EFFICACY OF FUNGICIDAL AND NUTRITIONAL TREATMENTS ON COTTON ROOT ROT SUPPRESSION

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Abstract

Phymatotrichum omnivorum causes substantial losses in cotton lint yields on many soils of the Southwest. Surveys of the soil-plant ecosystems in cotton fields exhibiting Phymatotrichum root rot (PRR) on cotton and those having a history of no disease problem suggested a strong association between topographical elevations, particle size distribution and soils being suppressive or supportive of this pathogen. Aerial infrared photography and visual inspections were used to document PRR affected soils producing cotton and the nutritional status of grain sorghum crops seeded on identical soils. Results of these aerial and ground observations strongly indicated an association between levels of iron (Fe) deficiency chlorosis and other micronutrient deficiencies on this monocot and the severity of PRR incidence on cotton. Validation of field observations through soil sample analyses proved that at least two plant nutrients, iron (Fe) and magnesium (Mg) and possibly others including zinc (Zn) and Nickel (Ni) are usually present in short supply in these problem soils. Field studies were conducted evaluating various organic, biological, cultural and chemical methods for effects on the disease. Ammoniacal form of nitrogen reduced the severity of the disease while the nitrate form increased plant mortalities. Stem drenching with Fe chelate, propiconazole (fungicide) or lithium chloride were effective in suppressing PRR. Nickel applied as foliar spray or in the seedrow at planting appeared to reduced disease intensity. Additional materials evaluated in the field included the fungicides, cyproconazole and iprodione. These materials were evaluated under field conditions during this past season. Iron chelate (Fe-EDDHA) applied in the seedrow reduced plant kill to 36% compared to 61% for the control. Controlled-release propiconazole had the greatest effect with plant mortalities of only 10%. Cyproconazole appeared to perform similarly to propiconazole.

Introduction

Cotton root rot is one of the major diseases of cotton in high pH, calcareous soils of the Southwest. In addition to cotton, more than 2000 species of wild and cultivated plants are susceptible to attack from this soil fungus. The unique nature of the pathogen, *Phymatotrichum omnivorum*, enables it to survive over extremely long periods of time. Many control methods proposed in the past either have not been proven effective or have been economically unfeasible in the production of cotton. Previous research (Matocha, et al. 1986; Motaghimi and Matocha, 1987; Matocha and Hopper, 1995) have suggested improving host plant nutrition (IHPN) including trace elements as a means of delaying and reducing the severity of Phymatotrichum root rot (PRR). Extending the period of efficacy through controlled release formulation of fungicides and chelation of trace elements may counter some of the interacting factors working in the soil that affect the degree of control. Studies were conducted to develop economically feasible, field applicable methods to suppress PRR on cotton.

Material and Methods

Field experiments were conducted using a South Texas soil typical of that used in cotton production. The Clareville clay loam (*Pachic Argiustoll*) had histories of producing sorghum suffering from slight to moderately severe Fe deficiency chlorosis. Cotton grown previously on this soil suffered moderate to severe infestation from PRR.

Following earlier field observations of a possible relationship between plant nutrition and severity of PRR on cotton, a field experiment was designed to evaluate three sources of nitrogen (N) fertilizer and several sources of trace elements. Chelated Fe was supplied as ethylenediamine di(0-hydroxy phenylacetic acid-Fe (Fe-EDDHA) while the inorganic Fe salt was supplied as copperas ($Fe\ S0_4\ 7H_20$). Zinc was supplied as EDTA chelate and as zinc sulfate. The synthetic Fe-EDDHA chelate was the most stable Fe chelate available under the high soil pH and Ca status of these soils. Table 1 presents many of the materials evaluated and methods used in treatment application.

Field studies of PRR on cotton in South Texas extended over a period of several years and early work has been reported previously. Early surveys of numerous fields located in Hidalgo, Jim Wells, Nueces and San Patricio counties involved soil sampling of paired sites (root rot supportive soils vs root rot suppressive). Elevations using a transit were determined at each site. Soil samples at depths extending down to three feet were characterized for particle size distribution and chemical analysis for selected cations and anions. These results are reported in a previous paper (Matocha and Hopper, 1995). The present studies were conducted on two sites with the predominate soil type being Clareville sandy clay loam. The first Tynan site used in field studies was located on the Fojtik Farm which had a higher level of *Phymatotrichum omnivorum* than the second site located on the Mengers Farm.

As part of the IHPN program to assess plant tolerance to PRR, sources of N fertilizer tested included those comparing 100 percent ammoniacal with 100 percent nitrate N forms. Later treatments included low rates of controlled

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release propiconazole applied with the seed as dry granules, low rates of seedrow placed chelated Fe, and high rates of elemental sulfur (S) for soil acidification. Treatments also included foliar applications of trace elements including nickel (Ni). Most recent field studies included cyproconazole, also a sterol inhibiting systemic fungicide similar to propiconazole, and iprodione, a broad spectrum fungicide already approved for use on cotton. A V-design mechanical mixture was used to impregnate cyproconazole on the two clays used as carriers for seedbed placements. The controlled release form of iprodione was an experimental commercial formulation. Ammoniacal source of N along with certain chelate trace elements for improved nutrition of the cotton plant were band applied prior to planting. All treatments were arranged in randomized complete block design with three replications. Plot size involved four rows spaced 38 inches apart and 80 feet in length. Plot counts and yields were determined on the center two rows. A number of plant mortality counts were made starting as early as May 20. Earliness and severity of disease were usually dependent upon precipitation frequency.

Results and Discussion

Data from several field experiments evaluating biological, cultural, organic and chemical control treatments have been collected. Some of the results from experiments that showed the most promise in disease suppression are presented.

Improved host-plant nutrition (IHPN) was an important part of developing economically feasible methods for suppressing PRR on cotton in South Texas. Early research on the influence of N fertilizer on PRR produced impressive results. Plant mortality data indicated that ammoniacal N such as that present in ammonium sulfate (AS) or urea caused a reduction in PRR especially in the early season (Table 2). Increasing the rate of AS to 80 lb N/Ac (slightly above soil test recommended rate) reduced plant mortalities from 39 to 14 percent at the mid-summer counts. This compared with 68 and 62 percent losses for the control and calcium nitrate source of N, respectively. Progression of PRR continued rapidly after June 27 and approached 100 percent mortality for the calcium nitrate source. Other field studies (data not shown) at the same location showed deep moldboard tillage alone and preplant use of high rates of anhydrous ammonia showed only minimal effects on reducing losses from PRR.

Additional research with certain trace elements and a fungicide applied as stem drenches produced marked reductions in plant mortalities (Table 3). These data show large effects from Fe-chelate, LiCl and Propiconazole on disease suppression.

Recent results from field tests at a new location where initial PRR damage on cotton was of moderate intensity in contrast to the extremely severe disease pressure at the previous test site show varying response to certain treatments. In this study, all N was supplied as ammoniacal or AS. A controlled release, granular formulation of propiconazole applied in the seedrow at planting had a large influence on reducing plant mortalities at both early and late season (Table 4). This effect was only equaled or surpassed by an application which included K-Mg $S0_4$ (K-mag) combined with a foliar spray with nickel (Ni). Stem drench with Fe chelate which showed good results in earlier tests continued to show suppressive activities with a 25% reduction in dead plants as compared to the control. Lint yields were highest for the Ni treatment with a 123 lb/Ac lint increase over the Ni control.

Field tests in 1995 and 1996 concentrated on evaluating minimal doses of fungicides, carriers and placement methods in and out of seedrow as additional strategies to the IHPN method for suppressing PRR. Matrices of starch and vermiculite clays and more highly structured clays were compared with standard liquid phases of the fungicides.

Results show 0.25 lb a.i./A propiconazole impregnated on dry vermiculite and placed in the seedrow at planting with 250 lb/A granular elemental S reduced plant losses to PRR and was more effective than S alone or in combination with propiconazole in a starch matrix (Table 5).

In 1996, cyproconazole was substituted for propiconazole and proved to be as toxic to germinating seed when placed in the seedrow as propiconazole unless it was applied with a carrier that suppressed its release rate. Vermiculite and organically complexed N, P and Fe fertilizer were effective carriers for the 0.25 a.i./A rate of cyproconazole (Table 6).

Summary

In summary, results from these recent studies indicate that delay in plant subcoming to attack from PRR and actual reductions in mortalities can occur from improved host plant nutrition via nitrogen fertilizer form and supplemental nutrition from selected trace elements. The use of soil amendments such as elemental sulfur to acidify only the root zone can also have some beneficial effects. However, techniques to further suppress losses from PRR should include low rates of certain fungicides. One group which appears highly effective against this pathogen is the sterol-inhibiting systemic types. Substantial reductions in plant mortalities were measured with propiconazole, cyproconazole and a non-sterol inhibiting, broad spectrum type, iprodione. Ideally, these fungicides should be formulated as time control release materials and be applied at planting directly in the seedrow and furnish additional plant protection beyond the IHPN factor starting some eight weeks following seeding. Considerable research is needed in developing time release formulations and in field evaluations for their effectiveness in PRR suppression.

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References

Matocha, J.E. 1984. Grain Sorghum Response to Plant Residue-Recycled Iron and Other Iron Sources, Jour. of Plant Nutr., p. 7:(1-5), 259-270.

Matocha, J.E., S. Mostaghimi, F.L. Hopper and L.S. Bird, 1986. Effect of Soil and Plant Treatments on Phymatotrichum Root Rot. Proceedings of Beltwide Cotton Production Research Conference, pp. 24-26.

Matocha, J. E. and F. L. Hopper. 1995. Influence of Soil Properties and Chemical Treatments on Phymatotrichum Omnivorum in Cotton. Proceedings of Beltwide Cotton Production Research Conference, pp. 224-229. San Antonio, TX.

Mostaghimi, S. and J.E. Matocha, 1987. Effect of Nitrogen Sources and Rates on Cotton Growth and Production. Proceedings of Beltwide Cotton Production Research Conferences, pp. 475-478.

Table 1. Material and methods evaluated in field experiments.

Materials Evaluated:

1. Dispersul - granular (90% S - 10% clay) sulfur.
2. Propiconazole - sterol inhibiting fungicide, systemic.
3. Cyproconazole - sterol inhibiting fungicide, systemic.
4. Iprodione - broad spectrum, contact fungicide.Trade name: Rovral/Chipco.
5. Vermiculite - fine granular, soil insecticide grade.
6. Byproduct clay - fine granules.
7. Ammonium sulfate $(NH_4)_2$ $S0_4$ - acid forming nitrogen fertilizer.
8. Calcium nitrate
9. Urea
10. Organically blended nitrogen and phosphorus (Actagro, 6-21-0)
11. Chelate iron - sesquestrene chel-138 (EDDHA).
12. Nickel chloride and nickel sulfate
13. Organically complexed zinc and iron fertilizer (Actagro).
14. Zinc and iron sulfate - inorganic source of micronutrients.

Methods:

- Preplant placements - 4 inches to side and 2 inches below seed: all N fertilizer; sulfur.
- In-seedrow placement - directly with the seed in band but from different spouts: sulfur, vermiculite and clay carriers of cyproconazole, Rovral, Chel-138 Fe source.
- Stem drench - approximately 15 ml sprayed on each stem at 12 inch plant height: cyproconazole, chelate iron (Chel-138), chelate zinc, Ferrous sulfate, Lithium chloride, Propiconazole.

Table 2. Plant mortalities as affected by sources and rates of nitrogen applied to the soil (Clareville soil, Fojtik Farm).

Nitrogen Source	N-rate (lb/Ac)	June 6	June 27	July 30
		---------% Dead Plants---------		
Ammonium sulfate	40	8.2	39	52
Ammonium sulfate	80	1.5	14	54
Fluid (32-0-0)	40	6.5	51	86
Urea	40	0.8	31	93
Calcium nitrate	40	13	57	99
Calcium nitrate	120	5.8	62	96
Controld	0	13	68	78

Table 3. Plant mortality and lint yields as affected by stem drench with chemical treatments (Clareville soil, Fojtik Farm).

Treatment[1]	June 6	June 27	July 7	July 30	Lint Yield (lb/Ac)
	-----% Plant Mortality-----				
Fe-EDDHA	2.9	23	25	32	252a[2]
Propiconazole	15	33	47	53	170ab
LiCl	1.0	32	40	53	139bc
FeS04	4.9	34	59	79	90bc
Zn-chelate	13	71	78	87	68c
Controld	14	82	93	98	67c

[1] All treatments received 40 lb N/Ac as ammonium sulfate

[2] Duncan's Multiple Range Test at P=0.05

Table 4. Plant mortality and yield response to treatments with Zn, Fe, Ni, K, Mg, S and fungicide (Clareville soil, Mengers Farm).

	-------Date-------		
Treatment	June 6	July 29	Lint Yield
[2]N-P$_2$0$_5$-K$_2$0 Other	% Plant Mortality		lb/Ac
40-20-0	13.9	57.7	468 bc[1]
80-20-0 (Control)	23.3	69.8	424 c
80-20-0 + Fe-EDDHA (stem drench)	6.7	45.5	490 bc
80-20-0 + Fe S0$_4$ + ZnS0$_4$	10.0	32.6	575 bc
80-20-0 + Propiconazole, slow release (0.5 lb a.i./A)	5.8	29.0	586 b
80-20-240 + (K as K-Mg S0$_4$)	21.8	39.1	642ab
80-20-240 + (K as K-Mg S0$_4$) + NiCl$_2$ (Foliar)	7.8	26.0	765a

[1] Duncan's Multiple Range Test at P=0.05

[2] All N applied as ammonium sulfate

Table 5. Effect of sulfur, micronutrients and fungicide on plant mortalities at three counting dates (TN-95).

	Plant Mortality (plants/plot)		
Treatment	Count Dates		
N-P$_2$0$_5$-K$_2$0 + Other	6/20	6/30	8/9
60-20-0 (Control)	16	86	508
60-29-0 + Granular S-250 lb/A	12	45	112
60-20-0 + Granular S-500 lb/A	12	70	188
60-20-0 + Granular S-250 lb/A + 0.25 lb a.i./A Propiconazole (Verm. clay carrier)	0	12	47
60-20-0 + Dispersul S-250 lb/A + 0.25 lb a.i./A Propiconazole on starch with seed	13	25	70
60-20-0 + Dispersul S-250 lb/A + 0.50 lb a.i./A Propiconazole on starch with seed	0	7	84
60-20-0 + Actagro Zn + Fe + 0.25 lb a.i./A Propiconazole soln. with seed	20	45	112
60-20-0 + Actagro Zn + Fe with seed no Propiconazole with seed	28	78	359

Table 6. Effect of fungicide type/carrier and plant nutrients on cotton plant mortality from PRR at four counting dates (TN-96).

	Date of Count			
	6/20	7/1	7/15	8/21
[1]Treatment	plants/plot			
Control	6	13	88	231
[2]Cyproconazole 0.50 lb on soil with seed	3	7	47	183
[2]Cyproconazole 0.50 lb on clay with seed	1	3	20	85
[2]Cyproconazole 0.25 lb on vermiculite with seed	0	0	5	27
[2]Cyproconazole 0.50 lb on vermiculite with seed	3	7	50	164
Rovral-standard and/seed	8	21	113	309
Rovral-Control release (1)	1	2	17	63
Rovral-Control release (2)	14	35	189	345
+Fe+NiS04	1	2	24	79
+Dispersul S in seedrow	2	7	39	72
+Dispersul S preplant + Fe S0$_4$+ZnS0$_4$	0	2	31	95
+Organic F (6-21-0)+Organic Fe(Actagro products)	2	7	54	154
+Organic F (6-21-0) + Organic Fe + Cyproconazole (0.25 a.i./A) with seed	0	1	6	10
+Organic F (6-21-0) + Organic Fe + Cyproconazole (0.50 a.i./A) with seed	3		12	28

[1] All treatments received N-P$_2$0$_5$-K$_2$0 rate, 60-20-0 preplant

[2] Fe chelate-138 banded with the seed