, the role herbicides play in weed control has become more important.

Most producers desire a broadleaf herbicide that can be applied POST[1] without cotton injury. DSMA and MSMA herbicides are important for POST broadleaf weed control, although the potential for cotton injury does exist. There are no selective broadleaf herbicides registered that can be applied POST over the top to mid-season cotton without crop injury. DPX-PE350 is an experimental herbicide being developed for POST application in cotton. DPX-PE350 has demonstrated broadleaf weed control at only a few grams per hectare with little injury to cotton.

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[1] Abbreviation: POST, postemergence; abbreviations as recommended by the WSSA Terminology Committee.

Therefore, DPX-PE350 could provide producers an alternate management tool in their weed management program.

While DPX-PE350 has no effect on cotton development in preliminary studies in Mississippi under near optimum growing conditions, effects may be more pronounced under cooler wetter conditions often experienced in West Tennessee and the Missouri bootheel in early spring. While MSMA, causes a lag in fruiting and generally decreased yields, its affect on fruiting at different application timings and environments is not well understood. Therefore, the objective of this research was to elucidate the cotton plant response to POST DPX-PE350 and MSMA at different growth stages under Tennessee growing conditions.

CHAPTER 2

ARSENICALS

Inorganic Arsenical History

Elemental arsenic (As) has been incorrectly defined as a heavy metal such as lead and mercury. It is not a metal, but a metalloid. By having both metallic and nonmetallic properties, compounds can be formed with the As atom being a cation or an anion (12). Arsenic has been used as a poison, a stimulant and a conditioner for animals (3). Arsenic in sufficient quantities is an acute poison. It was used at low dosage to stimulate athletes and mountain climbers. It produced shiny coats on animals when used as a conditioner. Arsenic is a common element in most soils and consequently is also present in plants and animals. Normal soil levels (1 to 20 ppm) support plant growth. It mainly occurs in the inorganic arsenate AS(V) form, which is tightly bound to soil minerals particularly the colloidal metal hydrous oxides, by ionic bounds (16). Therefore, root availability is low and plants seldom contain more than 1 ppm. At 1 ppm and below there is no known harmful effect from arsenic (3).

Herbicide compounds of As are correctly called arsenicals. Inorganic arsenical compounds were introduced as herbicides in the early 1900's (17). Sodium arsenite was used as a weed killer for many years. Large quantities were used in the

U.S. on railroad rights-of-way and in tropical countries in sugar cane and rubber plantations. For several years an acidified solution of dilute sodium arsenite was used for perennial weed control (8,9). Sodium arsenite was also used around the home for weed control and as a soil sterilent on driveways, tennis courts and sidewalks. Many cases of poisoning occurred due to inappropriate storage. Frequently, sodium arsenite was stored in soft drink bottles and would be consumed by mistake. Sodium arsenite released aromatic compounds that would attract animals when sprayed on mixed vegetation. When animals consumed vegetation sprayed with this herbicide they were poisoned. Therefore, thousands of horses, cattle, sheep and wildlife poisoning incidents occurred around areas of application (5). Sodium arsenite is no longer used in the United States and many countries due to extreme toxicity.

Organic Arsenical

Organic arsenicals have a low mammalian toxicity. For example, arsenic acid (H_3AsO_4) has an oral LD_{50} of 48 mg kg^{-1} compared to 1800 mg kg^{-1} for MSMA $(CH_3AsO_3)^{-2}$ (17). Organic pentavalent organoarsenicals of the methylarsonic family are primarily salts of methylarsonic acid (MA) (Table 1). Also included in this group is the herbicide cacodylic acid $[(CH_3)_2AsO_2]$ (CA). Cacodylic acid is a foliar contact herbicide used to defoliate or desiccate many plant species (5). It is used in forest management, lawn renovation, noncrop, orchard and vineyard weed control and as a directed spray in cotton. A lethal dose could be 29.57 ml, but it has no dermal

Table 1. Methanearsonate Salts

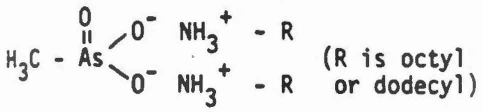
Common name	Chemical name
MA	Methyarsonic acid
MSMA	Monosodium salt of methylarsonic acid
DSMA	Disodium salt of methylarsonic acid
MAMA	Monoammonium salt of methylarsonic acid
AMA	Octyl- and dodecyl ammonium methylarsonic acid
CA	Dimethylarsinic acid

toxicity (3). MSMA, DSMA and MAMA are available as formulated materials, some with surfactant and some with 2,4-D or other supplementary herbicides.

Organic arsenicals are used to control weeds in turf, cotton, citrus and noncrop areas. These compounds are used to control several weeds: Johnsongrass (*Sorghum halepense*), Watergrass (*Echinochloa crysgalli*), Cocklebur (*Xanthium* spp.), Ragweed (*Ambrosia* spp.), Puncture vine (*Tribulus terrestris*) Pigweed (*Amaranthus* spp.), Nutsedge (*Cyperus* spp.), Sandbur (*Cenchrus* spp.), Foxtails (*Setaria* Spp.), Goosegrass (*Elucine indica*), Quackgrass (*Agripyron repens*), Barnyardgrass (*Echinochlo crusgalli*) and Dallisgrass (*Paspalum dilatum*) (5). Chemical structures for the Methanarsonate family are relatively simple as shown in (Figure 1).

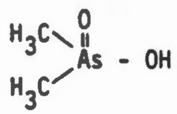
Organic Arsenical Progression

Herbicidal properties of MSMA were discovered by Schwerdle in 1951 (12). He found this compound to effectively control crabgrass (*Digitaria* spp.) in turf. In the early 1960's DSMA or MSMA applied alone or with companion herbicides replaced herbicidal oil for POST weed control in cotton. Thompson first discovered that DSMA or MSMA plus dicryl was highly effective in controlling weeds (18). A tank mixture was marketed containing both DSMA and dicryl, however it was only marketed for 2 to 3 years because arsenicals alone or in combination with other herbicides were more effective. In 1963, 28,800 hectares in Mississippi were treated POST with DSMA or MSMA (3). By 1969, almost 600,000 hectares in Mississippi



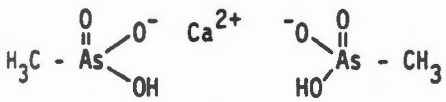
AMA

(Antrol™; Methar™, others)



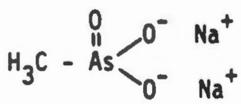
cacodylic acid

(Phytar 560; others)



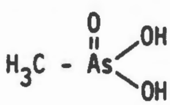
CMA

(Calar™; others)



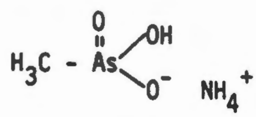
DSMA

(Ansar™; Ansar 184™; others)

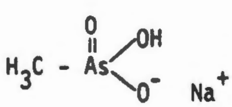


MAA

(Trans-Vert™; Weed-E-Rad™, others)



MAMA



MSMA

(Ansar 170™; Ansar 529™; Bueno™; others)

Figure 1. Chemical structures for Methanearsonate family.

were treated with an arsenical applied alone or with a companion herbicides. Adjacent states developed a similar use pattern. In Tennessee the area treated with arsenicals increased from 42,800 hectares in 1966 to almost 120,000 hectares in 1970 (3). Arsenicals were used on about 240,000 to 320,000 hectares in Texas from 1965 to 1970 (3). Even today, DSMA and MSMA continue to be the most widely used POST herbicides in cotton because they are more economical than alternatives.

CHAPTER 3

PLANT RESPONSE TO ARSENICAL HERBICIDES

Mode and Mechanism of Action

Herbicidal mode of action is the way a herbicide affects a plant or plant species (17). This is usually a sequence of events that eventually kills the plant. Herbicide mechanism of action is biochemical activity directed at specific cellular and molecular sites and processes (17). In some cases the effect on the plant may be known, while the actual cause for that effect at the cellular and molecular level is unknown.

Herbicide mode of action determination may allow herbicide improvement through structure activity studies. If a herbicide kills a plant by inhibiting a particular enzyme, test tube screenings could be conducted with other analogues to determine their ability to inhibit the enzyme (3). The holder of a patent for a herbicide may benefit from using mode of action information in a patent challenge or toxicology defense. Similar molecules may be ruled as different chemistry in court if herbicidal activity is caused at different molecular sites than stated by a competitor's patent. Also, toxicological problems should be reduced for compounds known to cause herbicidal activity by inhibiting enzymes only found in plants (3).

Mechanism of action is useful in predicting herbicide interactions. Herbicide antagonism may occur if a herbicide that causes rapid cellular collapse is used in conjunction with a herbicide that must be translocated to meristem locations for activation (3). However, herbicides that inhibit photosynthetic processes activate slowly. This increases weed control by allowing translocation of one herbicide before the other becomes lethal at the cellular level. Therefore, additive, synergistic and antagonistic effects may be predicted from mechanism of action knowledge.

Sequence of Events

The mode of action of MSMA is relatively slow, with the first symptoms occurring within 7 days after application. These symptoms include chlorosis and cessation of growth. Later observations reveal a gradual browning of the leaves and stems followed by necrosis (12). Rhizome and tuber storage structures may also show browning. If regrowth occurs, leaves should reach full size before a second application. This is to allow for herbicide translocation to underground structures (12).

Herbicide Movement

MSMA is primarily a foliar applied contact herbicide, but translocation in both apoplast and symplast occurred in wheat leaves (5). Primarily, translocation was in the symplast with some movement in the apoplast (14). Translocation was also observed in nutsedge (*Cyperus spp.*)and cotton. Arsenic accumulations were found in small nutsedge tubers, reducing small tuber vitality. Yellow nutsedge (*Cyperus esculentus*) absorbed and translocated more ^{14}C-MSMA than did purple nutsedge (*Cyperus rotundus*) (14).

Wilkinson and Hardcastle applied MSMA throughout the growth stages of cotton. Late POST MSMA increased arsenic concentrations in untreated leaves. This indicated that translocation from mature into young leaves followed a source-sink relationship (19). Another indicator of MSMA translocation within plant tissue was the high residue levels of arsenic found in cottonseed after treatment during the cotton bloom stage (15). Arsenic content of cottonseed was not increased when MSMA was applied during the prebloom phase (6).

Molecular Fate

The carbon-arsenic bond of organic arsenical herbicides remain intact in higher plants such as cotton (12). Therefore, the effects of inorganic arsenic ions on metabolism will not be discussed. The primary site of action for MSMA may be associated with modification of protein structure, especially that of enzymes. This could be related to a change in membrane permeability and metabolic pathway modification. Sckerl and Frans examined ^{14}C-MA metabolism in johnsongrass and cotton. They found a two to four-fold increase in most of the individual amino acids in johnsongrass and not in cotton. Increased amino acids in johnsongrass may be due to blockage of protein synthesis, or some unknown pathway (5). Experiments have shown that the ultimate death of johnsongrass rhizomes is not related to arsenic from MSMA applications. Some viable rhizomes had larger arsenic levels than dead ones. Ultimate death is probably due to the interruption of oxidation phosphorylation and the exhaustion of starch reserves from resprouting. Therefore, the suggested mechanism of action is related to increased amino acids concentrations and accelerated starch utilization in storage organs of perennials. Higher plants seem to detoxify MSMA through the formation of one or more conjugates with a sugar, organic acid, and/or amino acid (5).

CHAPTER 4

LABEL INFORMATION

Herbicide Label

Ross and Lembi define a label as "The directions for using a pesticide approved as a result of the registration process and attached to the herbicide container" (17). It is considered as a binding contract or law. Substantial research and money is required to obtain a label and register a herbicide.

Important Concepts

Important concepts listed under the "directions for use in cotton" heading on the MSMA label are: Do not apply MSMA through any type of irrigation system. A second or repeat application, if needed, should be timed about 1 to 3 WAT[1]. Apply only when cotton is 3 inches in height to first bloom. Do not apply after first bloom. Slight burning or reddish discoloration may occur with recommended treatment; however, the cotton plant will recover and yield will not be affected. Apply under warm temperatures. Keeley and Thullen observed that young cotton (first true-leaf stage) exposed at 31°C tolerated 3.36 kg ha^{-1} MSMA. However, plants treated at

13°C were severely injured. Only slight injury occurred at 20°C (13) (Table 2). Therefore, MSMA mobility in plants may increase under cool temperatures compared to warm temperatures. This could account for severe injury to young cotton when MSMA is applied in cool temperatures.

Section 24(c)

A special local needs pursuant to section 24 (c) of amended FIFRA is also included in this label for cotton in Tennessee (TN-830017). The main concept of this section 24 follows: Apply as an over-the-top broadcast spray only when cotton is 7.5 to 15 cm or up to early fruit square stage, whichever comes first. Arle and Hamilton determined that cotton yield was not affected by an over-the-top MSMA 4 wk after emergence, while treatments made 8 to 12 wk reduced yields, boll components and fiber properties (4) (Table 3,4).

Table 2. Fresh weight (% of the control) of five week old cotton treated at first true leaf stage with 3.36 kg ha^{-1} of DSMA or MSMA at various temperatures.

		Temperature °C		
Treatment	Surfactant	13	20	31
	%	----------	Fresh wt (% of control)	----------
Control	none	100 A[a]	100 A	100 A
DSMA	none	82 AB	92 A	100 A
DSMA	0.5	69 B	83 A	94 A
MSMA	none	5 C	79 A	100 A
MSMA	0.5	5 C	16 B	91 A

[a] Means followed by the same letter (s) are not significantly different at the 5 % level as determined by Duncan's Multiple Range Test.

Source: Keeley, P.E. and R.J. Thullen. 1971. Cotton response to temperature and organic arsenicals. Weed Sci. 19:298.

Table 3. Cotton yield as influenced by MSMA POST over the top at 2.2 kg ha^{-1} in Phoenix, Arizona.

Time of MSMA applications after cotton emergence	Yield of Seed Cotton 1973	1974	Average
Weeks after cotton emergence	----------kg ha^{-1}----------		
Control	4,210 A[a]	3,860 A	4,040 A
4	4,020 AB	3,600 AB	3,810 AB
4, 8	3,640 C	3,420 AB	3,530 B
4, 8, 12	2,560 F	3,230 B	2,900 C
8	3,890 BC	3,350 B	3,620 B
8, 12	2,730 EF	3,160 B	2,940 C
12	3,090 D	3,320 B	3,200 C
4, 12	3,000 DE	3,200 B	3,100 C

[a] Values in a column followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.

Source: Arle, H.F. and K.C. Hamilton. 1976. Over-the-top applications of herbicides in cotton. Weed Sci. 24:167.

Table 4. Average cotton boll components and fiber properties as influenced by MSMA POST at 2.2 kg ha^{-1}.

	----------Boll Components[a]----------			----------Fiber Properties----------		
Time of MSMA application after cotton emergence	Weight	Lint	Seed per boll	Length	Strength Pressley Breaker	Fineness Micronaire
Weeks after cotton emergence	g	%	#	cm	index	index
Control	5.7 A	37 A	33 A	2.8 A	3.3 A	5.1 A
4	5.7 A	37 A	33 A	2.8 A	3.3 A	5.1 AB
4, 8	5.7 AB	36 A	33 A	2.9 A	3.2 A	4.8 BC
4, 8, 12	5.2 C	34 B	33 A	2.8 A	3.3 A	4.1 E
8	5.6 AB	36 A	33 A	2.9 A	3.2 A	4.8 BC
8, 12	5.4 ABC	34 B	34 A	2.9 A	3.3 A	4.7 CD
12	5.4 BC	34 B	33 A	2.9 A	3.3 A	4.3 E
4, 12	5.4 BC	34 B	33 A	2.8 A	3.3 A	4.4 DE

[a] Values based on eight 10-boll samples taken before harvest. Values in a column followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.

Source: Arle, H.F. and K.C. Hamilton. 1976. Over-the-top applications of herbicides in cotton. Weed Sci. 24:168.

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PART II

MSMA AND DPX-PE350 EFFECTS ON COTTON DEVELOPMENT, YIELD AND QUALITY

CHAPTER 1

INTRODUCTION

MSMA Recommendations

MSMA (monosodium salt of methylarsonic acid) is an important herbicide for weed control in cotton. However, MSMA may injure cotton and should only be used for 'salvage' control of weeds larger than cotton (7). MSMA applied POST[1] over the top during cotton bloom stage can decrease cotton yield and increase arsenates in cottonseed (2,16). MSMA is recommended alone and in combination with other post-directed (PD)[1] herbicides. To prevent cotton injury a height differential should exist between cotton and weeds (10).

The University of Tennessee Agriculture Extension Service recommends MSMA early POST to 8 to 16 cm cotton and PD on larger cotton to control broadleaf weeds including common cocklebur (*Xanthium strumarium*). However, repeated MSMA applications can select for MSMA-resistant weeds. MSMA-resistant common cocklebur has been confirmed in South Carolina, Alabama, Mississippi and most recently in Tennessee (3,5,17). Common cocklebur is one of the most competitive

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[1] Abbreviations: POST, postemergence; PD, post-directed; PRE, preemergence; WALT, weeks after late treatment; HVI, high volume instrument

weeds in cotton. Cotton lint yield may be reduced by 90% at densities of seven common cocklebur plants per meter of row (3). No POST herbicides are currently available for use in cotton that provide selective control of common cocklebur and other broadleaf weeds with cotton crop tolerance. However, DPX-PE350, [sodium 2-chloro-6-(4,5-dimethoxy-pyrimidin-2-ylthio) benzoate]; is an experimental herbicide being developed to control a wide spectrum of broadleaf weeds in cotton including MSMA-resistant common cocklebur.

DPX-PE350

DPX-PE350 (proposed common name is sodium salt of pyrithiobac) is being developed by E.I. dupont de Nemours and Company for weed control in cotton. It was originally introduced in the United States as KIH-8921 by Kumiai, Inc. of Japan. The mechanism of action of DPX-PE350 is acetolactate synthase inhibition (11), which is a key enzyme in production of the aminio acids: valine, leucine and isoleucine. DPX-PE350 and several other herbicides were evaluated in the greenhouse for control of organic arsenical resistant (R-biotype) common cocklebur at the University of Tennessee and Delta Research Center in Mississippi (5,17). Among herbicides evaluated, only DPX-PE350 could be applied POST without cotton injury. DPX-PE350 at 67 to 112 g ai ha^{-1} provided 70 to 80% MSMA-resistant common cocklebur control without injury to cotton.

DPX-PE350 also has herbicide activity on several other competitive broadleaf weeds. DPX-PE350 at 56, 112 and 168 g ai ha^{-1} applied POST to cotton at the cotyledon to 1-leaf stage controlled velvetleaf (*Abutilon theophrasti* Medicus), pitted morningglory (*Ipomoea lacunosa* L.), entireleaf morningglory (*Ipomoea hederacea* var. *integriuscula* Gray), palmleaf morningglory (*Ipomoea wrightii* Gray), hemp sesbania (*Sesbania exaltata* L.), and prickly sida (*Sida spinosa* L.) > 90% at 3 WAT[1]. Sicklepod (*Cassia obtusifolia* L.) control was < 55% and tall morningglory (*Ipomoea purpurea* L.) was < 70% with these rates. Control of all species was decreased when DPX-PE350 was applied to larger weeds (9).

Differential response of morningglory species to DPX-PE350 were obtained in North Carolina and Texas. In North Carolina, DPX-PE350 applied POST at 35, 70 and 105 g ai ha^{-1} to 2 to 3-leaf morningglory, caused > 90% control of entireleaf and pitted morningglory at 3 WAT. However, tall morningglory control was 60 to 83% at these rates (15). In field studies in Texas, DPX-PE350 POST at 56 g ai ha^{-1} controlled entireleaf, ivyleaf, smallflower (*Jacquemontia tamnifolia*) and palmleaf morningglory > 85%. However, purple moonflower (*Ipomoea turbinata*) and tall morningglory control was 10 to 20% lower (6). DPX-PE350 POST at 56 g ai ha^{-1} controlled pigweed (*Amaranthus* spp.) but not johnsongrass [*Sorghum halepense* (L.) Pers.] in Oklahoma studies (1).

DPX-PE350 has cotton tolerance both preemergence (PRE)[1] and POST (11). Plant mapping was conducted to determine the effects of POST DPX-PE350 and MSMA on cotton fruiting and yield. DPX-PE350 applied POST at 212 g ai ha^{-1} did not adversely affect cotton fruiting or yield. MSMA applied POST at 1.7 kg ai ha^{-1}

created a lag in fruiting and caused a decrease in yield (14).

Research Objectives

While DPX-PE350 had no effect on cotton fruiting in preliminary studies in Mississippi under near optimum growing conditions, effects may be more pronounced under the cooler, wetter conditions often experienced in West Tennessee and the Missouri Bootheel in early spring. While MSMA causes a lag in fruiting and generally decreased yields, its affect on fruiting with different application timings and environments is not well understood. Therefore, the objective of this research was to elucidate the cotton plant response to POST DPX-PE350 and MSMA at different growth stages under Tennessee growing conditions. Cotton plant response was monitored by plant mapping procedures, quantity of cotton lint yield, quality of lint and determination of cotton seed arsenic levels by fruiting site.

CHAPTER 2

MATERIALS AND METHODS

General Experiment Comments

Field research was conducted on a Loring/Calloway silt loam in 1991 at Jackson, TN and in 1992 at Milan, TN on a Memphis silt loam. Standard soil-applied programs were used at planting. Fluometuron: (N,N-dimethyl-N-[3-(trifluoromethyl) phenyl] urea) at 1.7 kg ai ha^{-1} plus metolachlor (2-chloro-*N*-(2-ethyl-6-methylphenyl)-*N*-(2-methoxy-1-methyl-ethyl) acetamide) at 1.7 kg ai ha^{-1} was applied PRE for weed control in 1991. Pentachloronitrobenzene (PCNB) + Etridiazole (5-ethoxy-3-(trichloromethyl)-1,2,4-thiadiazole) at 0.28 and 1.1 kg ai ha^{-1}, respectively was applied to control seedling plant diseases and aldicarb (2-methyl-2-(methylthio) propionaldehyde *O*-(methylcarbamoyl)oxime) insecticide at 0.56 kg ai ha^{-1} were used in furrow at planting. In 1992, fluometuron at 1.7 kg ai ha^{-1} plus pendimethalin (N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine) at 1.1 kg ai ha^{-1} was applied PRE for weed control. Aldicarb insecticide at 0.56 kg ai ha^{-1} and PCNB + metalaxyl (*N*-(2,6-dimethylphenyl)-*N*-methoxyacetyl) alanine methyl ester) fungicides at 1.1 + 0.11 kg ai ha^{-1} were used. 'Deltapine 50' cotton was planted on May 23 and May 1 in 1991 and 1992, respectively. Individual plots were four rows spaced 1 m apart by 9 m in length. The five treatments were replicated four times in a randomized complete block design. MSMA 2.24 kg ai ha^{-1} and DPX-PE350 0.14 kg ai ha^{-1} were applied POST to 15 to 25 cm (early) and 45 to 55 cm (late) cotton. An untreated check was included for treatment comparisons. Early applications coincided with first square, while late applications were immediately prior to first flower. Experiments were maintained weedfree by hand-hoeing and herbicides previously listed. Plant growth regulators and harvest aids were not used in these experiments to prevent interactive effects. ANOVA and Fisher's protected LSD statistical procedures were used to determine treatment differences.

Plant Mapping Procedure

A plant map procedure developed by Jenkins et al. was modified to provide descriptive measurements for plant height, number of fruiting nodes, number of opened/unopened bolls and fruiting site yield (8). Descriptive measurements were taken from plants in 1 m of a middle row at 5 weeks after late treatment (WALT)[1] or 12 WALT. The same 1 m of row was hand harvested by fruiting site and ginned on a six roller laboratory gin. Lint weight by fruiting site was averaged among reps for each treatment and an area conversion factor was used to determine lint yield in kg ha^{-1}.

Terms used in this procedure are defined as follows (8).

1. Sympodium - a fruiting branch.
2. Monopodium - a vegetative branch.
3. Node - the place on the mainstem where sympodia or monopodia arise, numbered beginning with the cotyledonary node as Number 0.
4. Position - the order in which buds (potential bolls) are produced on a sympodium. In this study, only bolls produced at positions one, two and three were considered. Bolls with position numbers greater than three were classified as position three. Thus, the term position is not branch specific; for example, position one refers to the first potential boll on any or all sympodia.
5. Fruiting site - specific node/position combination.

Machine Harvest

A two-row spindle picker was used to harvest the two center rows of each plot. Each plot was harvested twice which provided first and second harvest seed cotton field samples. Sub-samples of seed cotton from each replication of each treatment at each harvest was weighed and ginned by a 20-saw laboratory gin at first and second harvest. Gin equipment, in order of operation, consisted of one inclined cleaner, one stick machine, one feeder, one 20-saw 16-inch gin, two 12-inch lint cleaners, and one laboratory size condenser (7). Lint weight was recorded from the ginned sample and percent gin turnout was determined by the formula:

$$\% \text{ Gin turnout} = [(\text{ginned lint wt} / \text{pre-ginned seed cotton wt}) \times 100]$$

Plot lint yield was derived by multiplying seed cotton field weight by percent gin turnout and an area conversion factor was used to calculate kg lint ha^{-1}, by using the formula:

$$\text{kg lint ha}^{-1} = [\text{field plot wt (lint wt / seed cotton wt)} \times \text{area factor}]$$

Plot lint yield was averaged across replications for each treatment and the addition of first and second harvest yield determined total yield.

Fiber Quality

High Volume Instrument (HVI)[1] systems were used to determine fiber properties[2] from machine harvested samples from each treatment. Micronaire readings are determined by airflow instruments that measure cotton fineness. Low

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[2] Properties were determined by Mr. David Jones at the United States Department of Agriculture Cotton Classing Office in Memphis, TN.

micronaire measurements indicate fine fiber and high measurements indicate coarse fiber. Fine fiber will produce fine, strong yarn. Micronaire readings also measure maturity or cell wall development. The ratio of cell wall thickness to fiber diameter indicates the degree of maturity. Premium micronaire readings range from 3.5 to 4.9 (10). Fiber length is measured by an air flow instrument. A fiber beard cross section partially blocks an orifice causing a pressure drop in relation to the cross section fiber amount (10). Non-lint material is determined as a percentage of sample weight. The fiber beard used for length test is also used for strength test in which the fibers extent the width of breaker jaws (10).

Arsenic Determination in Cotton Seed

Total arsenic concentrations in cotton seed for positions 1 and 2 at node 8 were determined for the untreated check and MSMA-late plots by chemical extraction followed by atomic adsorption spectroscopy[3]. Seed samples were collected from node eight because plant growth was approaching node eight when MSMA-late was applied and lint yield began a decline for these fruiting sites in 1991. Position 3 was not evaluated due to insufficient seed. Node 8 of the untreated check was included for treatment comparison.

Sample homogenation was achieved by placing cotton seed samples and

[3] Total arsenic concentrations in cotton seed were determined by Dr. Fred Claussen at the Bio-Analytical Services in Harristown, Illinois.

deionized water in separate cups. Samples were blended, then 1 g of each homogenized sample was weighed and oven dried over night. Samples were cooled and weighed again to determine homogenized sample water content. Samples were digested by concentrated nitric acid and a hot plate. Graphite furnace atomic absorption spectroscopy analysis was used to determine arsenic concentrations.

The following calculations were used:

a. $$\% \text{ Water} = \frac{\text{wet weight (g) - dry weight (g) x 100}}{\text{wet weight (g)}}$$

b. Corrected Analytical Sample Weight (g) =

Analytical Sample Weight (g) x (1 - decimal of % water)

c. Arsenic Concentration (ppm) =

$$\frac{\text{analytical result (ng/ml) / 1000 x total volume (ml)}}{\text{corrected analytical sample weight (g)}}$$

where total volume =

initial dilution volume (50 ml) x any subsequent dilution factors

d. Recovery (%) =

$$\frac{\text{spike As conc (ppm) - control As conc (ppm) x 100}}{\text{ppm added}}$$

Differences in arsenic concentrations between the MSMA-late and the untreated check at position one and two were determined by the one tailed T-test statistical method.

CHAPTER 3

RESULTS AND DISCUSSION

Plant Mapping at 5 WALT

Cotton plant internode length and plant height at 5 WALT was affected both years by MSMA POST when compared to the untreated check. (Table 5). MSMA decreased plant internode length by 0.5 to 1.0 cm both years and plant height by 11 to 12 cm in 1991. In 1992 only MSMA-late reduced plant height. DPX-PE350 generally did not adversely affect plant internode length or plant height.

Plant mapping by fruiting site at 5 WALT illustrates the influence of MSMA and DPX-PE350 in 1991 (Table 6). Monopodia squares were increased by MSMA-late, while bolls decreased. MSMA-early decreased blooms and bolls (Figure 2). The increase in squares and decrease in blooms and bolls reflected a delayed growth response caused by MSMA. DPX-PE350 did not affect monopodia fruiting structures when compared to the untreated check.

For sympodia at position one, MSMA-early increased squares and MSMA-late decreased bolls when compared to the untreated check in 1991. DPX-PE350 did not affect fruiting structures at sympodia position one (Figure 3). MSMA and DPX-PE350-late increased square production and decreased boll production for sympodia at

Table 5. Cotton internode length and height at 5 weeks after late treatment of POST MSMA and DPX-PE350 at Jackson, TN 1991 and Milan, TN 1992.

Tmt	Jackson '91 internode	Jackson '91 height	Milan '92 internode	Milan '92 height
	cm			
Untreated Check	5.0	73.0	6.0	106.0
MSMA early	4.0[b]	62.0	5.0	97.0
MSMA late	4.5	61.0	5.0	94.0
DPX-PE350 early	5.0	70.5	5.5	99.0
DPX-PE350 late	5.0	72.0	6.0	105.0
LSD[a]	0.5	6.0	0.5	11.0

[a] Fisher's least significant difference (LSD) is the observed difference between two sample means necessary to declare the corresponding population means different (P=0.05).

[b] Underlined numbers are different compared to the untreated check.

Table 6. Number of fruiting structures 5 weeks after late treatment as influenced by POST MSMA and DPX-PE350 at Jackson, TN in 1991.

Fruit site[a]	Untreated check	MSMA-early	MSMA-late	DPX350-early	DPX350-late	LSD[b] 0.05
	no. x 10^3 ha^{-1}					
M-SQ	91.7	70.3	186.4[c]	74.8	71.8	54.8
M-BL	11.3	1.7	3.6	5.4	3.9	8.3
M-BO	13.0	0.9	0.9	11.5	3.9	11.7
S1-SQ	49.2	66.8	60.6	54.3	63.0	14.8
S1-BL	9.2	15.7	4.8	7.6	6.3	NS
S1-BO	45.0	25.2	21.7	46.3	36.0	20.5
S2-SQ	49.8	66.9	61.7	53.4	61.7	10.7
S2-BL	10.9	8.4	2.7	5.0	4.2	5.8
S2-BO	22.5	4.4	2.7	18.0	11.5	9.6
S3-SQ	92.8	72.4	65.6	65.6	75.6	NS
S3-BL	2.2	1.0	0.4	2.3	0.7	NS
S3-BO	1.8	0	0	1.8	0	NS

[a] M-SQ, monopodia squares; M-BL, monopodia blooms; M-BO, monopodia bolls; S1-SQ, sympodia squares at position one; S1-BL, sympodia blooms at position one; S1-BO, sympodia bolls at position one; S2-SQ, sympodia squares at position two; S2-BL, sympodia blooms at position two; S2-BO, sympodia bolls at position two; S3-SQ, sympodia squares at position three; S3-BL, sympodia blooms at position three; S3-BO, sympodia bolls at position three.

[b] Fisher's least significant difference (LSD) is the observed difference between two sample means necessary to declare the corresponding population means different (P=0.05).

[c] Underlined numbers are different compared to the untreated check.

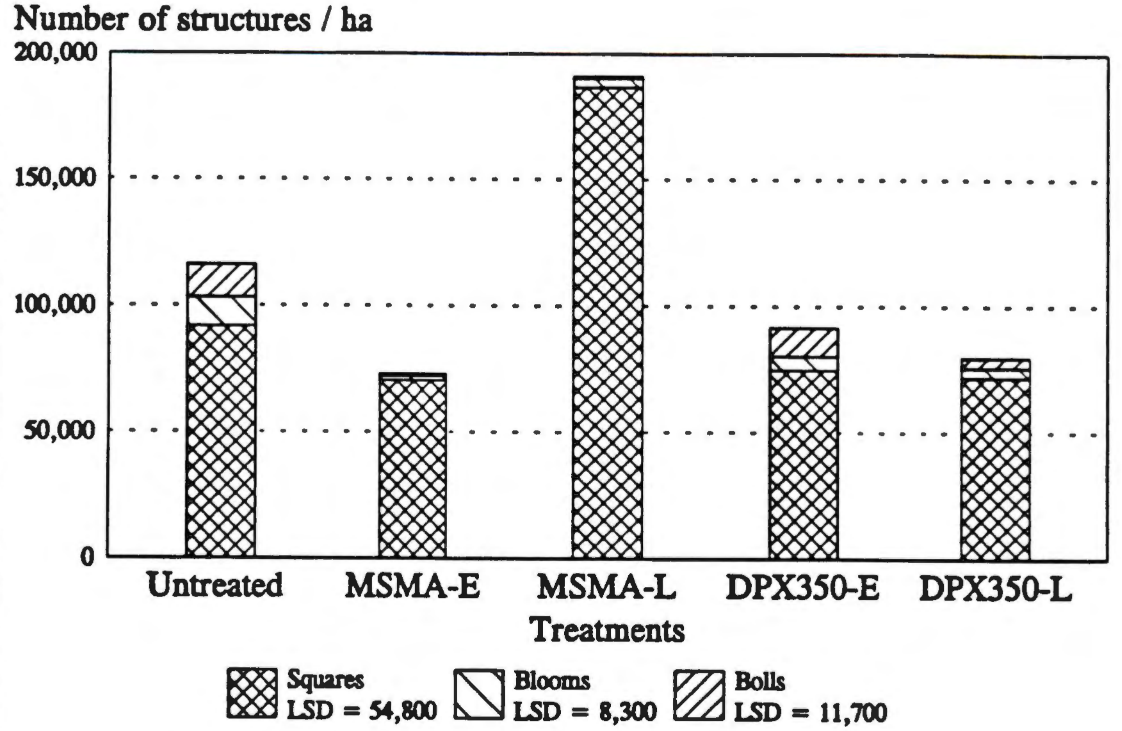

Figure 2. Squares, blooms and bolls at 5 weeks after late treatment on monopodia as influenced by POST MSMA and DPX-PE350 at Jackson, TN in 1991.

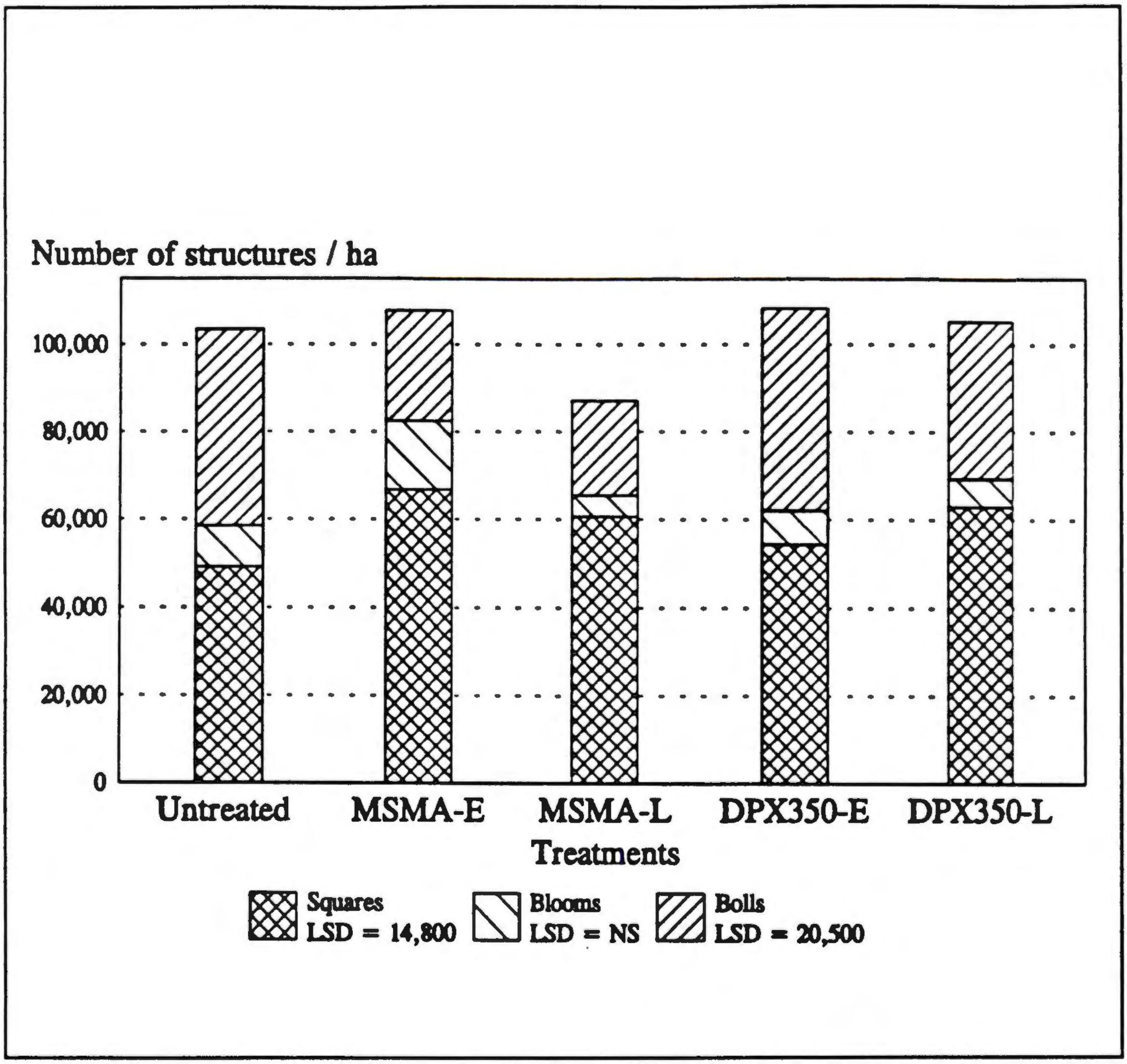

Figure 3. Squares, blooms and bolls on sympodia at position one, 5 weeks after late treatment as influenced by POST MSMA and DPX-PE350 at Jackson, TN in 1991.

position two (Figure 4). Therefore, DPX-PE350-late may be delaying growth. At sympodia position three, MSMA and DPX-PE350 did not adversely influence fruiting when compared to the untreated check (Figure 5).

Plant mapping at 5 WALT in 1992 illustrated trends similar to those established in 1991, but only MSMA-late caused an increase in squares on monopodia (Table 7).

Environmental conditions in 1992 could have provided a more favorable growing season for cotton than conditions in 1991. Adverse growing conditions in 1991 were influenced by extreme rainfall and low solar radiation during early season cotton development (Figure 6 and 7).

Plant Mapping at 12 WALT

Cotton plant mapping at 12 WALT in 1991 illustrate differences in plant height, opened bolls, closed bolls and number of sympodia for MSMA-late compared to the untreated check (Table 8). MSMA-late decreased plant height by 11 cm, decreased open boll count by three, increased closed boll count by 4 and decreased sympodia by three branches. DPX-PE350 generally did not affect plant development at 12 WALT. Therefore, trends in early season plant mapping suggest delayed growth may continue throughout the growing season. In 1992, there was no affect on plant characteristics at 12 WALT (Table 9).

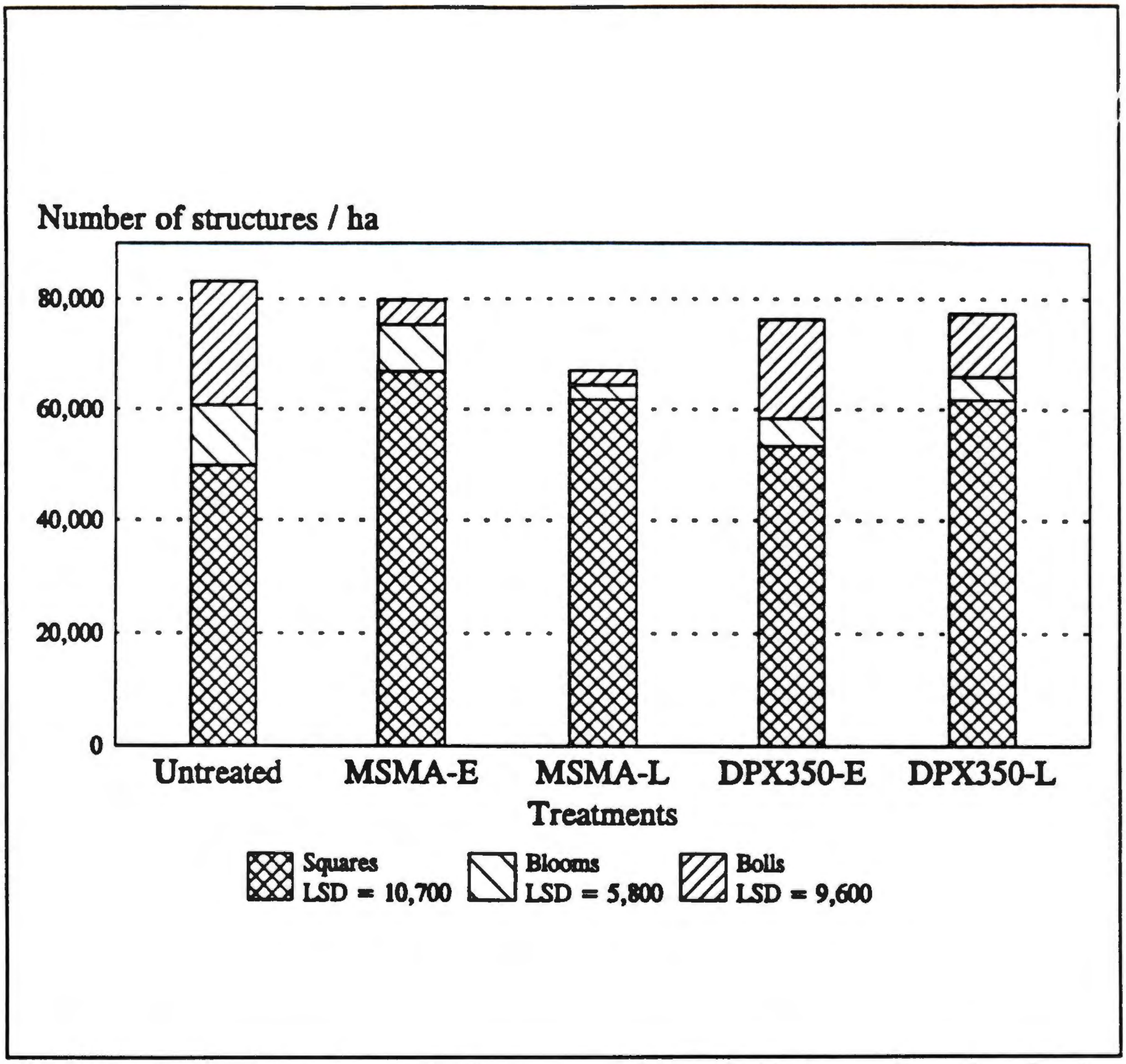

Figure 4. Squares, blooms and bolls on sympodia at position two, 5 weeks after late treatment as influenced by POST MSMA and DPX-PE350 at Jackson, TN in 1991.

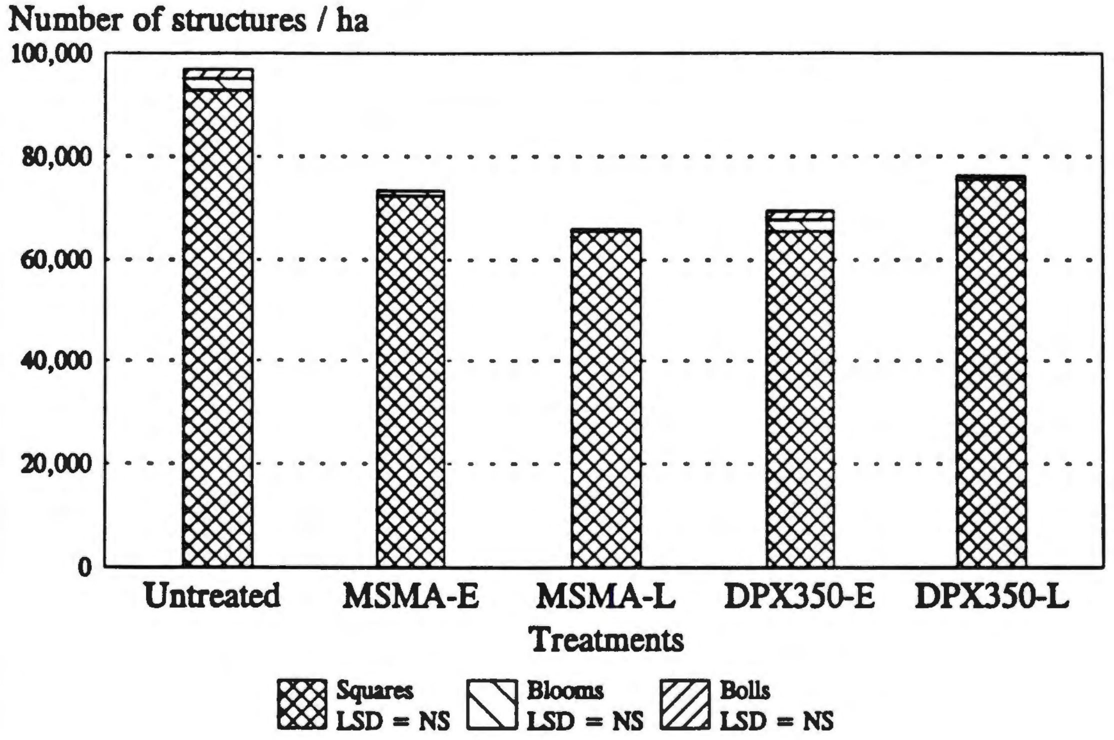

Figure 5. Squares, blooms and bolls on sympodia at position three, 5 weeks after late treatment as influenced by POST MSMA and DPX-PE350 at Jackson, TN in 1991.

Table 7. Number of fruiting structures at 5 weeks after late treatment as influenced by POST MSMA and DPX-PE350 at Milan, TN in 1992.

Fruiting site[a]	Untreated check	MSMA-early	MSMA-late	DPX350-early	DPX350-late	LSD[b] 0.05
	---------- no. x 10^3 ha^{-1} ----------					
M-SQ	50.0	73.7	127.8	31.7	39.9	59.9
M-BL	5.3	8.4	8.0	2.6	5.4	NS
M-BO	5.3	9.9	6.1	1.9	4.9	NS
S1-SQ	63.2	68.2	72.2	62.6	73.3	NS
S1-BL	11.0	11.8	12.1	10.6	8.7	NS
S1-BO	45.6	48.3	41.5	45.3	45.8	NS
S2-SQ	59.8	61.7	73.3	57.8	60.2	NS
S2-BL	8.0	12.5	11.0	9.8	6.8	NS
S2-BO	19.5	22.1	14.0	18.5	20.5	NS
S3-SQ	62.8	56.9	92.8	67.7	54.1	NS
S3-BL	3.0	3.4	1.5	4.9	4.9	NS
S3-BO	1.5	1.9	0.8	1.1	0	NS

[a] M-SQ, monopodia squares; M-BL, monopodia blooms; M-BO, monopodia bolls; S1-SQ, sympodia squares at position one; S1-BL, sympodia blooms at position one; S1-BO, sympodia bolls at position one; S2-SQ, sympodia squares at position two; S2-BL, sympodia blooms at position two; S2-BO, sympodia bolls at position two; S3-SQ, sympodia squares at position three; S3-BL, sympodia blooms at position three; S3-BO, sympodia bolls at position three.

[b] Fisher's least significant difference (LSD) is the observed difference between two sample means necessary to declare the corresponding population means different (P=0.05).

[c] Underlined numbers are different compared to the untreated check.

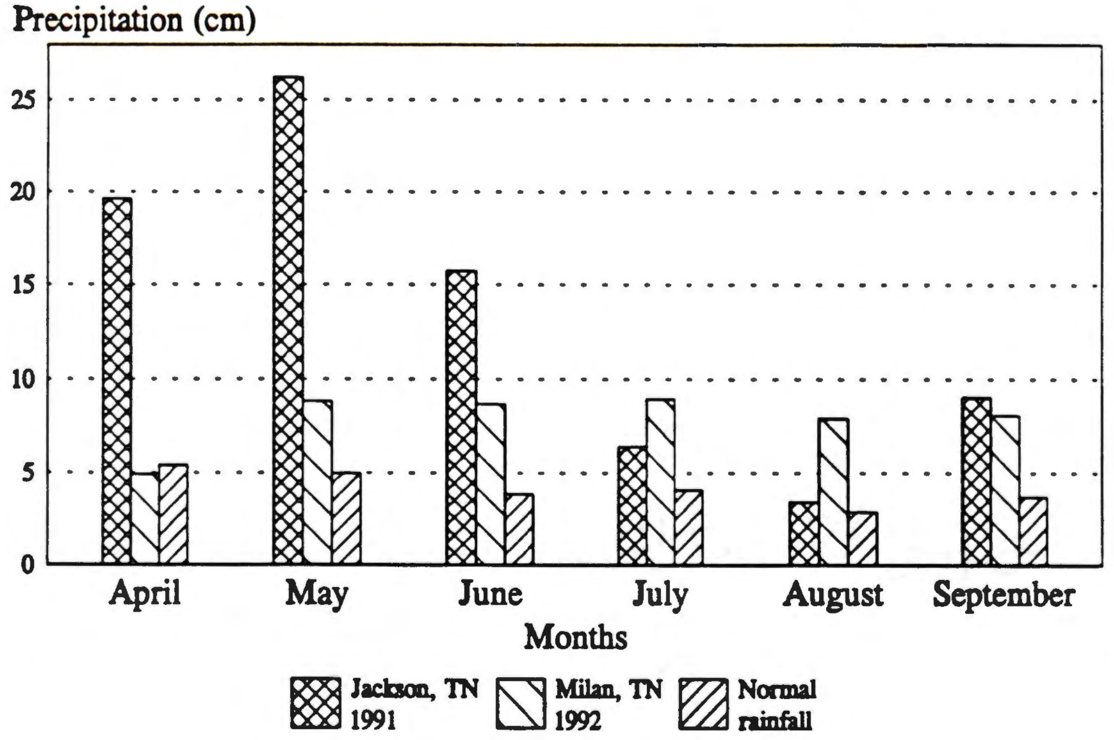

Figure 6. Precipitation at Jackson, TN in 1991 and Milan, TN in 1992.

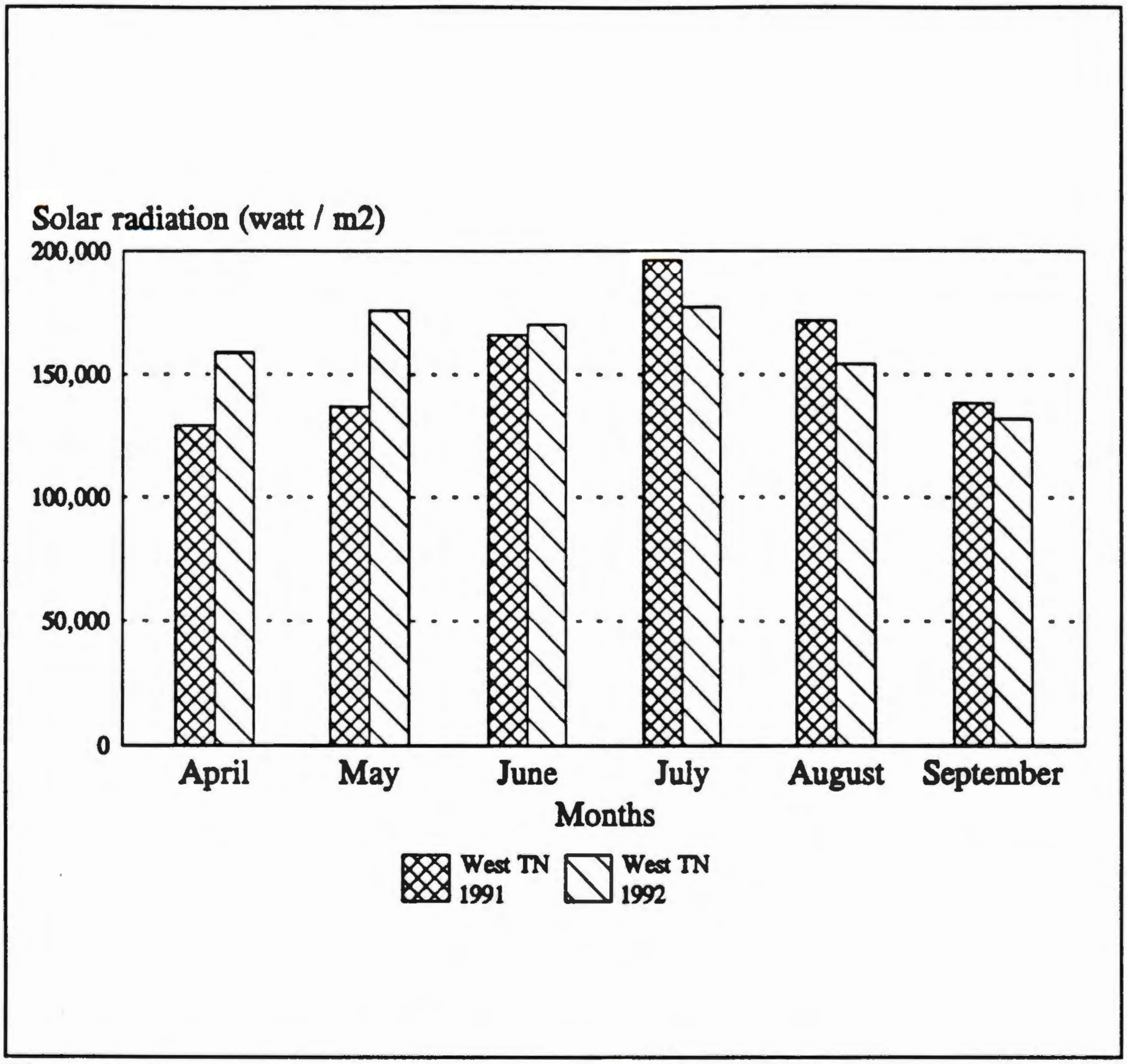

Figure 7. Solar radiation for West Tennessee in 1991 and 1992.

Table 8. Cotton plant mapping evaluations at 12 weeks after late treatment for plant height, opened and closed bolls, and number of fruiting nodes as influenced by POST MSMA and DPX-PE350 at Jackson, TN in 1991.

Treatment	Plant height	Sympodia branches	Opened bolls	Closed bolls
	cm	---------- no. per plant	----------	----------
Untreated check	80	13	7	3
MSMA-early	74	13	<u>5</u>	<u>6</u>
MSMA-late	<u>69</u>	<u>10</u>	<u>3</u>	<u>7</u>
DPX-PE350 early	81	<u>12</u>	8	3
DPX-PE350 late	80	13	7	4
LSD[a]	10	1	2	3

[a] Fisher's least significant difference (LSD) is the observed difference between two sample means necessary to declare the corresponding population means different (P=0.05).

[b] Underlined numbers are different than the untreated check.

Table 9. Cotton plant mapping evaluations at 12 weeks after last application for plant height, opened and closed bolls, and number of fruiting nodes as influenced by POST MSMA and DPX-PE350 at Milan, TN in 1992.

Treatment	Plant height	Sympodia branches	Opened bolls	Closed bolls
	cm	---------- no. per plant	----------	
Untreated check	115	16	4	9
MSMA-early	109	16	5	7
MSMA-late	102	15	4	10
DPX-PE350-early	111	15	5	8
DPX-PE350-late	114	15	5	9
LSD[a]	NS	NS	NS	NS

[a] Fisher's least significant difference (LSD) is the observed difference between two sample means necessary to declare the corresponding population means different (P=0.05).

Lint Yield from Plant Mapping

At Jackson 1991, lint yield at position one was decreased by MSMA for sympodium at node 7 through 13. The greatest difference occurred at node 11 where yield was 98 kg ha^{-1} less than the untreated check. DPX-PE350 was not different from the untreated check (Table 10). At position two MSMA-late decreased lint yield from the untreated check by >30 kg ha^{-1}. DPX-PE350 generally did not affect lint yield (Table 11). At position three in 1991, MSMA-late increased lint yield for sympodia at nodes 8 through 11. Lint yield for all sympodia was decreased with MSMA-late when compared to the untreated check. DPX-PE350 did not affect lint yield (Table 12). This indicates that MSMA-late could decrease early fruiting at positions one and two. Therefore, compensation for loss of early fruit may occur during later fruiting at position three (Figures 8,9 and 10). This compensation could be linked to the sequence of cotton fruiting. Fruiting begins at position one and continues through position three on each sympodium.

Plant mapping in 1992 indicated a decrease in total sympodia lint yield at position one for MSMA-late compared to the untreated check. DPX-PE350 did not affect lint yield (Table 13). MSMA and DPX-PE350 had no affect on lint yield at sympodia position two (Table 14). MSMA-early and DPX-PE350-early increased sympodia lint yield at position three (Table 15).

MSMA-late decreased sympodia lint yields for all positions by 570 kg ha^{-1} when compared to the untreated check in 1991 (Table 16). Lint yield for all sympodium was decreased due to reduced yielld at position one and two.

Table 10. Lint yields per node for sympodia at fruiting position one as influenced by POST MSMA and DPX-PE350 at Jackson, TN in 1991.

Plant node	Untreated check	MSMA-early	MSMA-late	DPX350-early	DPX350-late	LSD[a] 0.05
	------------	------------	kg ha^{-1}	------------	------------	------------
17	0	3	0	3	0	NS
16	3	3	0	4	0	NS
15	4	9	0	9	3	NS
14	20	20	0	13	14	NS
13	49	65	<u>0</u>[b]	35	31	37
12	87	69	<u>12</u>	74	65	42
11	118	105	<u>20</u>	107	90	54
10	130	84	<u>36</u>	88	128	51
9	125	100	<u>59</u>	136	137	40
8	156	<u>96</u>	<u>81</u>	139	156	33
7	119	102	<u>67</u>	133	140	33
6	75	98	44	<u>117</u>	<u>117</u>	42
5	22	20	26	36	34	NS
Total	908	774	<u>345</u>	894	906	175

[a] Fisher's least significant difference (LSD) is the observed difference between two sample means necessary to declare the corresponding population means different (P=0.05).

[b] Underlined numbers are different than the untreated check.

Table 11. Lint yields per node for sympodia at position two as influenced by POST MSMA and DPX-PE350 at Jackson, TN in 1991.

Plant node	Untreated check	MSMA-early	MSMA-late	DPX350-early	DPX350-late	LSD[a] 0.05
	kg ha^{-1}					
17	0	0	0	0	0	NS
16	0	0	0	0	0	NS
15	0	0	0	5	0	NS
14	0	1	0	1	0	NS
13	3	18	0	7	1	NS
12	6	19	0	7	10	NS
11	7	17	2	6	7	NS
10	30	27	4	38	33	NS
9	49	42	<u>7</u>[b]	30	49	33
8	84	57	<u>25</u>	64	79	56
7	69	70	45	86	53	NS
6	59	62	46	88	74	NS
5	11	25	23	41	19	NS
Total	318	338	<u>152</u>	373	325	155

[a] Fisher's least significant difference (LSD) is the observed difference between two sample means necessary to declare the corresponding population means different (P=0.05).

[b] Underlined numbers are different than the untreated check.

Table 12. Lint yields per node for sympodia at position three as influenced by POST MSMA and DPX-PE350 at Jackson, TN in 1991.

Plant node	Untreated check	MSMA-early	MSMA-late	DPX350-early	DPX350-late	LSD 0.05
	kg ha^{-1}					
17	0	0	0	0	0	NS
16	0	0	0	0	0	NS
15	0	0	0	0	0	NS
14	0	0	0	0	0	NS
13	0	0	0	0	0	NS
12	0	0	0	0	0	NS
11	0	0	17[b]	0	0	12
10	4	3	47	15	0	26
9	0	12	62	0	4	32
8	5	5	47	4	8	29
7	11	20	4	9	16	NS
6	40	17	30	11	15	NS
5	2	1	11	12	0	NS
Total	62	58	218	51	43	87

[a] Fisher's least significant difference (LSD) is the observed difference between two sample means necessary to declare the corresponding population means different (P=0.05).

[b] Underlined numbers are different than the untreated check.

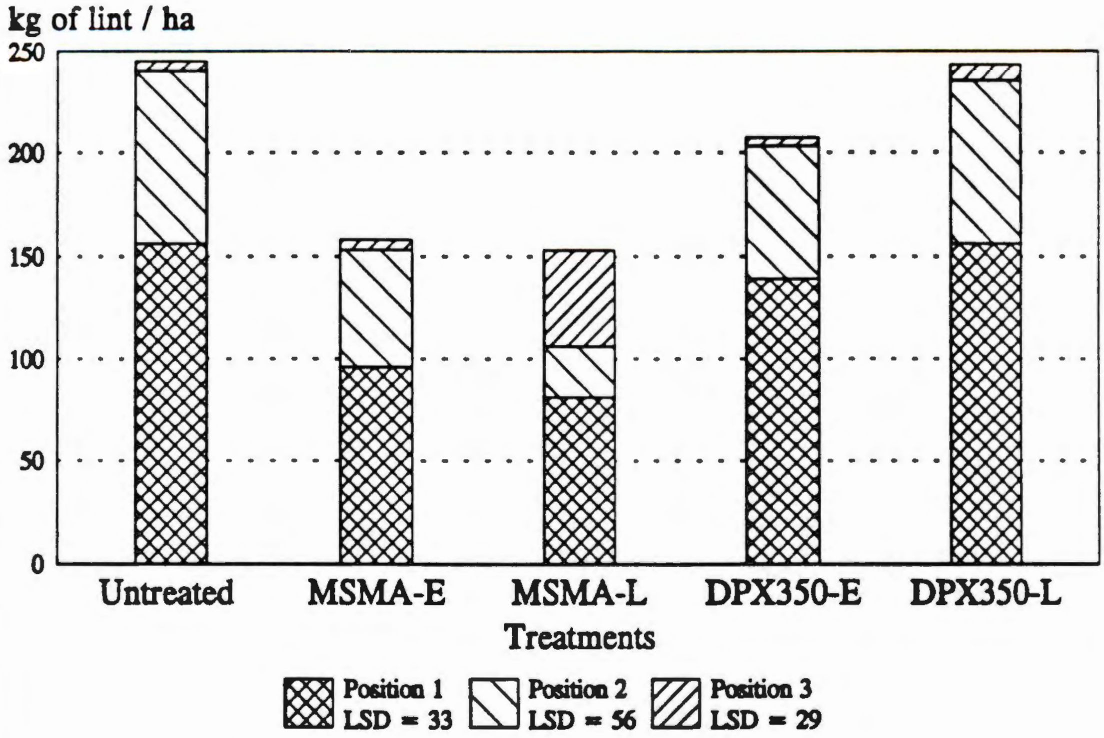

Figure 8. Lint yield from sympodium eight at position one, two and three as influenced by POST MSMA and DPX-PE350 at Jackson, TN in 1991.

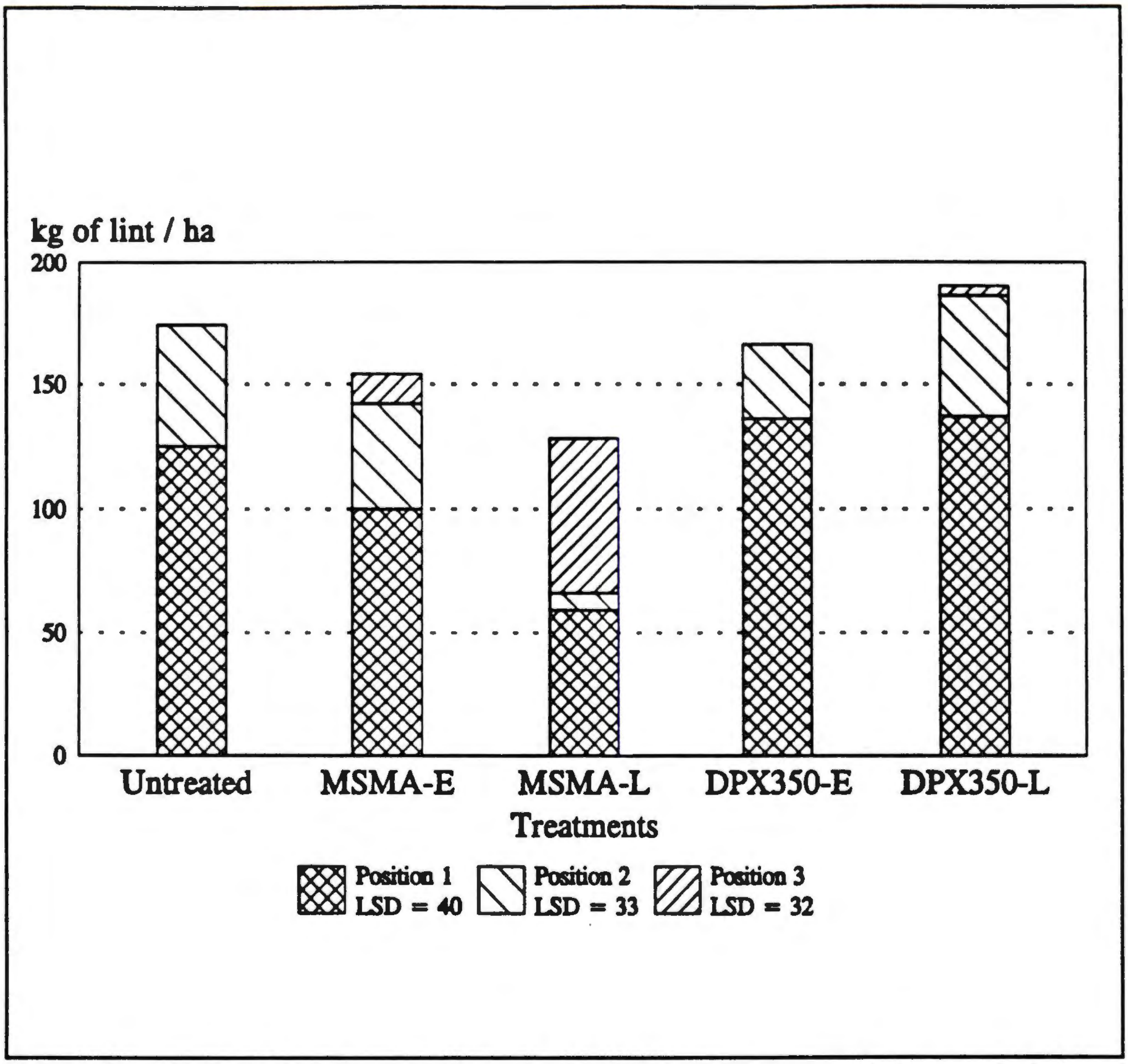

Figure 9. Lint yield from sympodium nine at position one, two and three as influenced by POST MSMA and DPX-PE350 at Jackson, TN in 1991.

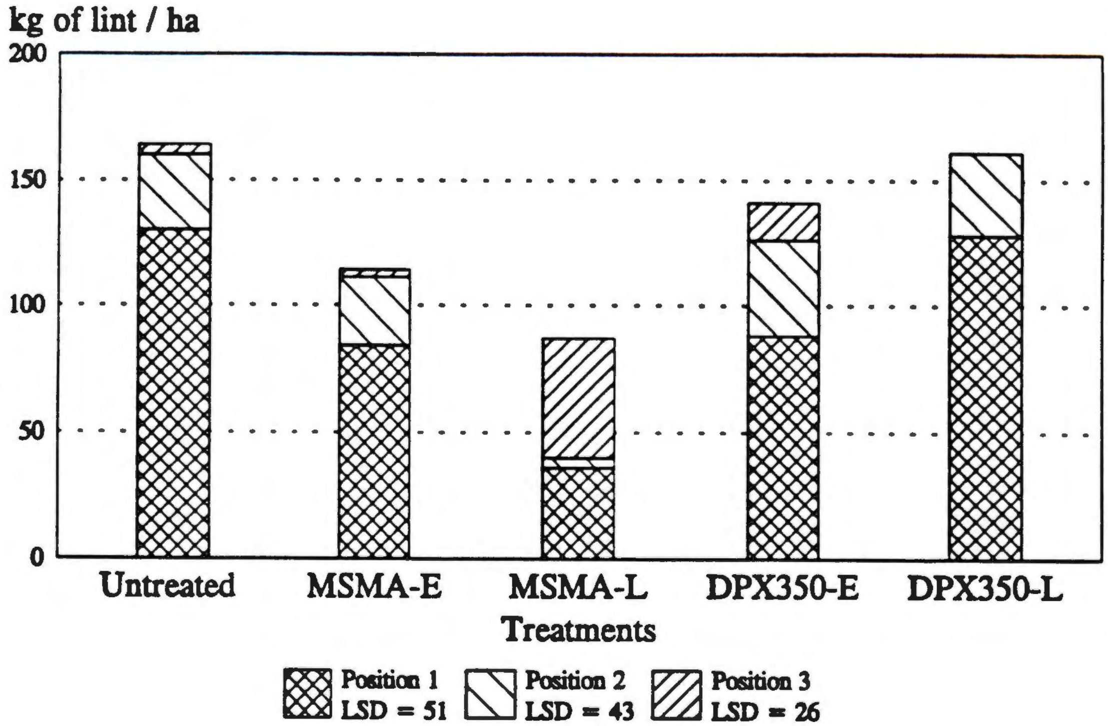

Figure 10. Lint yield from sympodium ten at position one, two and three as influenced by POST MSMA and DPX-PE350 at Jackson, TN in 1991.

Table 13. Lint yields per node for sympodia at fruiting position one as influenced by POST MSMA and DPX-PE350 at Milan, TN in 1992.

Plant node	Untreated check	MSMA-early	MSMA-late	DPX350-early	DPX350-late	LSD 0.05
	kg ha^{-1}					
17	10	11	12	26	9	NS
16	29	37	6	7	33	NS
15	64	31	30	26	61	NS
14	87	94	59	67	85	NS
13	89	130[b]	105	59	114	39
12	83	111	112	106	110	NS
11	115	139	93	120	135	NS
10	121	131	68	121	108	41
9	96	119	64	111	101	NS
8	109	86	54	102	114	NS
7	85	74	66	87	98	NS
6	65	35	8	35	65	45
5	5	0	0	5	11	NS
Total	958	998	677	872	1044	181

[a] Fisher's least significant difference (LSD) is the observed difference between two sample means necessary to declare the corresponding population means different (P=.05).

[b] Underlined numbers are different than the untreated check.

Table 14. Lint yields per node for sympodia at position two as influenced by POST MSMA and DPX-PE350 at Milan, TN in 1992.

Plant node	Untreated check	MSMA-early	MSMA-late	DPX350-early	DPX350-late	LSD[a] 0.05
	kg ha^{-1}					
17	1	4	0	0	0	NS
16	11	7	0	7	0	NS
15	14	8	0	14	6	NS
14	5	5	3	5	16	NS
13	18	17	9	34	26	NS
12	19	58	18	40	21	NS
11	49	67	28	75	18	NS
10	41	50	38	48	44	NS
9	53	73	53	81	48	NS
8	52	69	62	77	86	NS
7	63	64	54	47	41	NS
6	36	25	15	10	24	NS
5	3	0	0	12	8	NS
Total	365	447	280	450	338	NS

[a] Fisher's least significant difference (LSD) is the observed difference between two sample means necessary to declare the corresponding population means different (P=0.05).

Table 15. Lint yields per node for sympodia at position three as influenced by POST MSMA and DPX-PE350 at Milan, TN in 1992.

Plant node	Untreated check	MSMA-early	MSMA-late	DPX350-early	DPX350-late	LSD[a] 0.05
	kg ha^{-1}					
17	1	0	0	0	0	NS
16	1	0	0	0	0	NS
15	0	0	0	0	1	NS
14	1	4	0	3	0	NS
13	0	0	0	30	0	NS
12	0	<u>14</u>[b]	0	0	4	12
11	2	5	9	10	0	NS
10	0	19	4	24	0	NS
9	0	<u>32</u>	13	11	7	27
8	4	46	27	19	1	NS
7	8	11	6	14	2	NS
6	3	19	0	10	0	17
5	0	0	0	1	0	NS
Total	20	<u>150</u>	59	<u>126</u>	15	105

[a] Fisher's least significant difference (LSD) is the observed difference between two sample means necessary to declare the corresponding population means different (P=0.05).

[b] Underlined numbers are different than the untreated check.

Table 16. Plant mapping lint yield for sympodia at all positions as influenced by POST MSMA and DPX-PE350 at Jackson, TN 1991 and Milan, TN 1992.

Treatments	Jackson, TN 1991	Milan, TN 1992
	------------------------------ kg ha^{-1}	------------------------------
Untreated check	1290	1350
MSMA-early	1180	1600
MSMA-late	720[b]	1020
DPX-PE350-early	1330	1460
DPX-PE350-late	1290	1400
LSD[a]	270	NS

[a] Fisher's least significant difference (LSD) is the observed difference between two sample means necessary to declare the corresponding population means different (P=0.05)

[b] Underlined numbers are different than the untreated check.

DPX-PE350 did not adversely affect plant lint yield.

MSMA-late decreased monopodia plus sympodia lint yield by 530 kg ha^{-1} when compared to the untreated check in 1991 (Table 17). DPX-PE350 did not affect monopodia plus sympodia lint yield.

In 1992, MSMA and DPX-PE350 did not affect sympodia or monopodia plus sympodia lint yield when compared to the untreated check (Table 16 and 17).

Lint Yield from Machine Harvest

Lint yields from spindle picking indicate a trend similar to plant mapping lint yields in both years. MSMA-late decreased first harvest lint yield by 470 kg ha^{-1} compared to the untreated check in 1991 (Table 18). At second harvest in 1991, MSMA increased lint yield compared to check. However, a total lint yield decrease of >250 kg ha^{-1} was caused by MSMA-late. DPX-PE350 did not affect lint yield in 1991.

In 1992, lint yield did not differ among treatments (Table 18).

Fiber Properties

Cotton quality was determined by high volume instrument (HVI) system measurements of fiber properties. At Jackson 1991 and Milan 1992, micronaire was increased by MSMA-late compared to the untreated check (Table 19). Higher

Table 17. Plant mapping harvest lint yields for monopodia and sympodia at all positions as influenced by POST MSMA and DPX-PE350 at Jackson, TN 1991 and Milan, TN 1992.

Treatments	Jackson, TN 1991	Milan, TN 1992
	---------- $kg\ ha^{-1}$ ----------	
Untreated check	1591	1527
MSMA-early	1422	1868
MSMA-late	1062[b]	1287
DPX-PE350-early	1611	1596
DPX-PE350-late	1499	1552
LSD[a]	341	NS

[a] Fisher's least significant difference (LSD) is the observed difference between two sample means necessary to declare the corresponding population means different (P=0.05).

[b] Underlined numbers are different than the untreated check.

Table 18. Mechanical harvest lint yields as influenced by POST MSMA and DPX-PE350 at Jackson, TN 1991 and Milan, TN 1992.

	Jackson, TN 1991			Milan, TN 1992		
Treatment	First harvest	Second harvest	Total harvest	First harvest	Second harvest	Total harvest
	kg ha^{-1}					
Untreated check	920	200	1120	1290	320	1610
MSMA-Early	690	<u>310</u>[b]	1000	1270	300	1570
MSMA-late	<u>450</u>	<u>420</u>	<u>870</u>	1140	390	1530
DPX-PE350-early	920	200	1120	1420	230	1650
DPX-PE350-late	900	270	1170	1400	300	1700
LSD[a]	250	100	200	NS	NS	NS

[a] Fisher's least significant difference (LSD) is the observed difference between two sample means necessary to declare the corresponding population means different (P=0.05).

[b] Underlined numbers are different than the untreated check.

Table 19. Fiber properties determined by a high volume instrument (HVI) for cotton treated with POST MSMA and DPX-PE350 at Jackson, TN 1991 and Milan, TN 1992.

	Jackson, TN 1991				Milan, TN 1992			
Treatment	Micro-naire	Strength	Length	Trash	Micro-naire	Strength	Length	Trash
	index	g tex^{-1}	cm	%	index	g tex^{-1}	cm	%
Untreated check	4.4	27	2.75	0.60	3.7	28	2.95	2.55
MSMA-early	4.5	29	2.80	0.45	3.5	28	2.92	2.45
MSMA-late	5.0[b]	27	2.77	0.55	4.0	28	2.95	2.60
DPX-PE350 early	4.6	27	2.77	0.45	3.8	28	2.97	3.00
DPX-PE350 late	4.6	27	2.77	0.30	3.7	28	2.95	3.00
LSD[a]	0.5	NS	NS	NS	0.3	NS	NS	NS

[a] Fisher's least significant difference (LSD) is the observed difference between two sample means necessary to declare the corresponding population means different (P=0.05).

[b] Underlined numbers are different than the untreated check.

micronaire values indicate coarse fiber. DPX-PE350 did not affect micronaire at either location. In 1991, MSMA increased the micronaire index compared to the untreated check and the index was outside the premium range therefore, subject to discount. In 1992, micronaire was higher for MSMA-late than the untreated check, but still within premium range. Fiber length and percent trash were not affected by treatment either year (Table 19).

Fruiting Site Arsenic Concentration

MSMA-late and untreated check total arsenic concentration was determined for sympodia at position one and two in Jackson 1991 (Table 20). A one tailed-T test statistical procedure indicated that MSMA-late increased arsenic concentration at position one and two compared to the untreated check, while the greatest increase was at position two (Figure 11). The increase at position two suggests that arsenic movement in the plant could follow a source to sink relationship. Therefore, MSMA-late increased total cotton seed arsenic concentration which could partially explain slow plant development resulting in decreased yield.

There are suggested differences in tolerance to arsenic among species. However, the maximum tolerable dietary levels are set at 50 ppm for organic forms of arsenic for domestic animals (12). The highest arsenic concentration found in cotton seed at Jackson, TN in 1991 was 2.20 ppm which lower than the maximum tolerance level.

Table 20. Total arsenic determination in cotton seed for sympodia at node 8 at position one and position two as influenced by POST MSMA at 2.24 kg ai ha^{-1} to 45 to 55 cm (late) cotton at Jackson, TN 1991.

Treatments	Position	Wet weight	Dish+ dry weight	Water	Analyt sample weight	Analyt result	Total volume	Arsenic conc
Untreated	1	g	g	%	g	ng/ml	ml	ppm
Untreated	2	1.01	1.28	72.3	0.29	2.00	50	0.35
Untreated	1	0.96	1.20	79.2	0.20	2.30	50	0.57
Untreated	2	1.06	1.26	75.5	0.24	2.60	50	0.54
Untreated	1	1.00	1.24	76.0	0.25	2.60	50	0.53
Untreated	2	1.04	1.30	71.2	0.29	2.10	50	0.36
Untreated	1	1.00	1.18	82.0	0.18	2.10	50	0.57
Untreated	2	1.01	1.28	71.3	0.29	2.50	50	0.44
MSMA-late	1	1.06	1.28	72.6	0.29	5.40	50	0.93
MSMA-late	2	1.02	1.20	80.4	0.20	4.20	50	1.05
MSMA-late	1	1.08	1.31	71.3	0.30	6.60	50	1.08
MSMA-late	2	1.04	1.16	84.6	0.16	6.30	50	2.03
MSMA-late	1	1.05	1.23	78.1	0.22	6.70	50	1.53
MSMA-late	2	1.03	1.11	89.3	0.11	4.60	50	2.05
MSMA-late	1	1.03	1.17	82.5	0.18	5.60	50	1.56
MSMA-late	2	1.05	1.19	82.9	0.17	7.30	50	2.20

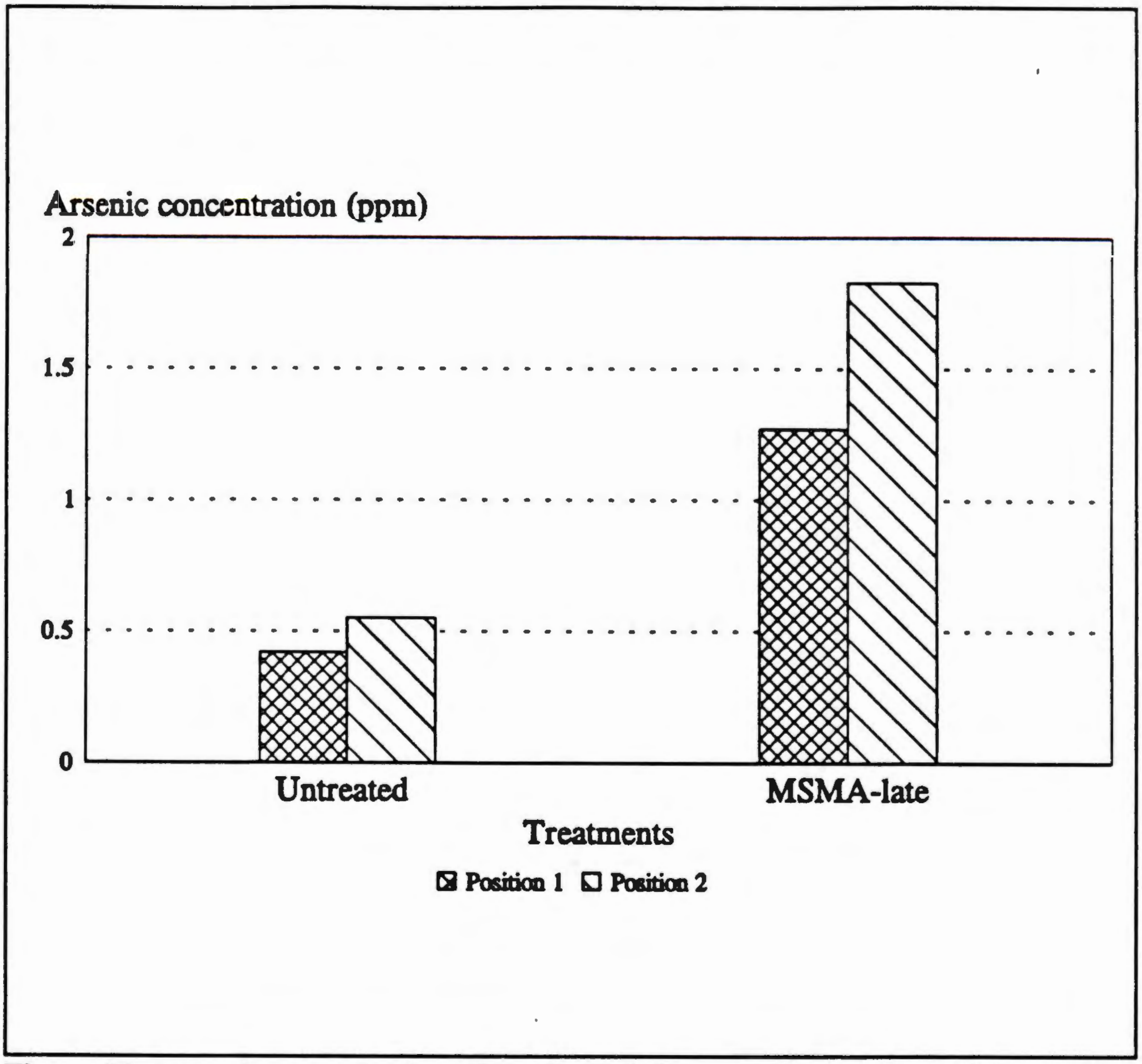

Figure 11. Arsenic concentration of cotton seed for sympodium at node 8 for position one and two as influenced by MSMA-late compared to the untreated check at Jackson, TN in 1991.

CHAPTER 4

GENERAL SUMMARY

Conclusion

The objective of this research was to elucidate cotton plant response to POST DPX-PE350 and MSMA at different growth stages under Tennessee growing conditions. Therefore, research involved the effects of MSMA and DPX-PE350 on cotton development, yield and quality and cotton seed arsenic accumulation at different fruiting sites.

Results from experiments indicated that DPX-PE350 generally does not adversely affect development, yield and quality of cotton. However, DPX-PE350-late applied to 45 to 55 cm cotton increased square production and decreased boll production for sympodia position two in 1991, which could cause a delayed growth response under adverse growing conditions.

MSMA did affect the development, yield and quality of cotton. Cotton plant internode length and height was reduced at 5 weeks after last application by MSMA for both years. However, only MSMA-late applied to 45 to 50 cm cotton decreased plant height in 1992. MSMA generally increased square production and decreased bloom and boll production for monopodium and sympodium position one and two which suggested a delay in plant development. However, the delayed plant development response was more pronounced for MSMA-late and was still prevalent in the late season. At 12 WALT in 1991 MSMA-late decreased plant height, number of fruiting nodes and number of opened bolls, while increasing the number of unopened bolls. The trend of delayed plant development caused by MSMA-late in 1991 was similar in 1992, but no difference was observed compared to the untreated check which was probably a result of more favorable growing conditions.

Lint yields from plant mapping and mechanical harvests were decreased by MSMA-late in 1991 but not in 1992. The decrease could be a result of delayed plant development encouraged by MSMA and adverse growing conditions. The fiber properties: length, strength and % trash were not different among treatments but, micronaire was increased by MSMA-late in both years.

MSMA-late increased the arsenic concentration in cotton seed for sympodia at position one and two and position two contained the highest amount. Therefore, arsenic movement in the plant may follow a source to sink relationship.

Therefore, the results of these experiments illustrate cotton tolerance to a high rate of DPX-PE350 at different timings which makes this herbicide an alternative to MSMA for POST broadleaf weed control. However, late applications of DPX-PE350 may cause a delay in plant development under adverse growing conditions.

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VITA

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