Peanut Seedling Response to Dinitroaniline Herbicides Applied Preplant Incorporated and Preemergence[1]

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ABSTRACT

Greenhouse studies were conducted in 1995, 1996, and 1998 to measure the effect of preplant incorporated (PPI) and preemergence (PRE) applications of ethalfluralin and pendimethalin on growth of individual peanut seedlings in pots. Herbicide rates evaluated were 0, 0.6, 1.1, and 2.2 kg ai/ha for each herbicide. Parameters measured were time of emergence, seedling height, canopy width, foliage biomass, root length, and root biomass of individual plants. PPI applications were more injurious than PRE applications for all parameters regardless of herbicide. Ethalfluralin PPI inhibited peanut seedling growth more than equivalent rates of pendimethalin PPI. However, peanut seedling responses to PRE applications of ethalfluralin and pendimethalin were generally the same.

Key Words: *Arachis hypogaea* L., ethalfluralin, herbicide phytotoxicity, peanut injury, pendimethalin.

Dinitroaniline herbicides are commonly used on peanut to control annual grasses and small-seeded broadleaf weeds. Benefin [*N*-butyl-*N*-ethyl-2,6-dinitro-4-trifluoromethyl) benzenamine] is efficacious and safe to use on peanut (Guse *et al.*, 1966), and eventually became the first dinitroaniline herbicide to be widely used on peanut. However, Greer *et al.* (1969) reported a "narrow margin of safety" with trifluralin [2,6-dinitro-*N*,*N*-dipropyl-4-(trifluoromethyl)benzenamine] and nitralin [4-(methylsulfonyl)-2,6-dinitro-*N*,*N*-dipropylbenzenamine], with rate and depth of incorporation influencing crop safety. Later research included other dinitroaniline herbicides (Buchanan *et al.*, 1978; Brecke and Currey, 1980; Grichar and Colburn, 1993), and some were effective for weed control in peanut with no noticeable differences in phytotoxicity among peanut cultivars. These studies led to registrations of ethalfluralin [*N*-ethyl-*N*-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl) benzenamine], pendimethalin [*N*-(1-ethylpropyl)-3,4 dimethyl-2,6 dinitrobenzenamine], and trifluralin for preplant incorporated (PPI) applications on peanut.

Dinitroaniline herbicides are volatile, although the potential for volatility loss varies according to chemical structure, depth and time of incorporation, and soil moisture (Bardsley *et al.*, 1968; Oliver and Frans, 1968; Menges and Tamez, 1974; Kennedy and Talbert, 1977; Weber, 1990). Dinitroaniline herbicides have low water solubility and are adsorbed to soil organic matter and clay, making them immobile (Weber, 1990). Therefore, dinitroaniline herbicides generally remain where they are initially placed by mechanical incorporation, irrigation, or rainfall (Jordan *et al.*, 1963; Menges and Tamez, 1974).

Dinitroaniline herbicides are normally applied PPI to minimize losses due to volatility and photodecomposition. With increased interest in conservation tillage and stale seedbed weed control in all crops, including peanut, alternatives to dinitroaniline herbicides applied PPI are being considered. Johnson *et al.* (1997) showed that high rates of ethalfluralin applied preemergence (PRE) and activated with irrigation were less phytotoxic than equivalent rates applied PPI in conventional tillage systems. In these studies, PPI and PRE applications of ethalfluralin at registered rates did not injure peanut. Control of Texas panicum (*Panicum texanum* Buckl.), southern crabgrass [*Digitaria ciliaris* (Retz.) Koel.], and crowfootgrass [*Dactyloctenium aegyptium* (L.) Willd.] with PPI and PRE applications of ethalfluralin and pendimethalin was similar (W. C. Johnson, III, unpubl. data).

There are advantages to applying dinitroaniline herbicides PRE and activation with irrigation compared to PPI applications. For example, the cost of using center-pivot irrigation to activate PRE herbicides was approximately $1.60/ha in 1996 (C. C. Dowler, pers. commun., 1997) while the cost of incorporation with a disk-harrow was estimated to be approximately $3.20/ha in 1996 (Givan and Shurley, 1995). Without irrigation or timely rainfall for activation, dinitroaniline herbicides applied PRE perform inconsistently (Byrd and York, 1987). Other herbicides have been successfully applied PRE and activated with irrigation without loss in efficacy or increased

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injury compared with PPI applications (Jordan *et al.*, 1963; Gasper *et al.*, 1994).

Symptoms of dinitroaniline herbicide injury on peanut seedlings are often expressed as overall stunting, swollen hypocotyls, and abnormal lateral root growth (Greer *et al.*, 1969; Buchanan *et al.*, 1978). These symptoms can be confounded by cool temperatures and poor seed quality. Occasionally, dinitroaniline herbicide injury is not detected until harvest. In these cases, peanut vegetative growth appears unaffected. However, injured plants often have large numbers of pegs and very few pods (Merkle, 1975; Johnson *et al.*, 1997; Buchanan *et al.*, 1978). It appears that the unique process of peanut pegs forming above ground, penetrating the soil surface, and forming pods subsurface may predispose peanut to injury from dinitroaniline herbicides that accumulate near the soil surface.

While applications of dinitroaniline herbicides applied PRE effectively control annual grasses without peanut injury in field studies, there have been no studies on the effects of these herbicides on individual peanut seedlings. Therefore, greenhouse trials were initiated in 1995 to determine the effects of dinitroaniline herbicides applied PPI and PRE on emergence and growth of peanut seedlings.

Materials and Methods

Greenhouse trials were conducted January 1995, December 1995, and January 1998 at the Coastal Plain Experiment Station in Tifton, GA. The greenhouse did not receive any supplemental light. Temperature was maintained at a constant 30 C.

The experimental design was a split, split-plot, with four replications, with individual plastic pots (22 cm diam. × 38 cm tall) serving as plots. Main plot treatments were the herbicides ethalfluralin and pendimethalin. Subplot treatments were times of application, including PPI or PRE (immediately after seeding peanut). Sub, subplot treatments were the herbicide rates 0, 0.6, 1.1, and 2.2 kg ai/ha. The registered use rates for ethalfluralin and pendimethalin on peanut are 0.8 and 1.1 kg/ha, respectively.

Soil used in the trials was collected from a peanut field at the Coastal Plain Experiment Station Gibbs Farm in Tift County, GA. The soil was a Tifton loamy sand (thermic Plinthic Kandiudults) composed of 90% sand, 8% silt, and 2% clay, with 0.5% organic matter and pH 5.1. Soil was sieved (1.3 cm × 1.3 cm) to remove rocks, clods, and plant debris. Soil was then steam-pasteurized at 70 C for 1 hr to control weeds and soil-borne pathogens.

Plastic pots were filled with uniform amounts of soil based on weight. Since the soil had uniform moisture, the volume was equivalent among pots. Pots were lightly watered to uniformly settle the soil, then allowed to dry to field capacity in the greenhouse.

The top 7.6 cm of soil was temporarily removed from each pot used for PPI treatments. A piece of polyethylene film was placed in the pot, with the excess film extending over the sides of the pot. The removed soil was added back to the pot, with the excess film remaining over the sides.

All herbicides were applied in a spray chamber. A fixed nozzle (0.29 L/min at 173 kPa) was calibrated to deliver 342 L/ha. Pots were placed on a conveyor belt that moved the pots under the spray nozzle at a speed of 0.4 m/sec. Immediately after PPI herbicides were applied, the excess film was used to lift the top 7.6 cm of treated soil from the pot. The treated soil was placed in an agitator which throughly mixed the herbicide with the soil. The treated soil was added back to the pot without the plastic film. This procedure simulated field conditions in which PPI herbicides are sprayed and incorporated into the top 7.6 cm layer of soil.

Four Georgia Runner peanut seeds of uniform size and shape were planted 5 cm deep in each pot. Every effort was made to orient the seed in the same direction. Peanut in PPI and PRE treatments were seeded at the same time.

PRE herbicides were applied with the same sprayer directly to the soil surface immediately after seeding peanut. Pots used for PRE herbicides did not have the plastic film and the top 7.6 cm soil was not removed from these pots. All pots in the trial were lightly watered after PRE treatments were applied to activate herbicides.

Time of peanut seedling emergence was recorded for each pot. As seedlings emerged, they were thinned to one seedling per pot. Extra pots, nontreated with herbicide, were planted to peanut and used to determine progression of root growth. Root growth in the extra nontreated pots was periodically observed during the trials. Once the peanut tap root reached the bottom of an extra nontreated pot the entire trial was terminated, which was 47 d after planting. At that time, canopy width, seedling height, and foliage biomass were measured. Soil was washed from seedling roots, blotted dry with paper toweling, and root biomass and root length were recorded. Foliage and root biomass samples were dried at 38 C for 3 d before weighing.

All data were subjected to analysis of variance and regression analysis, where $^+$, *, and ** indicate $P \leq 0.10$, 0.05, and 0.001, respectively. The regression analysis was based on the principles outlined by Draper and Smith (1981) using:

$$Y = a + bx \qquad \text{[Eq. 1]}$$

where Y = parameter being measured, a = intercept, b = slope, and $x = X - \bar{X}$ or midpoint of herbicide rate range.

Results and Discussion

The year by treatment interactions were not significant; therefore, data from all parameters were pooled across years. Analysis of variance indicated significant interactions among herbicides, method of application, and rates for each of the parameters evaluated.

Time of Emergence. Peanut seedlings in nontreated controls emerged in 16 d, with emergence delayed by PPI applications of ethalfluralin and pendimethalin at increasing rates (Fig. 1). In contrast, PRE applications of either herbicide had no effect on time of seedling emergence. There was little difference in time of seedling emergence between peanut treated with ethalfluralin or pendimethalin applied PPI. Injury symptoms on peanut seedlings were swollen, disoriented hypocotyl, along with an overall reduced root system which are consistent with those previously reported (Merkle, 1975; Buchanan *et al.*, 1978). These symptoms were prevalent on peanut seedlings treated with PPI applications of ethalfluralin and pendimethalin at 2.2 kg/ha, which is more than twice the registered rate of either herbicide.

Vegetative Growth Parameters. Peanut seedling height was reduced by increasing rates of ethalfluralin and pendimethalin applied PPI (Fig. 2A). Ethalfluralin PPI at the highest rate evaluated (2.2 kg/ha) reduced

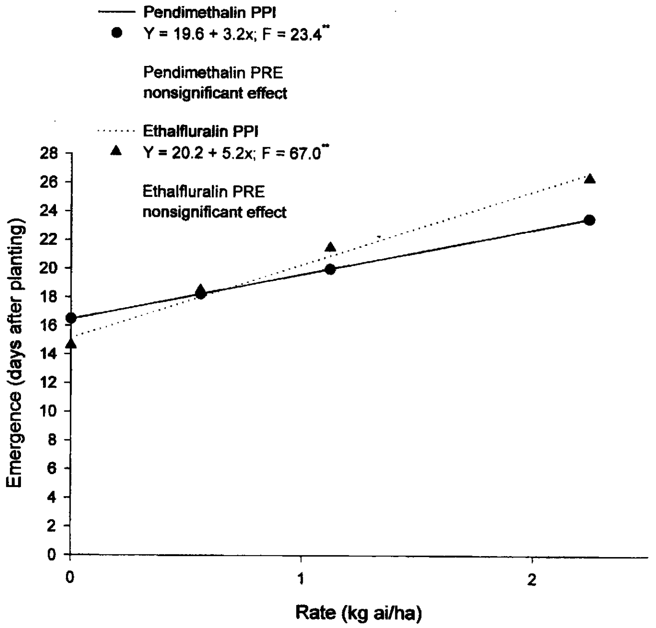

Fig. 1. Effect of ethalfluralin and pendimethalin on peanut seedling emergence in greenhouse trials; X - X̄, according to Draper and Smith (1981).

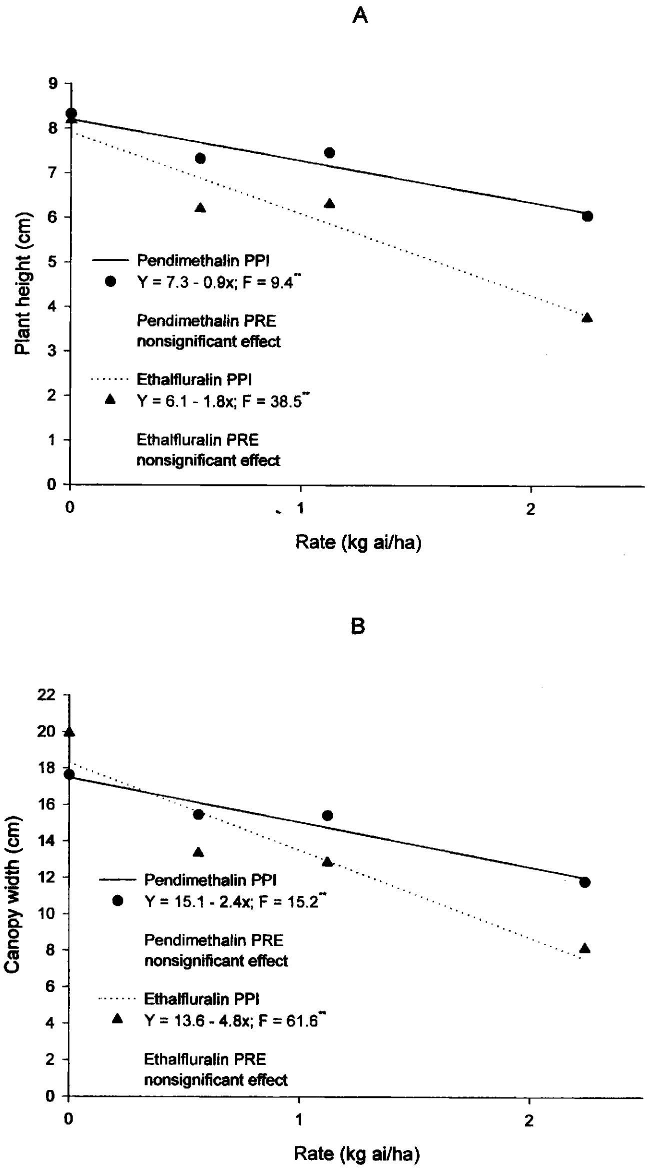

Fig. 2. Effect of ethalfluralin and pendimethalin on peanut seedling growth in greenhouse trials; A = seedling height, B = canopy width; X - X̄, according to Draper and Smith (1981).

peanut seedling height approximately 50%, compared to 25% reduction from the highest rate of pendimethalin PPI. At registered rates, peanut seedling height was reduced 20% by ethalfluralin PPI, and 13% by pendimethalin PPI. In contrast, PRE applications of pendimethalin and ethalfluralin at increasing rates had no effect on peanut seedling height.

Peanut canopy width response to ethalfluralin and pendimethalin is shown in Fig. 2B. The response of peanut canopy width and seedling height to dinitroaniline herbicides was similar. PPI applications of ethalfluralin and pendimethalin at increasing rates inhibited peanut seedling canopy width, whereas PRE applications had no effect. Ethalfluralin PPI inhibited peanut seedling canopy width more than pendimethalin PPI, which is consistent with peanut seedling height response (Fig. 2A).

Peanut foliage biomass response to dinitroaniline herbicides was generally similar to seedling height and canopy width responses (Fig. 3). PPI applications of ethalfluralin and pendimethalin at increasing rates inhibited foliage biomass, while PRE applications had no effect. In contrast to other vegetative growth parameters, there was little difference between peanut seedling foliage biomass response to ethalfluralin and pendimethalin applied PPI. Peanut seedling foliage biomass response to registered rates of ethalfluralin and pendimethalin PPI was similar.

Root Growth Parameters. PPI applications of ethalfluralin and pendimethalin reduced root length, while PRE applications had no effect (Fig. 4A). This is consistent with results from other parameters evaluated that showed PPI applications were more injurious than PRE applications. Peanut root length was reduced more by ethalfluralin PPI than pendimethalin PPI. At the highest rate evaluated (2.2 kg/ha), root length was reduced approximately 70% by ethalfluralin PPI and 25% by pendimethalin PPI. The registered rate of pendimethalin PPI reduced peanut root length 13%, but only 5% when applied PRE (data not shown). Similarly, the registered rate of ethalfluralin PPI reduced peanut root length 27%, but only 13% when applied PRE (data not shown).

Peanut seedling root biomass did not respond the same as root length to dinitroaniline herbicides. Root biomass was reduced more by either herbicide applied PPI compared to PRE applications (Fig. 4B). At registered rates, ethalfluralin PPI reduced peanut root biomass 37%, and pendimethalin PPI by 28%. In contrast, ethalfluralin PRE had no effect on root biomass, while registered rates of pendimethalin PRE reduced root biomass by 19%. These results contradict peanut root length response that showed ethalfluralin more injurious than pendimethalin (Fig. 4A).

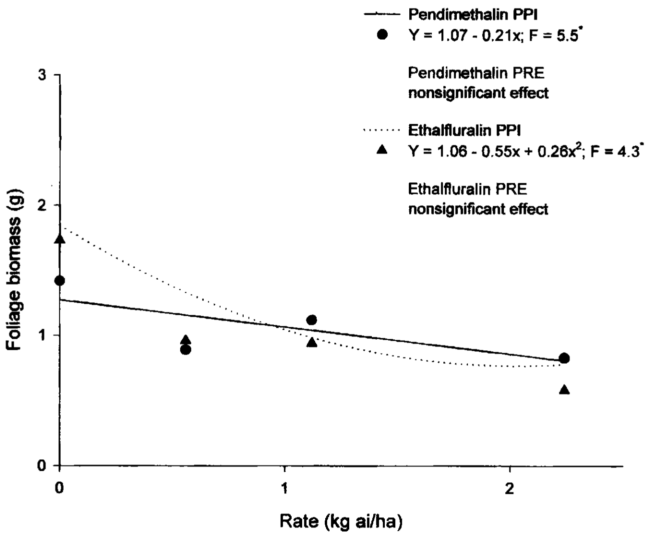

Fig. 3. Effect of ethalfluralin and pendimethalin on peanut seedling foliage biomass in greenhouse trials; X - X̄, according to Draper and Smith (1981).

It is difficult to extrapolate results from greenhouse trials directly to occurrence in the field. However, results from our greenhouse trials are further evidence that dinitroaniline herbicides applied PRE can be safely used on peanut. Field studies showed that ethalfluralin applied PRE was less injurious on peanut than PPI applications based on pod set and yield (Johnson *et al.*, 1997). In nearly every parameter measured in our greenhouse studies, peanut seedlings were not affected by dinitroaniline herbicides applied PRE, while PPI applications at increasing rates were inhibitory.

Our results also indicate that ethalfluralin is generally more injurious to peanut seedlings under greenhouse conditions than pendimethalin at equivalent and registered rates. Within the PPI application regime, pendimethalin was less phytotoxic to peanut seedlings than ethalfluralin in every parameter evaluated. The relevance of these findings is difficult to assess. Both herbicides are commonly used on peanut across the U. S. and neither herbicide has been implicated to cause widespread injury to peanut seedlings. If the injury observed in our greenhouse trials occurred in the field, peanut seedlings evidently recover quickly. This theory is in agreement with Merkle (1975) who stated that initial root stunting from dinitroaniline herbicides usually does not cause yield reduction, unless complicated by adverse weather conditions or diseases. Furthermore, Grichar and Colburn (1993) reported no yield differences between peanut treated with pendimethalin and ethalfluralin PPI at registered rates.

Hall *et al.* (1985) speculated that herbicides applied in greenhouse trials may be more active than in complimentary field trials. That may partially explain why ethalfluralin injured peanut more than pendimethalin in our greenhouse trials, which is contrary to previous observations and grower experiences. Furthermore, assuming that ethalfluralin and pendimethalin are more active in greenhouse trials than under field conditions, the consistent safety of PRE applications versus PPI applications to peanut is clearly evident.

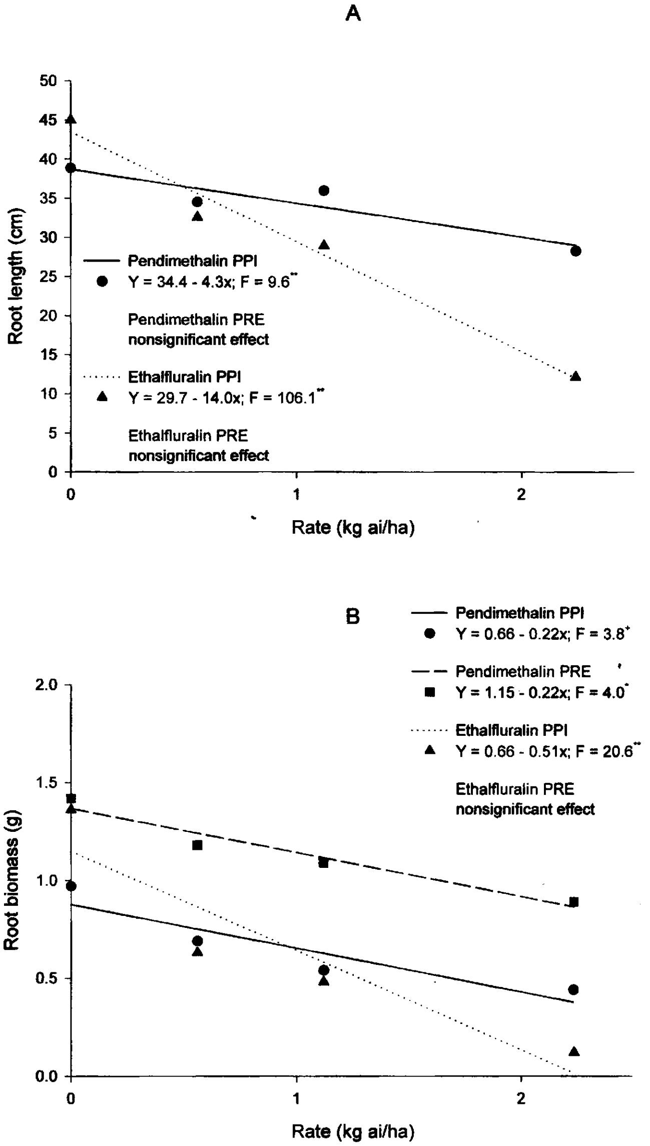

Fig. 4. Effect of ethalfluralin and pendimethalin on peanut seedling root growth in greenhouse trials; A = root length, B = root biomass; X - X̄, according to Draper and Smith (1981) (+ = P ≤ 0.10).

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