COMPARATIVE FIELD AND GREENHOUSE STUDIES OF TFLURALIN AND PENDIMETHALIN ON COTTON GROWTH, DEVELOPMENT, AND NUTRIENT UPTAKE

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Abstract

Lateral roots are essential to young cotton [*Gossypium hirsutum* (L.)] plants for acquisition of water and nutrients. Lateral root development in the surface soil could be critical for survival of young cotton plants in semi-arid environmental conditions. On the Texas High Plains, where evaporative demand is fairly high, the more root surface area a seedling has, the greater its water absorbing capability and the less chance for growth-reducing tissue water stress to occur. Herbicides, such as trifluralin, 2,6-dinitro-N, N-dipropyl 4(Trifluoromethyl) benzen- amine and pendimethalin, N- (1-ethylpropyl)-3,4-dimethyl-2, 6 dinitrobezeneamine are commonly used to control the weeds in cotton fields. The objectives of this research were to compare the effects of pendimethalin and trifluralin on depth to first lateral root, phosphorus concentration, and lint yield of cotton under different environmental conditions. Four rates of each herbicide were used, and treatments were replicated four times. Application of trifluralin increased depth to first lateral in some treatments relative to pendimethalin. In no instances within the conditions of this study was there a significant effect of herbicide source at any rate on phosphorus concentration or final lint yield.

Introduction

Incorporation of preplant applied herbicides is an effective form of weed control. Dinitroaniline herbicides reduce roots in responsive species of plants and cause swelling of root tips (Appleby and Valverde, 1988). Jordan et al. (1977) reported that trifluralin and pendimethalin except at low rates of pendimethalin significantly reduced the numbers of lateral roots produced by cotton seedlings. However, the value of this effect is not always apparent in final yield analysis. The presence of a normal, healthy complement of lateral roots on a young cotton plant has the potential to benefit early season plant growth and development, which could impact final productivity in some environments. In semi-arid environments, the more root surface area the seedling has, the greater its water absorbing capacity and less its chance for water stress. Nutrients such as zinc and phosphorus are usually concentrated in the top six inches of the soil profile. Lateral root development in this zone could be critical for acquisition of sufficient amounts of these minerals for maximum growth. Furthermore, soil applied systemic insecticides and fungicides that have relatively low water solubility are very dependent upon the presence of sufficient numbers of lateral roots in the topsoil for absorption of sufficient quantities of material for insect and disease control. From a physiological perspective, the number of root tips is directly related to the production of hormones, which determine rates of cell division and differentiation in the shoot meristems. Effects on lateral root growth and development could alter the rate of mainstem node production and associated leaf number and size. All of these conditions could affect the rate of development and even the survival of young cotton seedlings, which could effect potential yield.

Objectives

The objectives of this research were to compare the effects of pendimethalin and trifluralin on depth to first lateral root, phosphorus concentration, and lint yield of cotton under different environmental conditions.

Materials and Methods

1996 Irrigated Field Study

Field plots were established at the Texas Tech University Crop Production Research Center near Brownfield, Texas. HS-26 cotton was planted in plots that were 15-m long and 3.26-m (four rows) wide at 148,148 seeds/ha. Treatments were replicated four times in a randomized design. Trifluralin and pendimethalin were applied at 0.0, 0.63, 0.84, and 1.23-kg ai/ha on an Amarillo loamy fine sand (Fine-loamy, mixed, thermic Aridic Paleustalfs) and were incorporated with a bed leveler and listing of the rows. Irrigation was accomplished with a linear Trimatic. Data for depth to first lateral root were taken on day 28 after planting. Three plants were sampled to determine depth to first lateral root. To sample the roots, a spade was used to slice down into the soil and the plant and roots were removed. The soil was gently brushed away and depth to first lateral root was recorded. The plant samples were then dried at 55ºC. After drying, the samples were then ground to 1mm. A one-gram sample was digested with a mixture of nitric, perchloric, and sulfuric acids (5:2:1) for 2 hours at 300 ºC. Following digestion, the samples were diluted to 50 mL with deionized water. The resultant solution was analyzed for phosphorous colormetrically. Analyses of variance were done using the GLM procedure in SAS (SAS Institute, Inc., 1989). Yield data are not available for the 1996 field study due to hail damage.

1997 Irrigated and 1997 Dryland Field Studies

The 1997 irrigated and 1997 dryland experiments were setup as described previously with the following differences. The plots were 15-m long by 4.89-m (six rows) wide. The herbicides were incorporated with a double stalk-

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cutter and followed by listing of the rows. Paymaster HS-26 Roundup cotton was planted at 148,148 seeds/ha. Irrigation for the 1997 irrigated study was accomplished with a drip system.

Amarillo and Pullman Soils Greenhouse Studies

Surface samples (0-15-cm) of two soils were collected, allowed to air dry, and used for the greenhouse experiments. The two soils collected were an Amarillo loamy find sand and a Pullman clay loam (Fine, mixed, thermic Torrertic Paleustolls). These two soils are representative of the soils used for cotton production on the Southern High Plains of Texas. Plastic buckets (19.8-L) were used for soil containers. Each bucket was filled with the appropriate soil. The recommended rates of trifluralin and pendimethalin for the Amarillo and Pullman soils were 0.84-kg ai/ha and 1.12-kg ai/ha respectfully. Pendimethalin and trifluralin were applied at four rates: 0.0, 0.63, 0.84, and 1.26-kg/ha in the Amarillo soil and 0.0, 0.84, 1.12, and 1.67-kg ai/ha in the Pullman soil. To approximate the effects of incorporation depth, 5-cm of soil was removed from each bucket. Each soil sample was place in a cement mixer, and then the appropriate herbicide solution was applied. Following mixing, each soil was returned to its bucket. The buckets were placed randomly on carts in the greenhouse. Two cottonseeds were planted to a depth of 1.5-cm, and a nutrient solution was added to ensure growth. The plants received water as needed to keep the soil at field capacity, which required irrigating every 2 to 3 days. Approximately, 1-L of water was used when irrigation was needed. The carts were moved in a circular motion twice a week to minimize the effects of temperature and light variance in the greenhouse. One of the two plants was sampled at the third leaf stage and the other at the eight leaf stage (day 28) to determine depth to first lateral root. To sample the roots, a trowel was used to slide down into the soil and the plant, roots, and soil were removed. The soil was gently brushed away, and the depth to first lateral root from soil surface was recorded. Phosphorus concentration was not determined.

Results and Discussions

The growing environments included in this study represent a diverse set of conditions for comparative studies of trifluralin and pendimethalin. These conditions include irrigated and dryland field studies. Furthermore, the greenhouse studies included two soils that are quite different from each other but represent soils commonly used for cotton production on the Southern High Plains of Texas.

The effect of herbicide source and rate on depth to first lateral root within each environment is shown in Table1. Trifluralin significantly increased depth to first lateral root in the 1996 irrigated study at the 1.0x rate. Trifluralin significantly increased depth to first lateral root in the 1997 irrigated study at the 1.5x rate. Trifluralin significantly increased depth to first lateral root in the 1997 dryland study at the 1.0x and 1.5x rates. Trifluralin significantly increased depth to first lateral root in the Amarillo soil greenhouse study for all rates, and trifluralin significantly increased depth to first lateral root in the Pullman soil greenhouse study at the 1.5x rate. The effect of herbicide source and rate averaged over all environments on depth to first lateral root is shown in Table 2. Trifluralin significantly increased depth to first lateral root at the 1.0x and 1.5x rates.

The effect of herbicide source and rate on phosphorus concentration within each environment is shown in Table 3. No significant differences due to herbicide source at any rate were detected for phosphorus concentration in cotton plants. The effect of herbicide source and rate averaged over all environments on phosphorus concentration is shown in Table 4. No significant differences due to herbicide source at any rate were detected for phosphorus concentration. Therefore, even though the depth to first lateral root was sometimes increased by application of trifluralin, that effect did not influence concentration of phosphorus in cotton.

The effect of herbicide source and rate within each environment on yield is shown in Table 5. Due to hail damage, yield data for the 1996 season are not available. No significant differences due to herbicide source at any rate were detected for yield. The effect of herbicide source and rate averaged over all environments on yield is shown in Table 6. No significant differences due to herbicide source at any rate were detected.

Summary

Application of trifluralin increased depth to first lateral root in some treatments in each environment in this study. In no instances within the conditions of this study was there a significant effect of herbicide source at any rate on phosphorus concentration or final lint yield.

Table 1. Effect of herbicide source and rate on depth to first lateral root under different environments.

Env	Rate	Source	Depth to first lateral root
			----mm----
96 Irrigated	0.0	Control	46
96 Irrigated	0.75x	Pendimethalin	42
96 Irrigated	0.75x	Trifluralin	50
96 Irrigated	1.0x	Pendimethalin	40
96 Irrigated	1.0x	Trifluralin	52*
96 Irrigated	1.5x	Pendimethalin	43
96 Irrigated	1.5x	Trifluralin	51
97 Irrigated	0.0	Control	46
97 Irrigated	0.75x	Pendimethalin	49
97 Irrigated	0.75x	Trifluralin	55
97 Irrigated	1.0x	Pendimethalin	49
97 Irrigated	1.0x	Trifluralin	69
97 Irrigated	1.5x	Pendimethalin	57
97 Irrigated	1.5x	Trifluralin	88*
97 Dryland	0.0	Control	43
97 Dryland	0.75x	Pendimethalin	47
97 Dryland	0.75x	Trifluralin	52
97 Dryland	1.0x	Pendimethalin	43
97 Dryland	1.0x	Trifluralin	66*
97 Dryland	1.5x	Pendimethalin	55
97 Dryland	1.5x	Trifluralin	86*
Amarillo-GH[1]	0.0	Control	10
Amarillo-GH[1]	0.75x	Pendimethalin	10
Amarillo-GH[1]	0.75x	Trifluralin	25*
Amarillo-GH[1]	1.0x	Pendimethalin	13
Amarillo-GH[1]	1.0x	Trifluralin	43*
Amarillo-GH[1]	1.5x	Pendimethalin	15
Amarillo-GH[1]	1.5x	Trifluralin	46*
Pullman-GH[1]	0.0	Control	15
Pullman-GH[1]	0.75x	Pendimethalin	23
Pullman-GH[1]	0.75x	Trifluralin	26
Pullman-GH[1]	1.0x	Pendimethalin	21
Pullman-GH[1]	1.0x	Trifluralin	35
Pullman-GH[1]	1.5x	Pendimethalin	28
Pullman-GH[1]	1.5x	Trifluralin	38*

*Means within environment and rate are significantly different (P < 0.05).

[1.] Amarillo-GH= Amarillo soil greenhouse study, Pullman-GH= Pullman soil greenhouse study.

Table 2. Effect of herbicide source and rate on depth to first lateral root averaged over all environments.

Rate	Source	Depth to first lateral root
		----mm----
0.0	Control	25
0.75x	Pendimethalin	26
0.75x	Trifluralin	28
1.0x	Pendimethalin	25
1.0x	Trifluralin	33*
1.5x	Pendimethalin	28
1.5x	Trifluralin	41*

*Means within rate are significantly different (P < 0.05).

Table 3. Effect of herbicide source and rate on phosphorus concentration under different environments.

Env	Rate	Source	Phosphorus
			-----%-----
96 Irrigated	0.0x	Control	0.37
96 Irrigated	0.75x	Pendimethalin	0.39
96 Irrigated	0.75x	Trifluralin	0.34
96 Irrigated	1.0x	Pendimethalin	0.40
96 Irrigated	1.0x	Trifluralin	0.37
96 Irrigated	1.5x	Pendimethalin	0.39
96 Irrigated	1.5x	Trifluralin	0.39
97 Irrigated	0.0x	Control	0.42
97 Irrigated	0.75x	Pendimethalin	0.43
97 Irrigated	0.75x	Trifluralin	0.42
97 Irrigated	1.0x	Pendimethalin	0.42
97 Irrigated	1.0x	Trifluralin	0.44
97 Irrigated	1.5x	Pendimethalin	0.44
97 Irrigated	1.5x	Trifluralin	0.40
97 Dryland	0.0x	Control	0.43
97 Dryland	0.75x	Pendimethalin	0.44
97 Dryland	0.75x	Trifluralin	0.41
97 Dryland	1.0x	Pendimethalin	0.45
97 Dryland	1.0x	Trifluralin	0.42
97 Dryland	1.5x	Pendimethalin	0.42
97 Dryland	1.5x	Trifluralin	0.41

*Means within environment and rate are significantly different (P < 0.05).

Table 4. Effect of herbicide source and rate on phosphorus concentration averaged over all environments.

Rate	Source	Phosphorus
		--------%--------
0.0x	Control	0.44
0.75x	Pendimethalin	0.46
0.75x	Trifluralin	0.45
1.0x	Pendimethalin	0.45
1.0x	Trifluralin	0.44
1.5x	Pendimethalin	0.45
1.5x	Trifluralin	0.43

*Means within rate are significantly different (P < 0.05).

Table 5. Effect of herbicide source and rate on yield under different environments.

Env	Rate	Source	Yield
			-----kg/ha-----
97 Irrigated	0.0x	Control	828
97 Irrigated	0.75x	Pendimethalin	861
97 Irrigated	0.75x	Trifluralin	911
97 Irrigated	1.0x	Pendimethalin	846
97 Irrigated	1.0x	Trifluralin	1026
97 Irrigated	1.5x	Pendimethalin	824
97 Irrigated	1.5x	Trifluralin	814
97 Dryland	0.0	Control	584
97 Dryland	0.75x	Pendimethalin	629
97 Dryland	0.75x	Trifluralin	625
97 Dryland	1.0x	Pendimethalin	587
97 Dryland	1.0x	Trifluralin	614
97 Dryland	1.5x	Pendimethalin	726
97 Dryland	1.5x	Trifluralin	678

*Means within environment and rate are significantly different (P < 0.05).

Table 6. Effect of herbicide source and rate yield averaged over all environments.

Rate	Source	Yield
		-----------kg/ha-----------
0.0x	Control	529
0.75x	Pendimethalin	559
0.75x	Trifluralin	576
1.0x	Pendimethalin	538
1.0x	Trifluralin	615
1.5x	Pendimethalin	582
1.5x	Trifluralin	559

*Means within rate are significantly different (P < 0.05).

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References

Appleby, A.P. and B. E. Valverdae. 1988 Behavior of dinitroaniline herbicides in plants. Weed Technology 3:198-206.

Jordan, T. N., R. S. Baker, and W. L. Barrentine. 1977. Comparative toxicity of several dinitroaniline herbicides. Weed Science 26:72-75.

SAS Institute. 1989. SAS/SAT user's guide. Version 6.03. SAS Inst., Cary, NC.