Effect of Root Pruning Preemergence Herbicides on Root Morphology of Kentucky Bluegrass (Poa prantensis L.)

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Introduction

Preemergence herbicides are used to control various annual grasses like large crabgrass [*Digitaria sanguinalis* (L.) Scop.], smooth crabgrass [*Digitaria ischaemum* (Schreb. ex Schweig.) Screb. ex Muhl], yellow foxtail (*Setaria lutescens* Weigel.), green foxtail [*Setaria viridis* (L.) Beauv.], fall panicum (*Panicum dichotomiflorum* Michx.), barnyardgrass [*Echinochloa crus-galli* (L.) Beauv.], annual bluegrass (*Poa annua* L.), and goosegrass [*Eleusine indica* (L.) Gaertn.] in established cool-season turfgrasses like Kentucky bluegrass (*Poa pratensis* L.), perennial ryegrass (*Lolium perenne* L.) and creeping bentgrass (*Agrotis palustris* Huds.). The soil applied preemergence herbicides control weeds by inhibiting or pruning root meristems of germinating seedlings. Root pruning herbicides are those which inhibit root meristematic activity in susceptible plants by disrupting the cell division process. Susceptible plants include crabgrasses, foxtails and other grass species as well as several broadleaf weeds (Bhowmik 1996).

Dinitroaniline herbicides are a class of herbicides which are commonly used as preemergence herbicides in cool-season turfgrasses by binding to tubulin and inhibiting mitosis during the formation of microtubules (Bhowmik and Bingham, 1990). The effects often observed in dinitroaniline treated grass roots is abnormal swelling of root tips leading to nonemergence of germinating seedlings, stunting of plants with lack of lateral roots or severely pruned roots in the herbicide treated-zone. Emerged grass shoots are thick and stunted, often with a purple or reddish discoloration (Bhowmik, 1996).

Other classes of herbicides have similar effects on turfgrass roots. Dithiopyr, a pyridine class herbicide, inhibits mitosis by binding to another protein that may be a microtubule associated protein (MAP). Dithiopyr results in shortening of microtubule that can form spindle fiber and results in club-shaped root tips. Isoxaben, a benzamide class herbicide, affects cell division in root meristematic regions by inhibiting cell wall biosynthesis in susceptible plants. DCPA inhibits mitosis by affecting phragmoplast microtubule arrays and cell wall formation. Bensulide inhibits root elongation and cell division and may directly inhibit mitosis, resulting in binucleated cells (Bhowmik, 1996).

Prodiamine and oryzalin have been reported to reduce 'Tifgreen' bermudagrass root growth. These dinitroaniline herbicides decreased root weight at low concentration (4 ppb by weight) in a fine textured soil while higher concentration (8 ppb) was required in coarser soil texture (Frederick and Coats, 1993). Long-term exposure to dinitroaniline herbicides like pendimethalin and oryzalin on bermudagrass have been reported to suppress the growth of sprigs which can last up to six to eight weeks and can potentially cause genetic change in triploid bermudagrasses (Goatley et al. 2003). Kaminski et. al. (2004) reported reduced seedling emergence and reduced cover of creeping bentgrass (*Agrostis palustris* L.) in the spring following an autumn application of prodiamine at 0.36 kg. a.i. ha^{-1}. Researchers have reported the adverse effects of prodiamine on the spring recovery of Tifway bermudagrass when the herbicide was applied in the autumn of the previous year. In the same study pendimethalin had lesser and briefer suppressive effects than prodiamine on the sprig establishment of Tifway bermudagrass (Fagerness et. al., 2002).

The objective of the research project was to evaluate the effects of various preemergence herbicides on tiller production, rhizome, root growth and development of 'Baron' Kentucky bluegrass and to study the effect of different rates of the herbicide on the root growth and development.

MATERIALS AND METHODS

Experiment 1.

Experiments were conducted at the University of Massachusetts Turfgrass Research Center, South Deerfield, MA in 1987 and 1988. Preemergence herbicides were applied on 'Baron' Kentucky bluegrass to evaluate large crabgrass control and their response on Kentucky bluegrass tiller production and root morphology. Benefin (2.2 kg a.i.ha^{-1}), benefin and trifluralin pre-mix combination (2.2 kg a.i. ha^{-1}), pendimethalin (1.7 kg a.i. ha^{-1}), prodiamine (0.5 kg a.i. ha^{-1}), and flumetralin (0.8 kg a.i. ha^{-1}) were applied on 22 April 1987 and 25 April 1988 with a CO_2-backpack sprayer using Teejet XR 11004 VS nozzles at 152 kPa with a carrier volume of 450 L ha^{-1}.

Experiment 2.

Separate experiments were conducted with benefin, pendimethalin and prodiamine applied at three different rates on 'Baron' Kentucky bluegrass in the field. Benefin was applied at 2.0, 3.0, and 4.0 kg a.i. ha^{-1}, pendimethalin was applied at 1.5, 3.0, and 4.5 kg a.i. ha^{-1}, and prodiamine was applied at 0.5, 1.0 and 2.0 kg a.i. ha^{-1} on 22 April 1987 and 25 April 1988. A 0.25 m^{-2} quadrant was randomly tossed in the plots and the number of large crabgrass was counted and recorded every other week. The numbers were converted to plants m^{-2}. Percent turf injury and percent large crabgrass control were evaluated visually weekly until 8 weeks after application. The percent turf injury was based on the injury to individual plants. Tiller numbers, rhizome numbers, root dry weight and tiller dry weight was recorded at 4, 8, and 12 weeks after treatment (WAT). The data collected from the 0.25 m^{-2} quadrant was converted into g m^{-2} for the root dry weight and tiller dry weight, while the tiller numbers and rhizome numbers were reported in numbers m^{-2}.

Experiment 3.

The effect of five dinitroaniline herbicides, benefin (2.2 kg a.i. ha^{-1}), benefin and trifluralin combination (2.2 kg a.i. ha^{-1}), pendimethalin (1.7 kg a.i. ha^{-1}), prodiamine (0.5 kg a.i. ha^{-1}), flumetralin (0.8 kg a.i. ha^{-1}) on Kentucky bluegrass root growth was examined 4 weeks after treatment (WAT). One hundred twenty mm diameter plugs were removed from the field and planted in 150 mm diameter plastic pots in bleached sand in the greenhouse. The plants were irrigated to avoid any moisture stress and were fertilized every month with a liquid application of 20-20-20 fertilizer. Tiller numbers, dry weight of tillers, rhizome numbers, root length and root dry weight were measured at 4, 8 and 12 WAT.

The data was analyzed with analysis of variance with the general linear model (proc glm program of SAS). Normality and significance at $\alpha \leq 0.05$ and $\alpha \leq 0.01$ were calculated. Means were separated using Duncan's New Multiple Range Test (DNMRT) ($\alpha = 0.05$) and Fishers protected least significant difference (LSD) ($\alpha = 0.05$). Regression analysis was used to explain the effect of rates of herbicides on tiller numbers, rhizome numbers, dry weight of tillers, and dry weight of roots.

RESULTS AND DISCUSSION

All five dinitroaniline herbicides provided over 92% large crabgrass control. The control plots had a dense stand of large crabgrass (220 plants m^{-2}) compared to no plants in the pendimethalin and prodiamine treated plots. The effect of the dinitroaniline herbicides on root regrowth of 'Baron' Kentucky bluegrass was evaluated in the greenhouse. After 4 weeks of regrowth the root length for all the herbicide applications was not significantly different than the control or each other in the first year (1987). In 1988 the prodiamine application at 0.5 kg a.i. ha^{-1} resulted in the shortest root length compared to the untreated control and all the other herbicide applications. There was no difference between the other herbicide treatments. In the first year of the study (1987) highest root dry weight was observed with the pendimethalin application at 1.7 kg a.i. ha^{-1} compared to all the other herbicide treatments. There was no significant difference between the pendimethalin treatment and the untreated control. All the other herbicide treatments had lower root dry weights compared to the control but were not significantly different than each other. In the second year of study the benefin and trifluralin treatment at 2.2 kg a.i. ha^{-1} had the lowest root dry weight compared to the control but there was no significant difference between the herbicide treatments.

Turf injury on 'Baron' Kentucky bluegrass with benefin, benefin and trifluralin combination, pendimethalin, prodiamine, and flumetralin was evaluated at 6 and 8 WAT of the preemergence herbicides. In the first year of study the benefin and trifluralin combination applied at 4.0 kg a.i. ha^{-1} resulted in 18% and 23% injury to 'Baron' Kentucky bluegrass at 6 and 8 WAT, respectively. There was no significant difference in the level of injury between the benefin and trifluralin, pendimenthalin at 4.5 kg a.i. ha^{-1}, and prodiamine at 2.0 kg a.i. ha^{-1} applications at the 6 WAT. At 8 WAT the benefin and trifluarlin treatment reported highest turf injury followed by the prodiamine treatment applied at 2.0 kg a.i. ha^{-1}, but there was no significant difference between the two treatments. Benefin applied at 4.0 kg a.i. ha^{-1}, pendimethalin at 4.5 kg a.i. ha^{-1}, and flumetralin at 3.0 kg a.i. ha^{-1} had higher levels of injury compared to the control but there was no difference between the treatments.

In the second year of study the benefin and trifluralin combination applied at 4.0 kg a.i. ha^{-1} and the prodiamine treatment at 2.0 kg a.i. ha^{-1} resulted in highest injury at the 6 and 8 WAT. Turf injuries for all the other herbicide applications were not significantly different than each other but were significantly higher than the control. The difference in the level of injury to 'Baron' Kentucky bluegrass between the two years may be due to higher 1988 spring temperatures compared to 1987. All the herbicide treatments at the high rates of application resulted in significantly higher levels of turf injury compared to the control at the 6 and 8 WAT for both the years.

The effect of different rates of benefin, pendimethalin, and prodiamine on the tiller numbers m^{-2}, rhizome numbers m^{-2}, root dry weight and tiller dry weight (g m^{-2}) of 'Baron' Kentucky bluegrass was recorded at 4, 8, and 12 WAT. Application of the label rate of benefin (2.0 kg a.i. ha^{-1}) lead to an increase in tiller numbers at 8 and 12 WAT compared to the control. Higher rates of benefin (3.0 and 4.0 kg a.i. ha^{-1}) resulted in a decrease in tiller numbers at 8 and 12 WAT. At the 4 WAT benefin application at 3.0 kg a.i. ha^{-1} resulted in highest tiller numbers compared to the other rates of application and control. The rhizome numbers decreased with increasing rate of application of benefin at 8 and 12 WAT. The root dry weight and tiller dry weight of 'Baron' Kentucky bluegrass increased when benefin was applied at 2.0 kg a.i. ha^{-1} and then decreased as the rate of benefin increased to 3.0 and 4.0 kg a.i. ha^{-1} at the 4, 8 and 12 WAT (Figures 1, 2, 3).

The tiller numbers and rhizome numbers decreased as the rate of pendimethalin increased from 1.5 to 3.0 and 4.5 kg a.i. ha^{-1} at 4, and 12 WAT. The tiller numbers increased with the application of pendimethalin at 1.5 kg a.i. ha^{-1} compared to the control and then decreased as the rates increased to 3.0 and 4.0 kg a.i. ha^{-1} at 8 WAT. There was no significant difference in rhizome numbers, root dry weight and tiller dry weight between the treatments at 8 WAT (Figures 4, 5, 6).

Higher rates of prodiamine (1.0 and 2.0 kg a.i. ha^{-1}) resulted in lower tiller numbers, rhizome numbers, root dry weight and tiller dry weight compared to the control at 12 WAT. Rhizome numbers at 8 WAT, root dry weights at 4 WAT, tiller dry weights at 4 and 8 WAT were not significantly different than the control and each other. Tiller numbers increased with the application of prodiamine at 0.5 kg a.i. ha^{-1} compared to the control at 4 and 8 WAT (Figures 7, 8, 9).

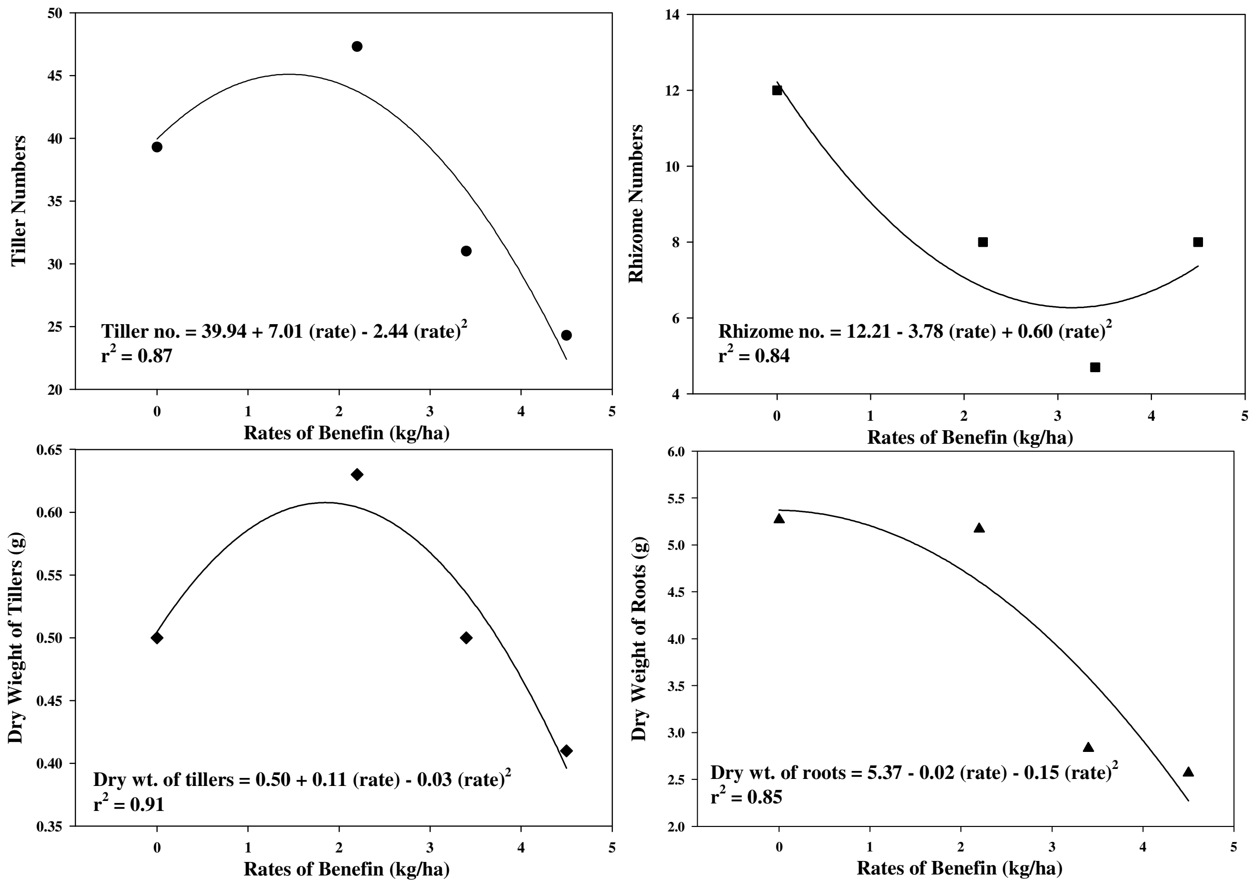

Figure 1. Effect of benefin on the tiller numbers, rhizome numbers, dry weight of tillers and dry weight of roots of Kentucky bluegrass as observed 4 weeks after treatment.

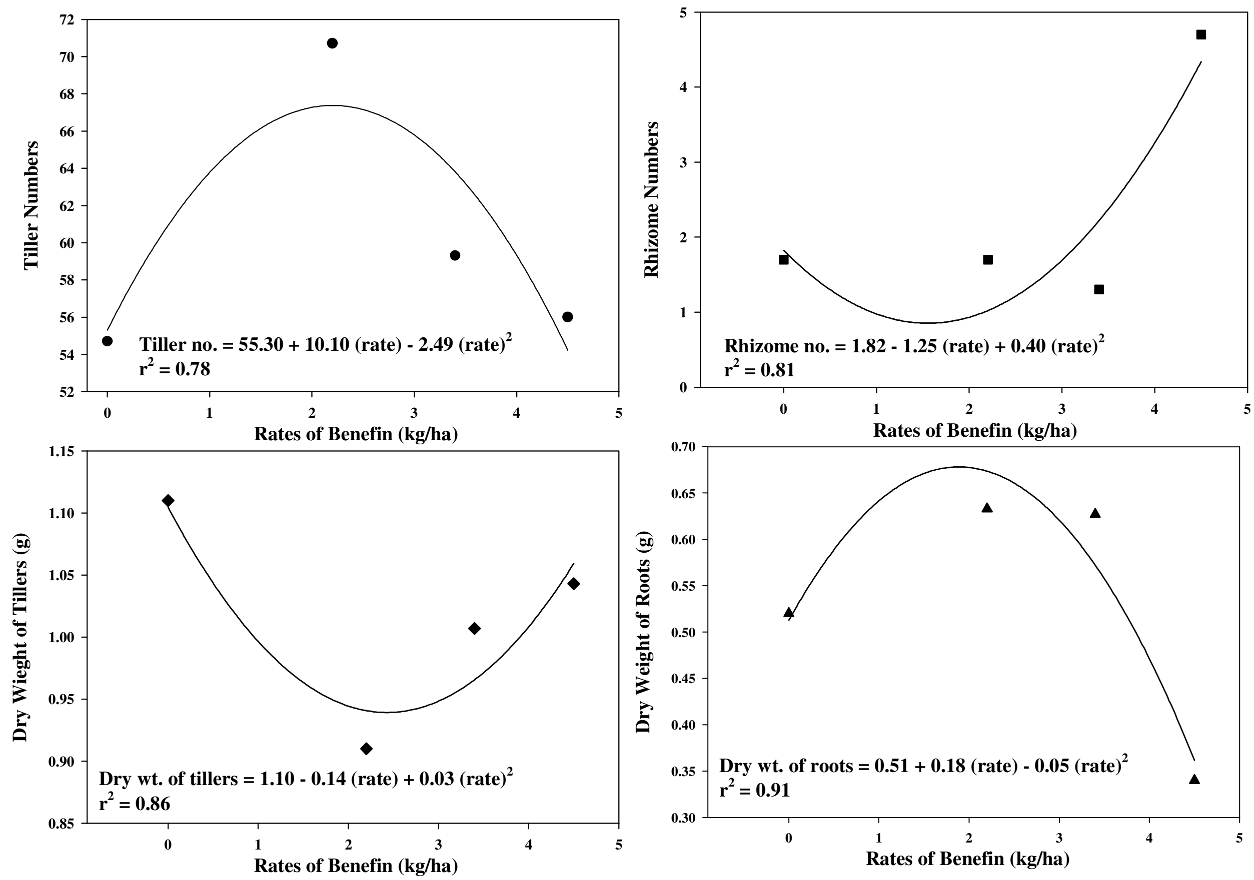

Figure 2. Effect of benefin on the tiller numbers, rhizome numbers, dry weight of tillers and dry weight of roots of Kentucky bluegrass as observed 8 weeks after treatment.

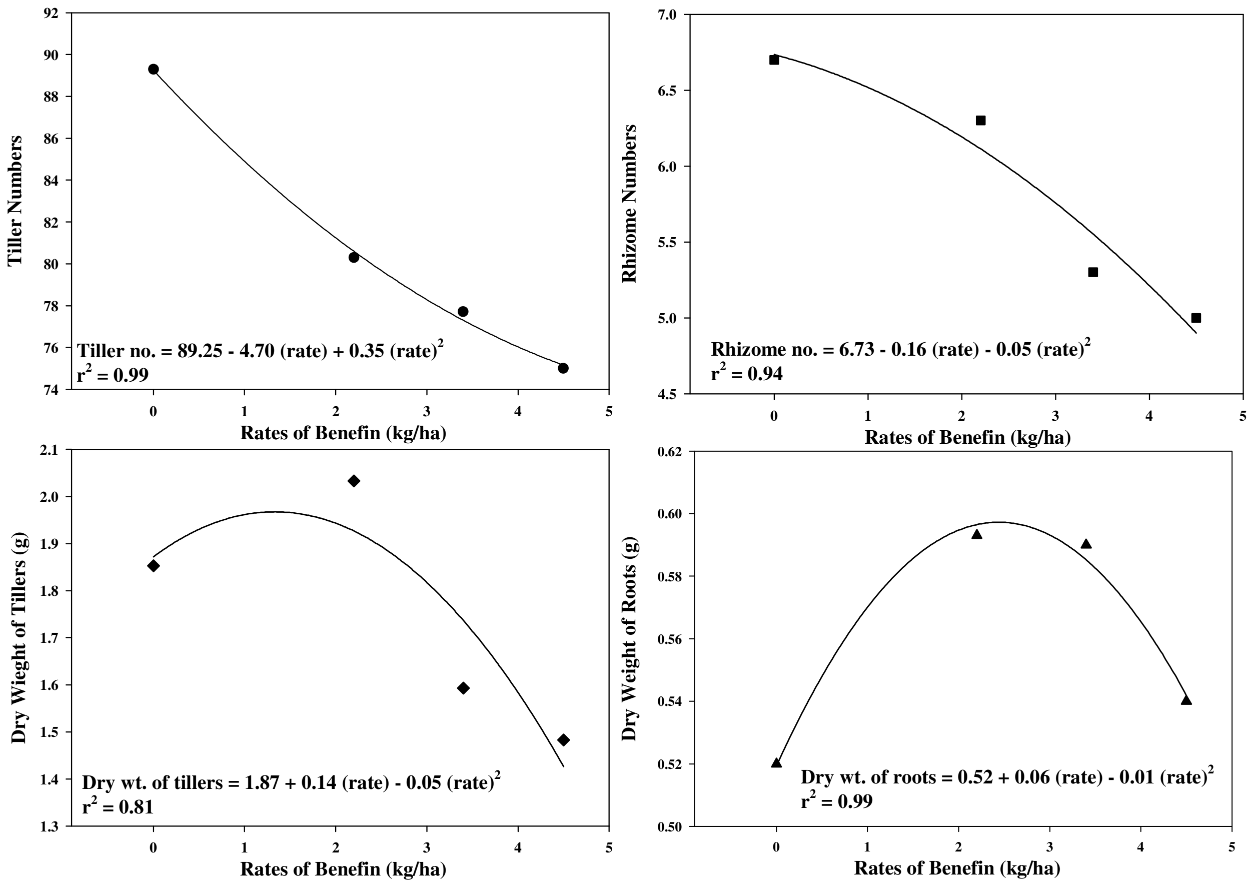

Figure 3. Effect of benefin on the tiller numbers, rhizome numbers, dry weight of tillers and dry weight of roots of Kentucky bluegrass as observed 12 weeks after treatment.

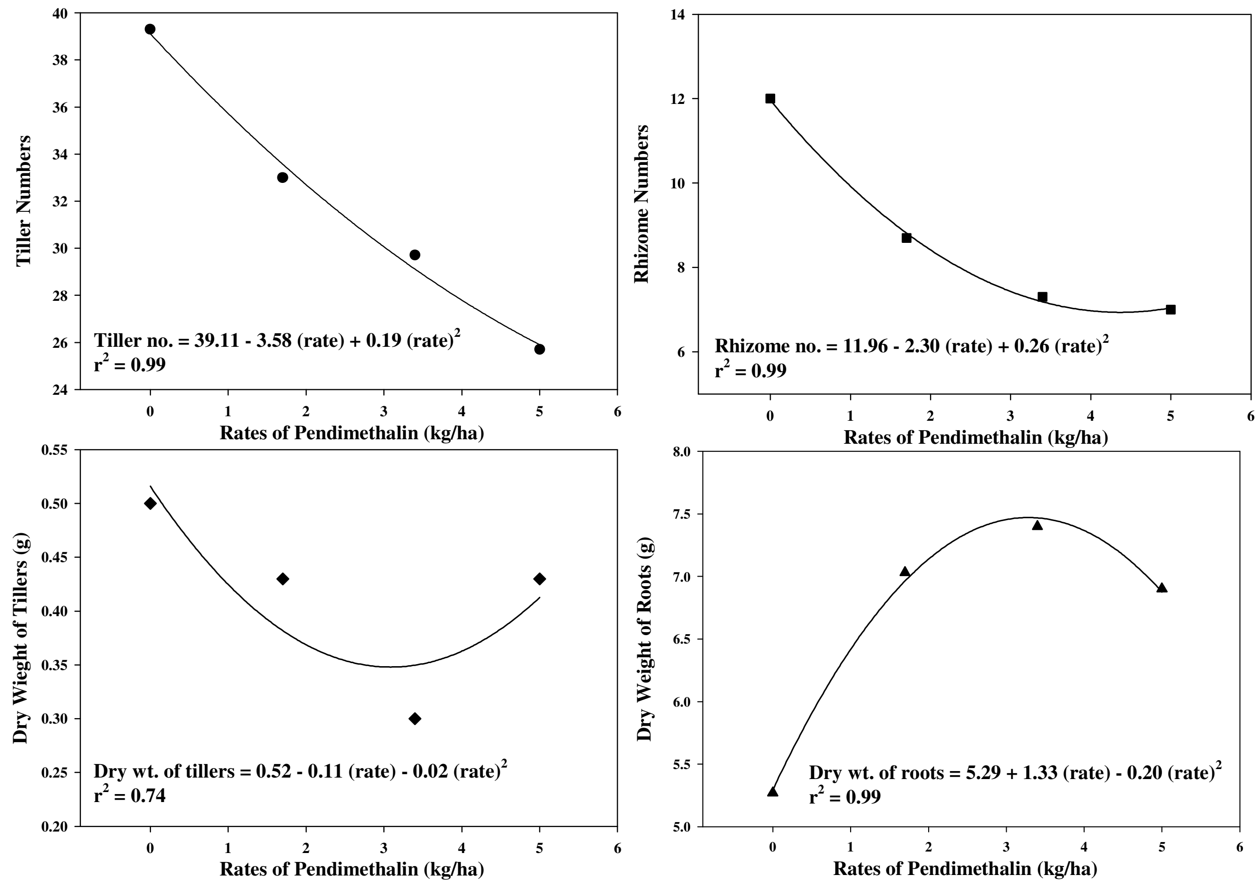

Figure 4. Effect of pendimethalin on the tiller numbers, rhizome numbers, dry weight of tillers and dry weight of roots of Kentucky bluegrass as observed 4 weeks after treatment.

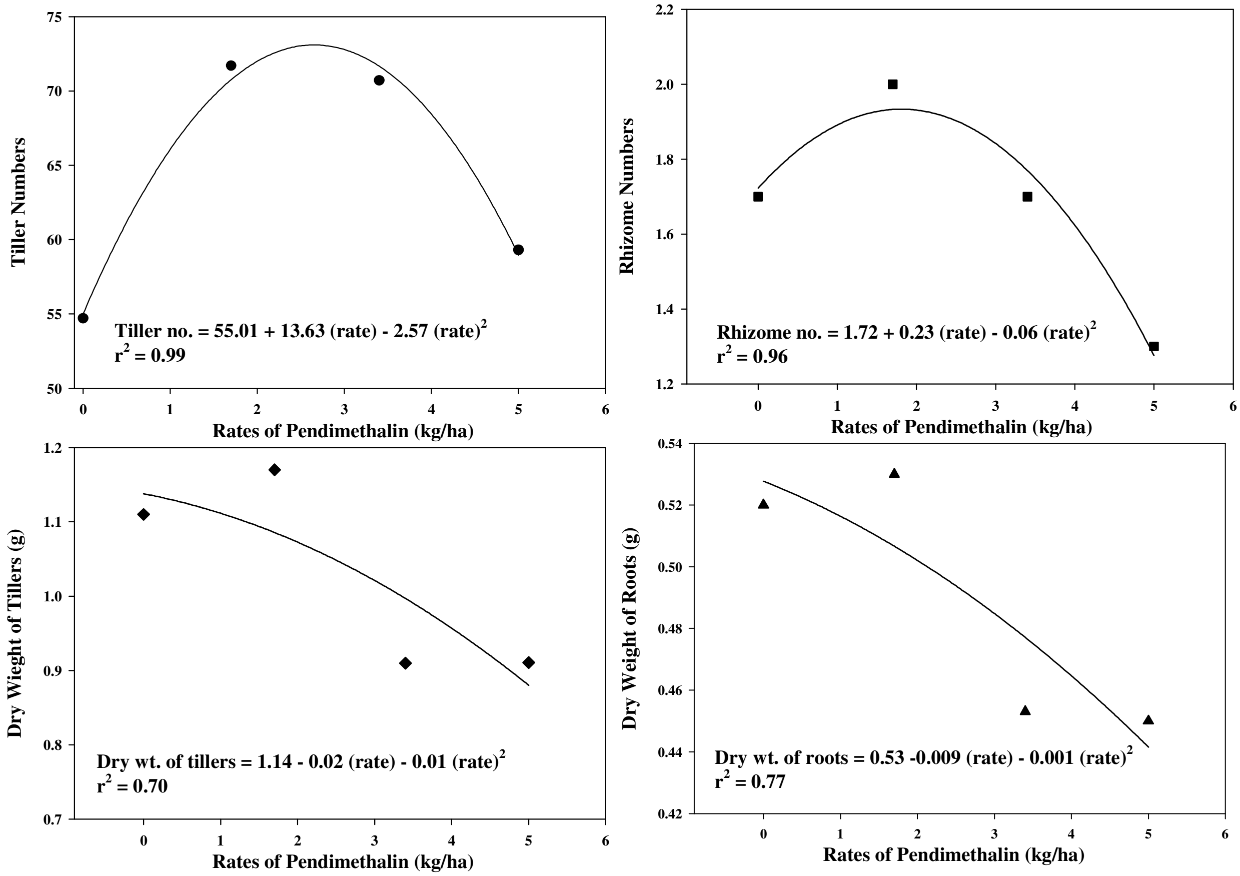

Figure 5. Effect of pendimethalin on the tiller numbers, rhizome numbers, dry weight of tillers and dry weight of roots of Kentucky bluegrass as observed 8 weeks after treatment.

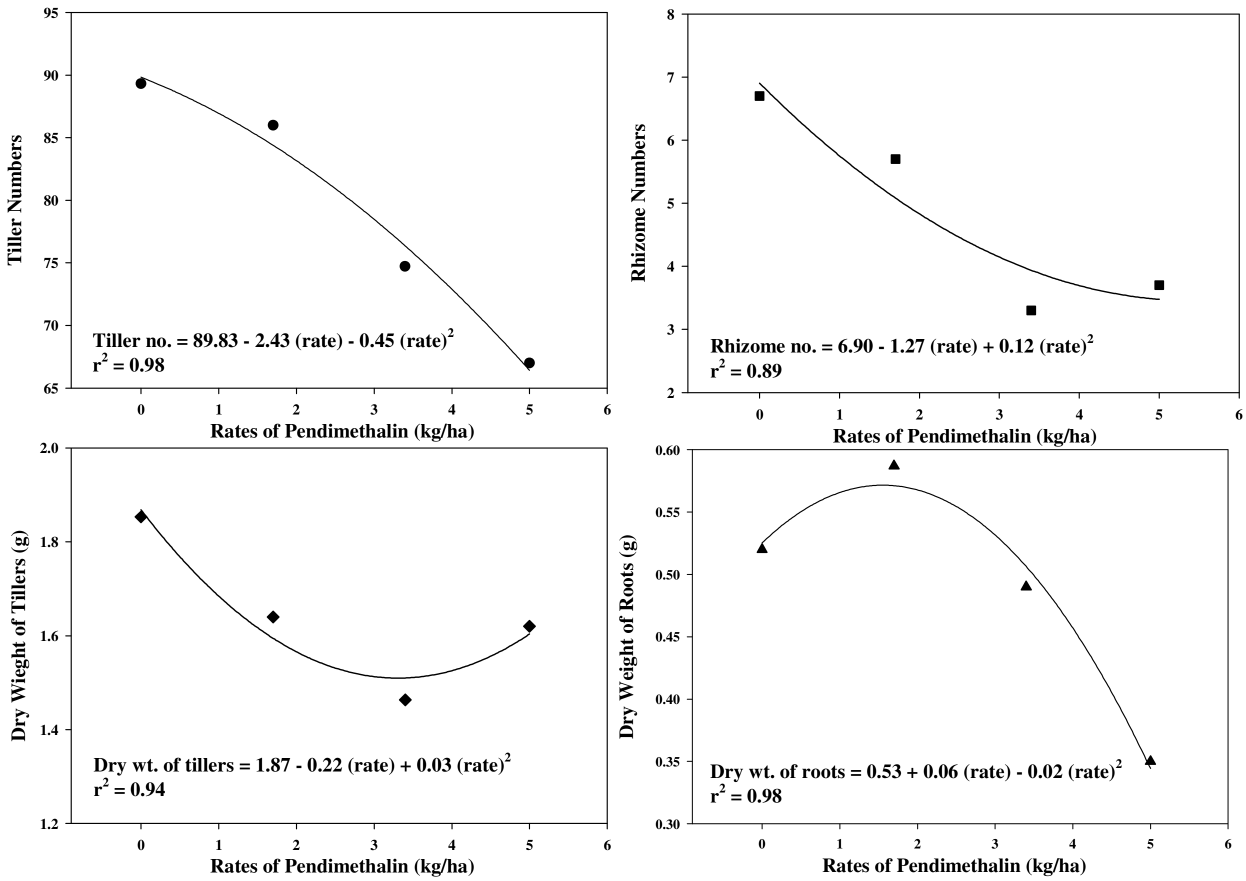

Figure 6. Effect of pendimethalin on the tiller numbers, rhizome numbers, dry weight of tillers and dry weight of roots of Kentucky bluegrass as observed 12 weeks after treatment.

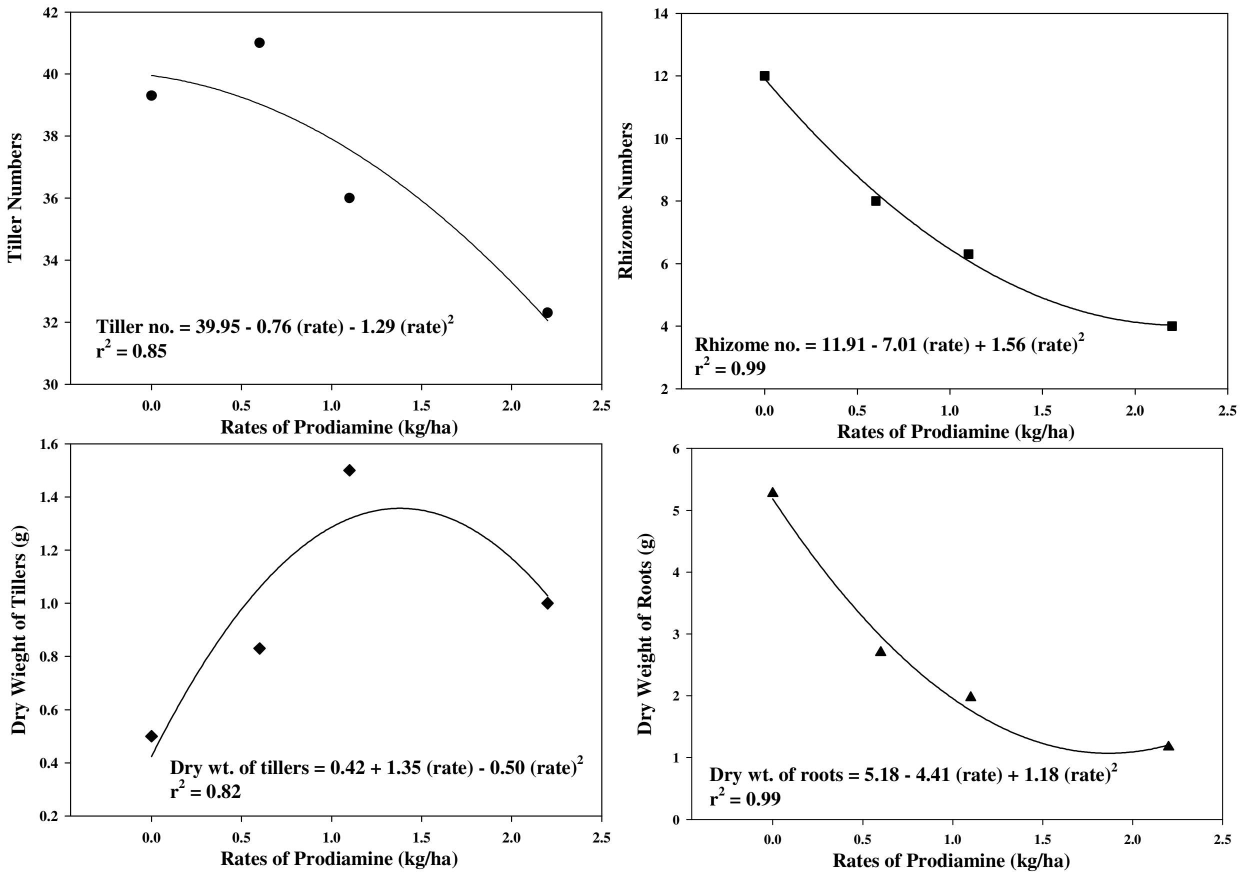

Figure 7. Effect of prodiamine on the tiller numbers, rhizome numbers, dry weight of tillers and dry weight of roots of Kentucky bluegrass as observed 4 weeks after treatment.

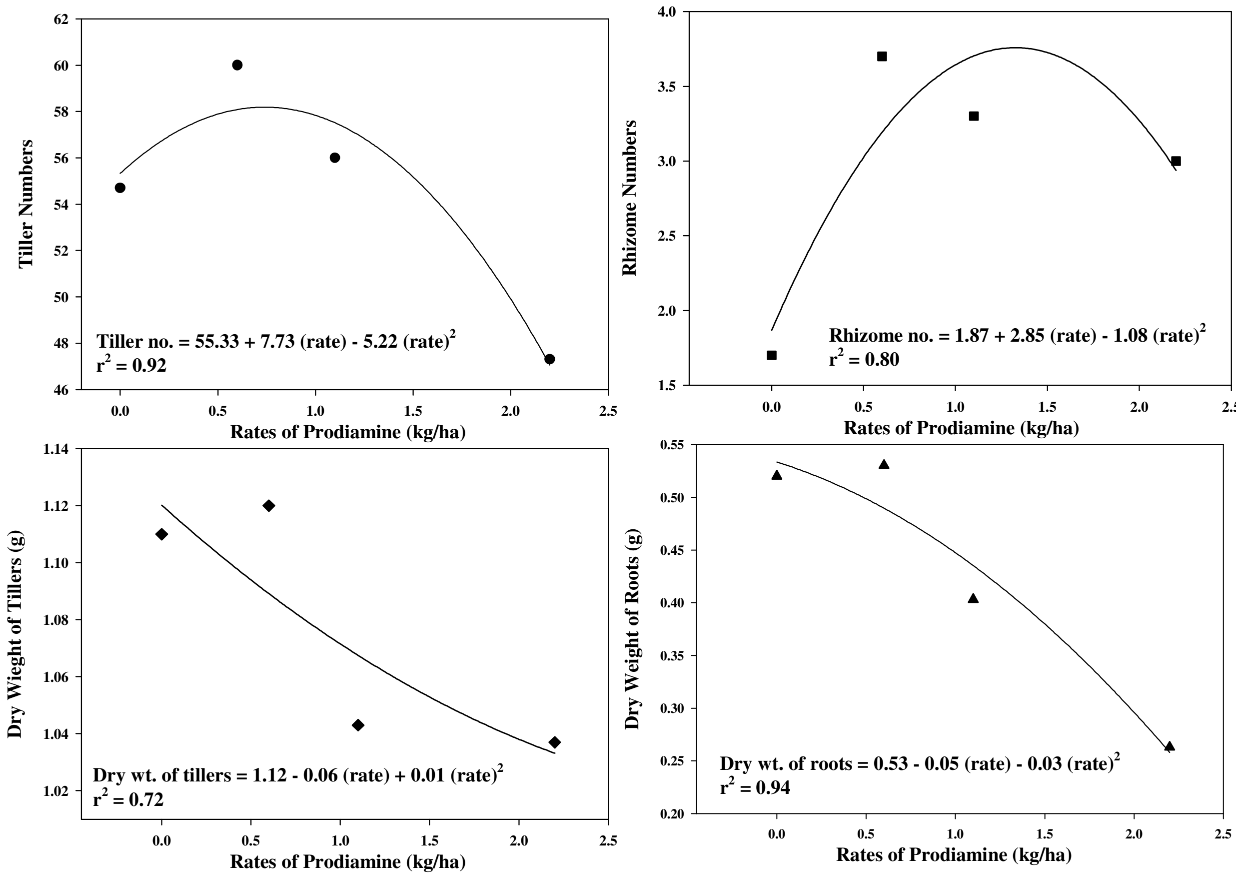

Figure 8. Effect of prodiamine on the tiller numbers, rhizome numbers, dry weight of tillers and dry weight of roots of Kentucky bluegrass as observed 8 weeks after treatment.

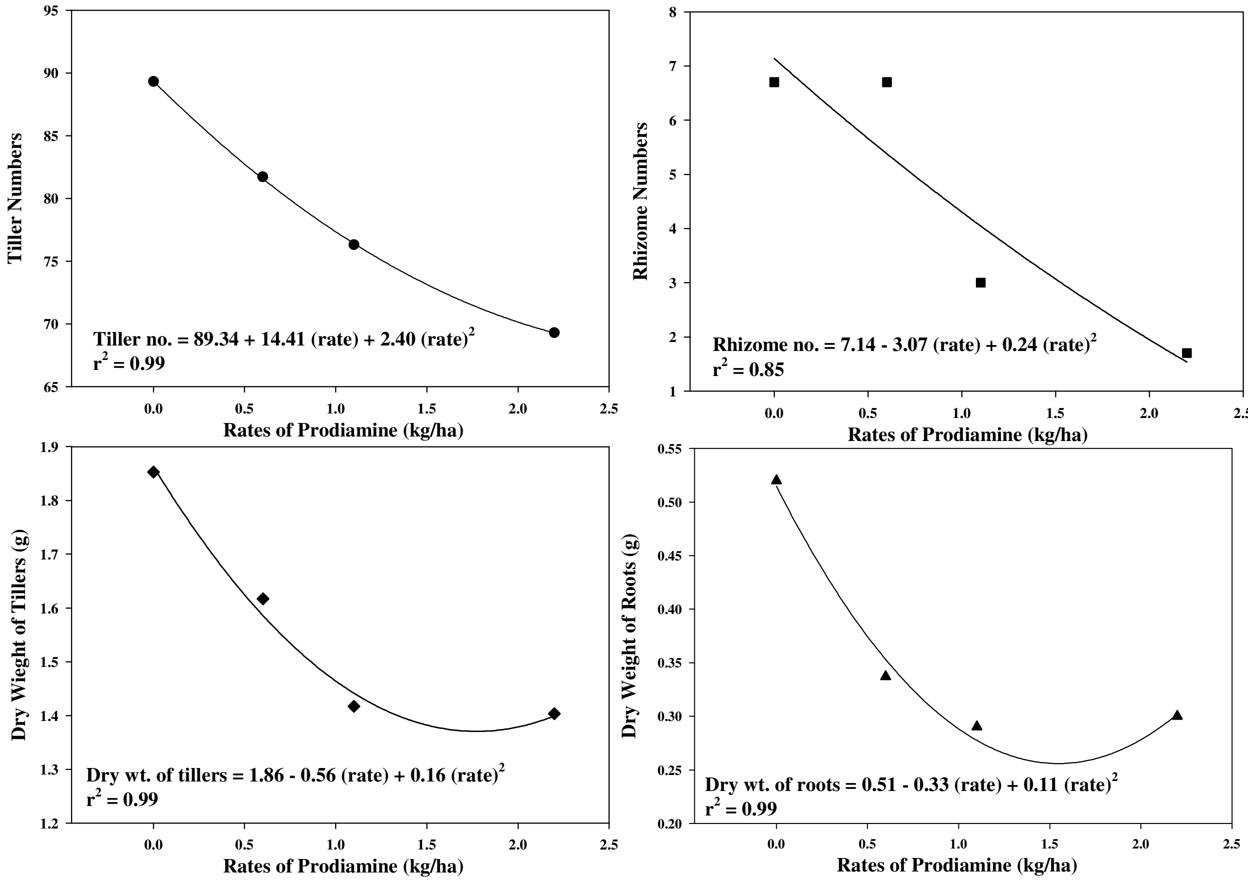

Figure 9. Effect of prodiamine on the tiller numbers, rhizome numbers, dry weight of tillers and dry weight of roots of Kentucky bluegrass as observed 12 weeks after treatment.

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