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Evaluation of a Greenhouse Procedure to Screen Oat Seedlings for Resistance to Iron-Deficiency Chlorosis

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Summary

Many oat (*Avena sativa* L.) cultivars express severe iron-deficiency chlorosis when grown on calcareous soils in Texas. Genetic variation for the trait is known to exist, but efficient greenhouse-screening procedures to detect the trait have evaded scientists. Rapid genetic improvement depends on a reliable and efficient screening procedure. Two oat cultivars known to be resistant and susceptible ('Coker 227' and 'TAM O-312', respectively) to iron-deficiency chlorosis were used to determine whether a greenhouse procedure developed for screening *Trifolium* spp. could be used on oat seedlings. The susceptible cultivar (TAM O-312) was consistently more chlorotic than the resistant cultivar (Coker 227). Degree of chlorosis expression varied with soil and temperature of the water used to saturate the soils. However, Parrita soil (pH 8.0) saturated with either ambient or cooled water consistently separated the cultivars with respect to chlorosis expression.

Introduction

Iron (Fe)-deficiency chlorosis has been documented to be a problem with growing several forage species in calcareous soils. Field and greenhouse studies have confirmed that there is genetic variability for response to Fe-deficiency among oat genotypes (McDaniel and Dunphy, 1978). McDaniel and Dunphy (1978) also reported that chlorosis expression in susceptible oat cultivars disappeared in the field with the onset of warm weather in the spring. Plant breeders need an effective method to screen lines for resistance to Fe-deficiency chlorosis.

Gildersleeve and Ocumpaugh (1989) developed a technique to screen *Trifolium* spp. seedlings for resistance/susceptibility to Fe-deficiency chlorosis. Our research was undertaken to determine the merits of applying this screening method to oat cultivars known to be resistant and susceptible to Fe-deficiency chlorosis.

Materials and Methods

Two trials (starting, respectively, in February and April 1990) were conducted in the greenhouse at the Texas A&M University Agricultural Research Station, Beeville (28°N, 97°W). Air temperature in the greenhouse was maintained above 59 °F by artificial heat, and evaporative cooling was provided when temperatures exceeded 77 °F. Soil temperature was monitored every 5 minutes and recorded every hour with a data logger.

All trials were a modification of the technique reported by Gildersleeve and Ocumpaugh (1989). This involved growing seedlings in a calcareous soil in Super-Cell Cone-tainers® until they reached a predetermined growth stage, then saturating the soil by submerging the base of the cones in distilled water for a predetermined period of time. All trials used the oat cultivars Coker 227 and TAM O-312 as resistant and susceptible, respectively, to Fe-deficiency chlorosis (Brown and McDaniel, 1978; McDaniel and Dunphy, 1978).

In addition to the standard procedure of using an ambient root temperature, two root temperature modification treatments were imposed. Root temperatures were modified by either heating or cooling the water used to saturate the soil. Boxes were constructed (19 x 32 x 10 in.) with foil-faced expanded polystyrene sheeting (0.5 in. thick) to insulate the root system and water from influences of ambient conditions of the greenhouse. Two layers of polystyrene were placed under the tubs to insulate them from contact with the bench surface, but only one layer was used for the side-walls and top (around the rack that held the Cone-tainers®). The spaces in the rack tops were filled with foam insulation from aerosol cans. Three temperature treatments were used: hot (water temperatures were maintained at 77 °F), cold (water temperatures were maintained at 38 °F), and ambient (water temperatures were relative to ambient conditions in the greenhouse). Hot and cold water temperatures were imposed by pumping heated and cooled water from water baths through polypropylene and glass tubing that was placed in the bottom of the tubs used as water reservoirs.

Trial 1.

Plants were grown to the 2-leaf growth stage in non-saturated pH 8.0 Parrita soil (clayey, mixed, hyperthermic, shallow Petrocalcic Paleustoll). Then they were set in tubs to undergo the saturation phase on February 9, 1990. Fourteen plants of each cultivar were placed in each of three water temperature treatments. Chlorosis scores (1 = green, no chlorosis to 5 = severe chlorosis) were taken at

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initiation of saturation and at weekly intervals. Four weeks after initiation of saturation (March 12, 1990), the plants were destructively harvested.

Trial 2.

Forty-two plants of each cultivar were grown to the 2-leaf growth stage in each of three soils (Parrita, pH 8.0; Clareville, pH 6.8; and Weesatche, pH 7.8) obtained from the Research Station at Beeville. The Clareville soil is classified as a fine, montmorillonitic, hyperthermic Pachic Argiustoll, and the Weesatche is a fine-loamy, mixed, hyperthermic Typic Argiustoll. Fourteen plants in each soil were placed in each temperature treatment on April 3, 1990. The water temperatures were imposed and the chlorosis scores were recorded as in Trial 1. All plants were destructively harvested on April 19, 1990. Means and standard errors were plotted.

Discussion and Summary

The observed root temperatures averaged 81, 63, and 54 °F for the hot, ambient, and cold treatments, respectively, in Trial 1. As seen in Figure 1, TAM O-312 was always more chlorotic than Coker 227. Note that even though chlorosis scores for Coker 227 increased the first week, they leveled and even decreased with time. The increase during the first week indicates an adverse response of even resistant plants to the saturated pH 8.0 Parrita soil. Top growth of TAM O-312 in the cold treatment was significantly less than that in the hot treatment (data not shown).

The observed root temperatures averaged 82, 66, and 55 °F for the hot, ambient, and cold treatments, respectively, in Trial 2. In Trial 2, chlorosis scores for Coker 227 were significantly lower than those for TAM O-312 in every treatment at 1 week after initiation of saturation (Figs. 2 to 4). The second-week scores show the same trends as those of Trial 1. Neither temperature nor soil type affected this general trend. TAM O-312 and Coker 227 had the same chlorosis scores after 2 weeks in the hot Parrita treatment. This is the only time that TAM O-312 and Coker 227 showed no difference. Coker 227 was least chlorotic in Clareville soil treatments. Weesatche soil produced the most chlorotic oat seedlings in both cold and ambient water treatments.

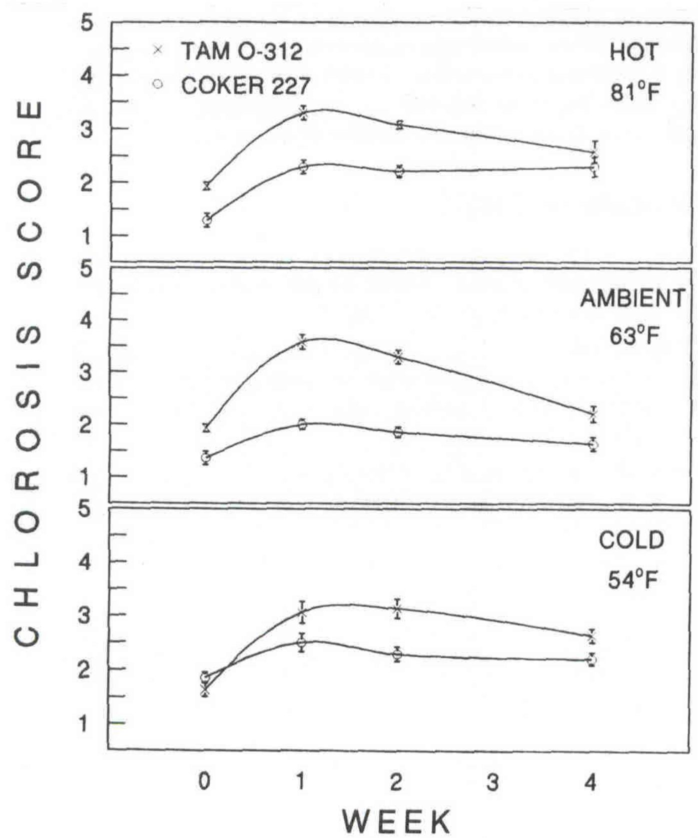

Figure 1. Mean chlorosis score response of Coker 227 and TAM O-312 oat seedlings to root temperature treatments in pH 8.0 Parrita soil at Beeville during the period February 9 to March 12, 1990 (Trial 1). 1 = no chlorosis, 5 = severe chlorosis. Bars indicate standard error of mean.

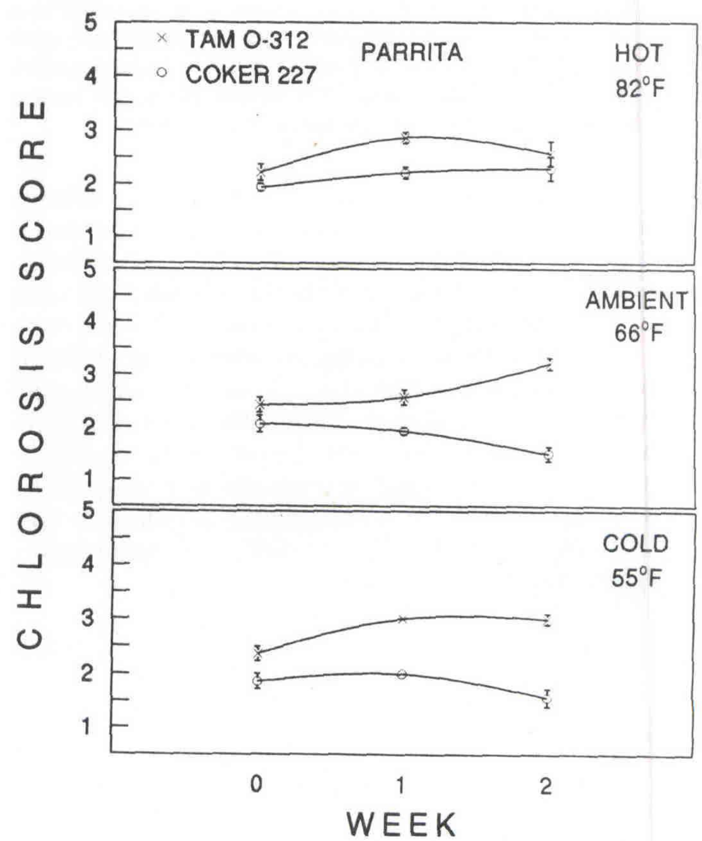

Figure 2. Mean chlorosis score response of Coker 227 and TAM O-312 oat seedlings to root temperature treatments in pH 8.0 Parrita soil at Beeville during the period April 3 to April 19, 1990 (Trial 2). 1 = no chlorosis, 5 = severe chlorosis. Bars indicate standard error of mean.

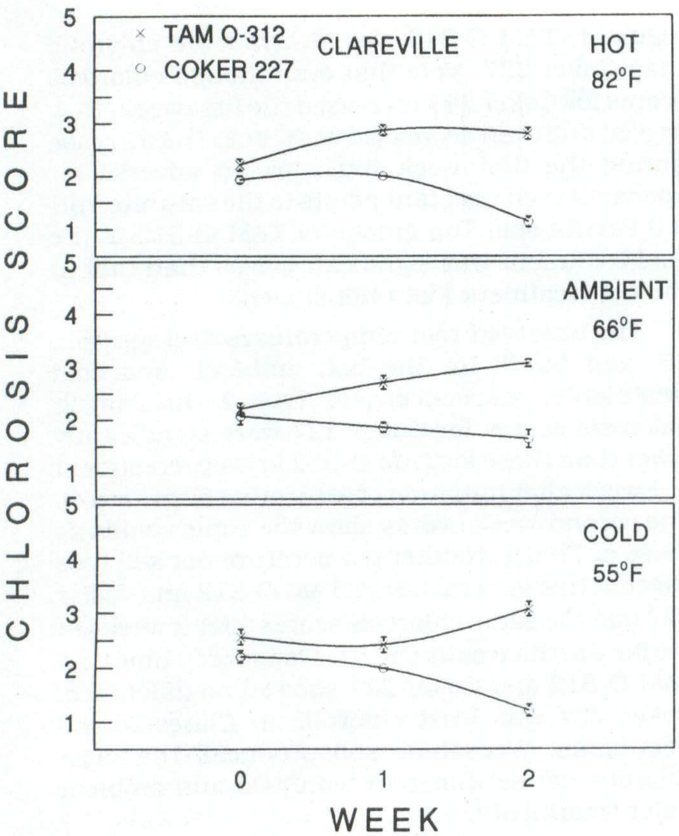

Figure 3. Mean chlorosis score response of Coker 227 and TAM O-312 oat seedlings to root temperature treatments in pH 6.8 Clareville soil at Beeville during the period April 3 to April 19, 1990 (Trial 2). 1 = no chlorosis, 5 = severe chlorosis. Bars indicate standard error of mean.

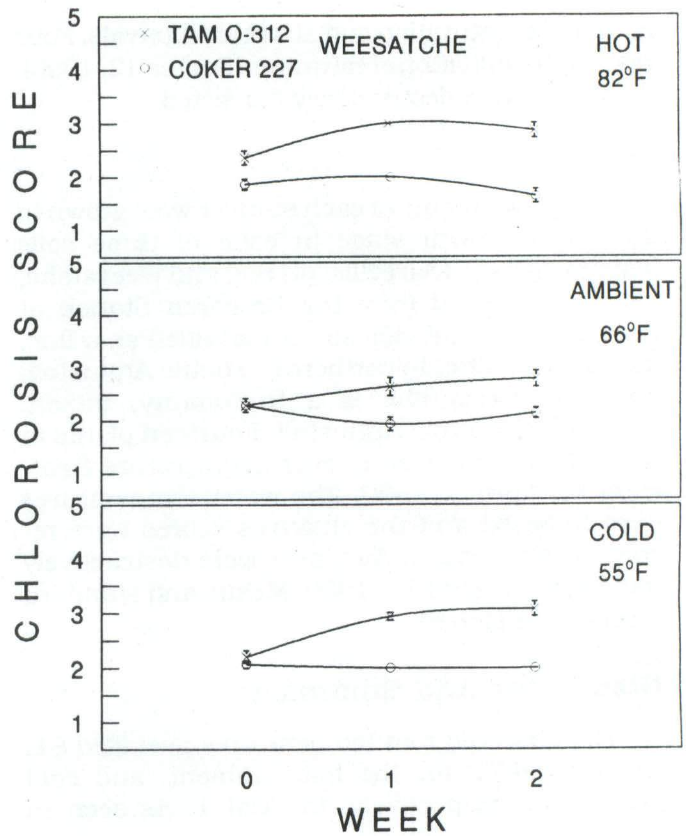

Figure 4. Mean chlorosis score response of Coker 227 and TAM O-312 oat seedlings to root temperature treatments in pH 7.8 Weesatche soil at Beeville during the period April 3 to April 19, 1990 (Trial 2). 1 = no chlorosis, 5 = severe chlorosis. Bars indicate standard error of mean.

The screening system reported by Gildersleeve and Ocumpaugh (1989) appears to have potential merit for screening oat seedlings for Fe-deficiency chlorosis. The number of plants screened does not have to be large to obtain reliable results. The effects of high soil temperature were adverse to root production (data not shown) and in some soils reduced chlorosis expression. Warm weather has previously been reported to be related to the disappearance of chlorosis symptoms in field studies with susceptible oat cultivars (McDaniel and Dunphy, 1978). Further testing with more genotypes and soils is needed.

Literature Cited

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