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Effects of Boron on Seedling Establishment of Annual Legumes

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Summary

A series of greenhouse experiments were conducted at Overton to investigate the relationship between annual clover seedling establishment and boron nutrition. Boron was shown to significantly increase taproot length, lateral root number, and lateral root size at 2 weeks of age for subterranean clover. Boron increased taproot length at 4 weeks of age for subterranean, crimson, arrowleaf, rose, ball, and berseem clover. Hairy vetch did not respond to boron at the rates used in this experiment. Seedling survival of subterranean and rose clover

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in moisture stress conditions was improved with the correction of soil boron deficiency.

Introduction

Winter-annual clovers are often overseeded on warm-season perennial grass sods for grazing in East Texas. Establishment, at initial planting or during natural reseeding, is a major management problem when using these annual forage legumes. Soils in the East Texas Timberlands are often sandy and acidic with low native fertility. Phosphorus and potassium fertilization and liming are generally necessary for annual clover forage production. Boron fertilization has been recommended but has not been used in recent forage fertilization programs. Field experiments at Overton have shown

number of lateral roots over 10 mm and over 30 mm in length. In most cases, the 3.4 kg B/ha rate caused a slight, but insignificant growth depression of the sub clover seedlings.

Plants which had not received boron exhibited typical boron deficiency symptoms: stunting of growth at the apical meristem, and wrinkled, thicker, bluish-green leaves. Most seedlings had not progressed beyond the cotyledonary stage. Stunted root growth was evident as well.

Experiment 2. Both boron fertilizer and an adequate water supply significantly increased shoot dry weights of sub clover seedlings (data not shown). The greatest yield was observed for well-watered plants receiving 1.7 kg B/ha. Plants not fertilized with boron, but well-watered produced 36 and 60 percent more dry matter than either fertilized or unfertilized plants which were under water stress, respectively.

Although differences in dry weights between boron fertilized and unfertilized plants under water stress were minimal, there were significant differences in seedling survival rates as the soil dried. (Figure 3). Twenty-five percent of the sub clover plants in zero boron treatments were dead on day 21, and all had died by day 31. Boron fertilized sub clover did not begin dying until day 31, and all were dead by day 44. Similar

results were noted for rose clover. Fertilized and unfertilized well-watered plants were maintained at a constant soil moisture level, and all seedlings survived until the end of the study (data not shown).

Again, typical boron-deficiency symptoms were observed for non-boron fertilized sub clover seedlings at both soil moisture levels. Plants were stunted, and leaves exhibited a bluish-green color and were thickened and wrinkled. Fertilized, well-watered plants were lush and growing vigorously. Fertilized plants under water stress did not exhibit boron-deficiency symptoms but were much smaller than their well-watered counterparts.

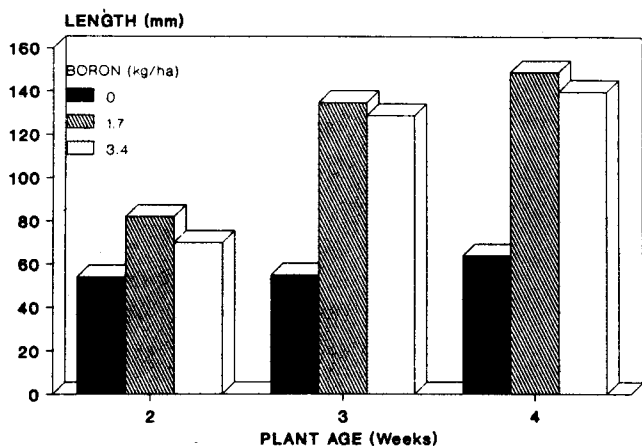


Figure 2.a. Taproot length.

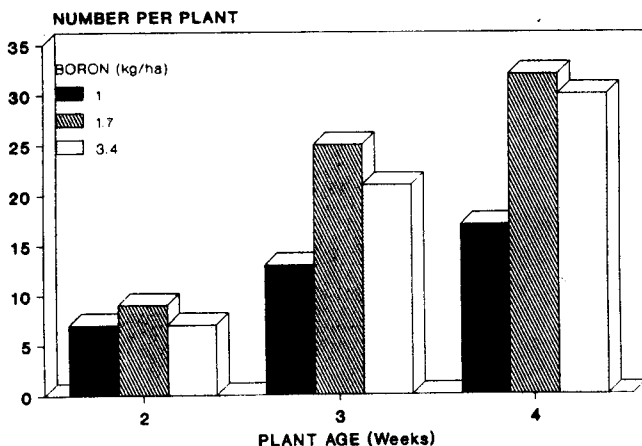


Figure 2.b. Total lateral roots.

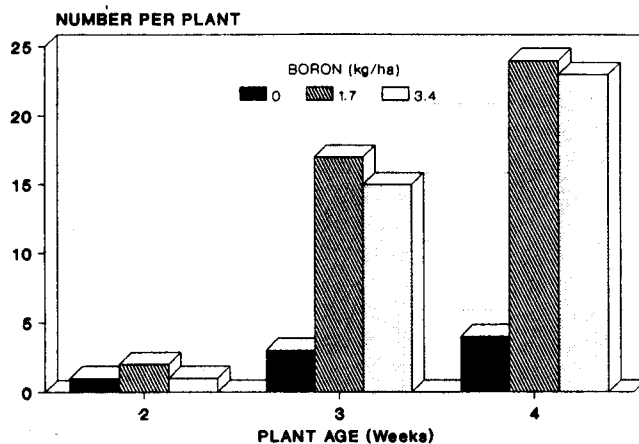


Figure 2.c. Lateral roots > 10mm.

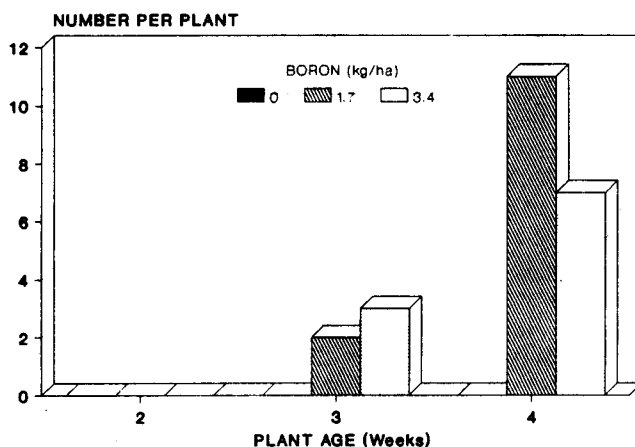


Figure 2.d. lateral roots > 30 mm.

Experiment 3. Boron fertilizer, whether applied at 1.1, 2.2, or 3.4 kg/ha, significantly increased some aspect of root growth compared to unfertilized controls for all clover species tested (Fig.4). Hairy vetch did not exhibit enhanced root growth. However, vetch seedling survival was significantly increased by boron, and improved with higher rates. Seedling survival also increased for berseem and sub clovers fertilized with boron.

All clovers possessed longer roots and more lateral roots over 30 mm when fertilized with boron. Except for sub and rose clovers, all clovers fertilized with boron had a greater

improved maintenance of reseeded annual clover stands when boron deficiencies were corrected. The objectives of this research were: 1) to evaluate the effects of boron on seedling establishment of annual clover, and 2) to evaluate the relationship between seedling drought tolerance and boron amendments.

Procedure

The pH of the Lilbert loamy fine sand used in these greenhouse experiments was 5.5. Potassium and phosphorus levels were very low, according to soil test. Calcium was added to the soil as hydrated lime at a rate of 1,232 kg/ha. Phosphorus and potassium were added as KH_2PO_4 at the rates of 107 and 113 kg/ha, respectively. The soil was air-dried, screened through a 0.63 cm screen, mixed, and weighed into individual 15-cm plastic pots, each receiving 2,200 g of soil. Mineral amendments were added on a soil weight basis.

Experiment 1. Boron (B) was mixed into individual pots at the rate of 0, 1.7, or 3.4 kg B/ha. Pre-germinated 'Mt. Barker' subterranean (*Trifolium subterraneum* L.) clover seed was planted 2 February 1989. Plants were thinned to nine plants per pot after 1 week. Plants were harvested at 2, 3, or 4 weeks. The 3 x 3 factorial treatment combinations were arranged in a randomized complete block design (RCB) with four replications. Taproot length, number of lateral roots, number of lateral roots over 10 mm, and number of lateral roots over 30 mm were recorded at each date. Plants were dried at 60°C for 2 days for shoot and root dry matter yield determinations.

Experiment 2. Boron was incorporated into individual pots at the rate of 0 or 1.7 kg B/ha. Pre-germinated seed of Mt. Barker subterranean (sub) and 'H-18' rose clover (*T. hirtum* All.) was sown on 17 February 1989. Plants were thinned after 1 week (n = 8 to 10 per pot). Pots were watered to 2,330 g and maintained at approximately this soil moisture level for 10 days. After 10 days, half of the pots were designated to receive no water for the remaining course of the study, and the remainder were maintained at an adequate soil moisture level (pot weight = 2,400 g). The 2x2x2 factorial treatment combinations were arranged in a RCB design with three replications. Pot weights were recorded periodically and plant deaths were noted. Plant shoots were harvested after death occurred and recorded. When all plants from the water-stressed treatments died, the study was terminated, and plants from well-watered treatments were also harvested.

Experiment 3. Boron was mixed into the soil on a soil weight basis at the rate of 0, 1.1, 2.2, and 3.4 kg B/ha. Pre-germinated seed of the legume varieties were sown 27 March 1989. Legume varieties used were Dixie crimson, Yuchi arrowleaf, Common ball, Bigbee berseem, RH-18 rose, Hairy vetch, and Mt. Barker sub. The 4x7 factorial treatment combinations were arranged in a RCB design with four replications. Plants were thinned after 1 week (n = 2 to 8 per pot). Pots were adequately watered for 28 days at which time the experiment was terminated. Measurements were taken at the close of the experiment on four replications on root length and shoot and root dry matter yield determination. Additional measurements obtained on two replications were number of lateral roots, number of lateral roots over 10 mm,

and number of lateral roots over 30 mm. Plant shoots and roots were dried at 60°C for 2 days for dry matter determination.

Results and Discussion

Experiment 1. Boron fertilizer significantly increased root, and to a lesser degree, shoot dry weights of sub clover seedlings when compared to unfertilized plants (Figure 1). These positive effects on growth were evident when plants were 3 weeks old; by 4 weeks, root dry weights of plants fertilized with 1.7 or 3.4 kg B/ha were nearly twice that of unfertilized controls. Shoot dry weights at 4 weeks were 14 and 20 percent greater for plants fertilized with 1.7 or 3.4 kg B/ha, respectively, than plants which received no boron.

The increased root mass was due to increases in taproot length, and number and size of lateral roots (Figure 2). Taproot lengths were already significantly longer at 2 weeks for boron fertilized plants and this difference was amplified by 4 weeks. Taproots of unfertilized plants grew an average of only 10 mm in 2 weeks, while those of plants receiving 1.7 or 3.4 kg B/ha grew 67 and 70 mm, respectively. The total number of lateral roots was higher in treatments with boron than in minus boron. A similar effect was observed for the

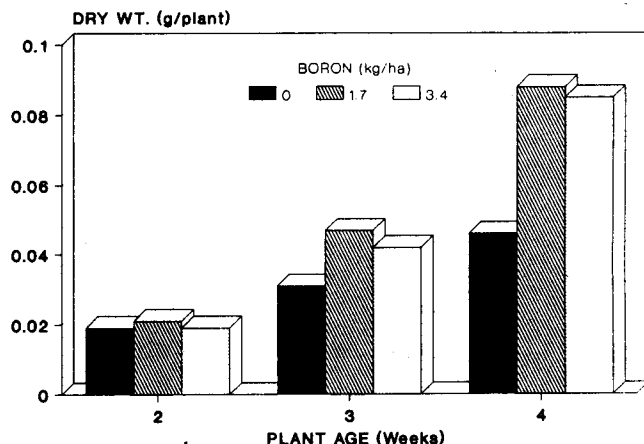


Figure 1.a. Average root dry weight.

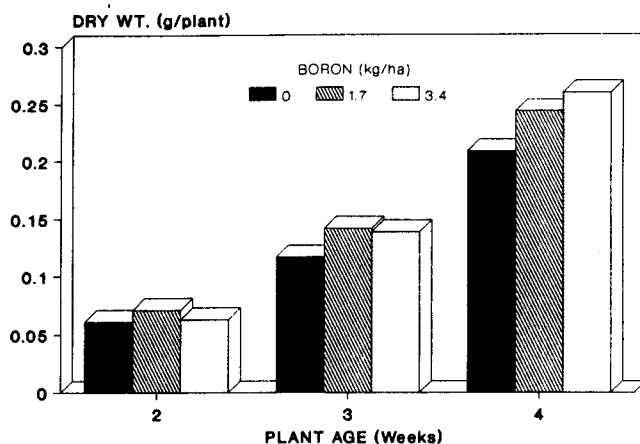


Figure 1.b. Average shoot dry weight.

number of total lateral roots. Fertilized sub clover plants also had more lateral roots but the differences between these and unfertilized plants were not significant. In contrast, rose clover plants fertilized with boron grew significantly fewer lateral roots than unfertilized controls. The number of lateral roots between 10 and 30 mm in length increased when clover

plants were fertilized with boron, except for rose and arrowleaf clovers. Only crimson and berseem clovers did not produce more shoot dry weight when fertilized with boron. Crimson, rose, and sub clovers were the only species with significantly higher root dry weights when fertilized with boron. Although differences were not significant for the other

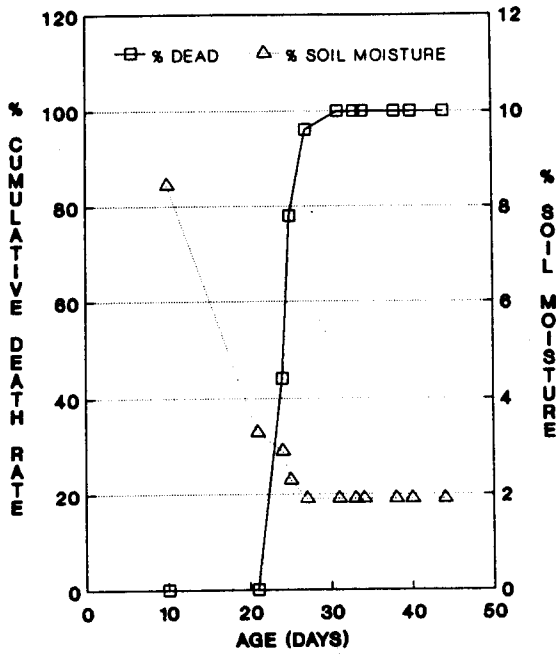


Figure 3.a. Rose Clover - Boron 0 kg/ha.

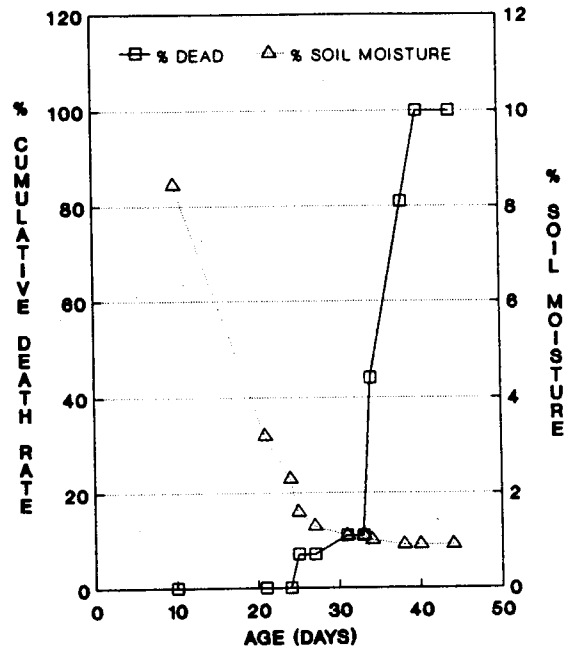


Figure 3.b. Rose Clover - Boron 1.7 kg/ha.

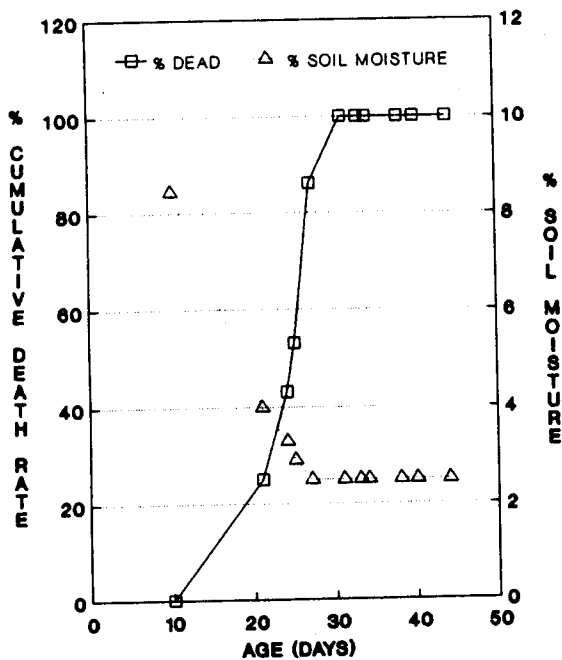


Figure 3.c. Sub Clover - Boron 0 kg/ha.

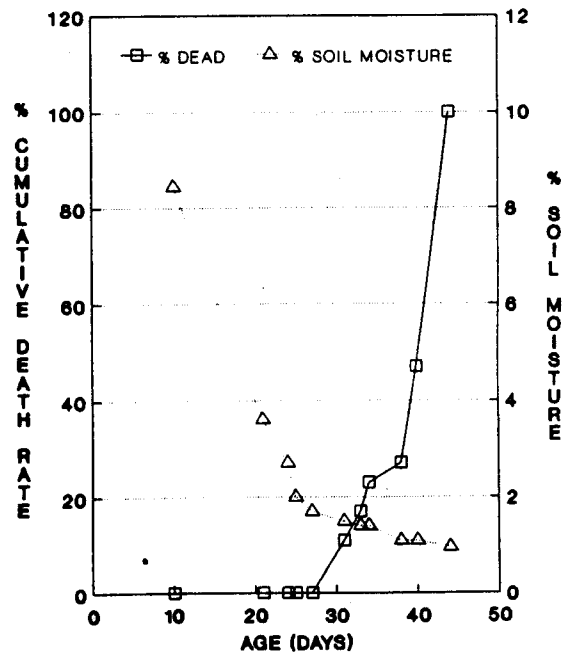


Figure 3.d. Sub Clover - Boron 1.7 kg/ha.

species, the root dry weights were smaller for unfertilized plants.

Our studies show that boron is crucial for annual clover seedling establishment, growth and survival. Boron applied at 1.7 kg/ha pre-planting resulted in dramatically larger plants under conditions of adequate water supply. Plants fertilized with boron were also more drought tolerant than unfertilized

plants. Annual clover forage production depends on successful seedling establishment. Amending the soil with boron before planting helps ensure greater seedling survival under drought conditions and improves early seedling growth and establishment.

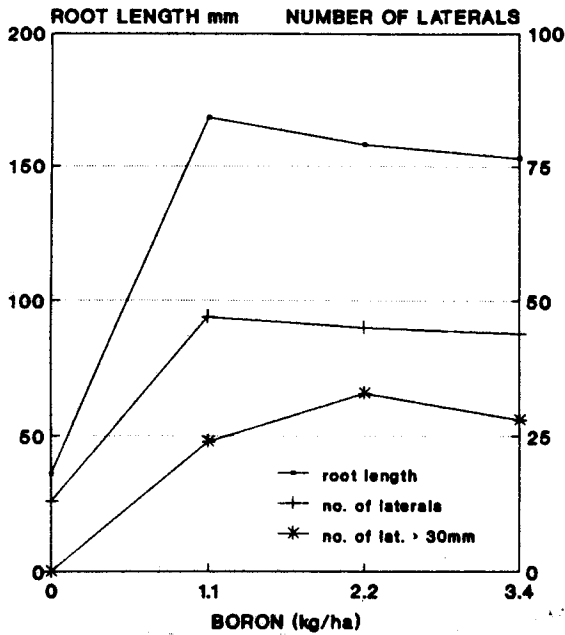


Figure 4.a. Effects of boron on root growth of arrowleaf clover at 4 weeks.

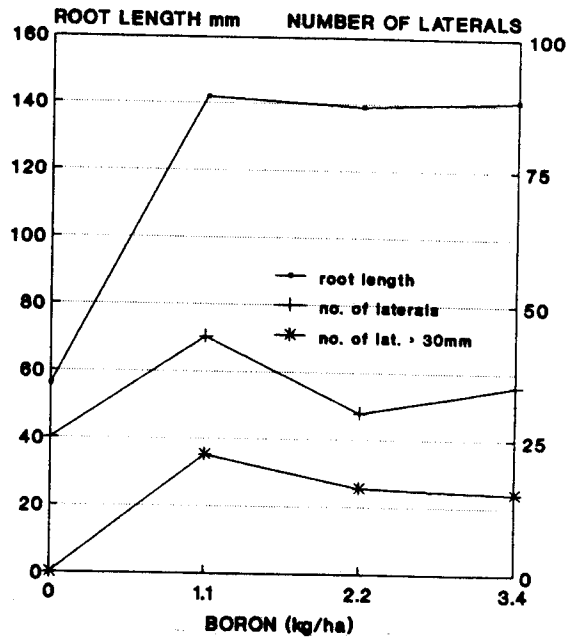


Figure 4.b. Effects of boron on root growth of ball clover at 4 weeks.

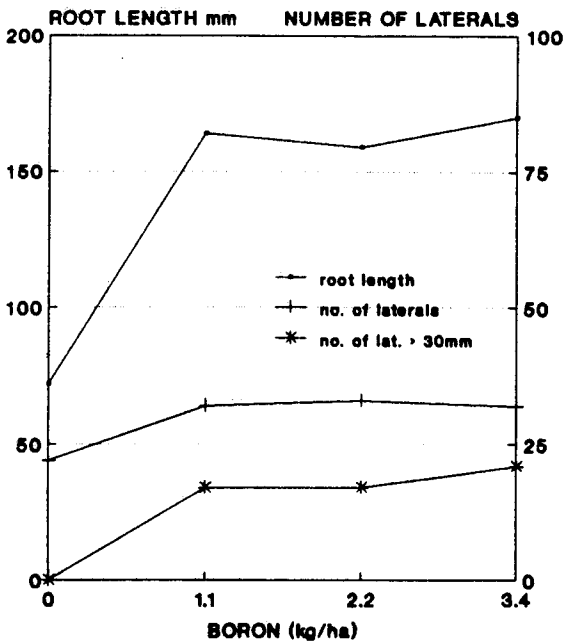


Figure 4.c. Effects of boron on root growth of berseem clover at 4 weeks.

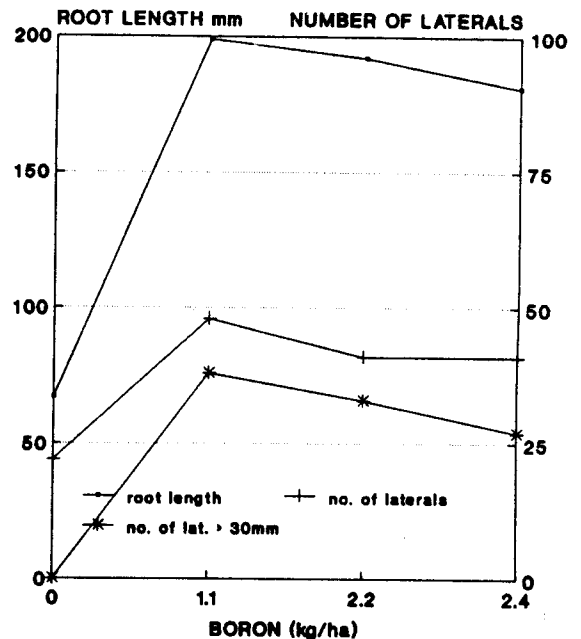


Figure 4.d. Effects of boron on root growth of crimson clover at 4 weeks.

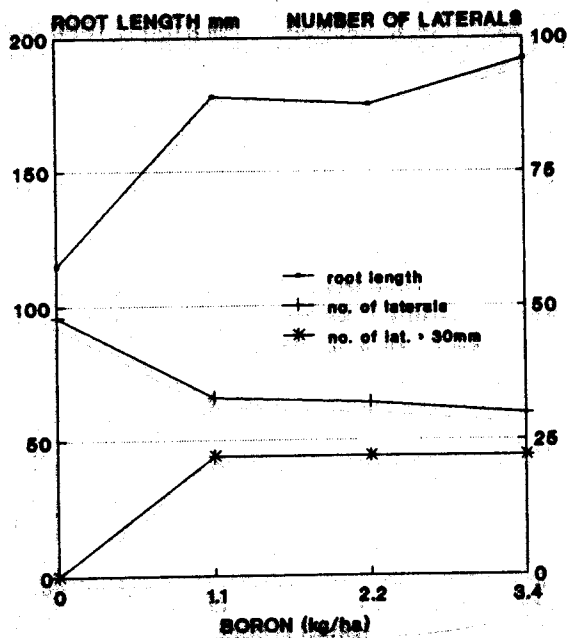


Figure 4.e. Effects of boron on root growth of rose clover at 4 weeks.

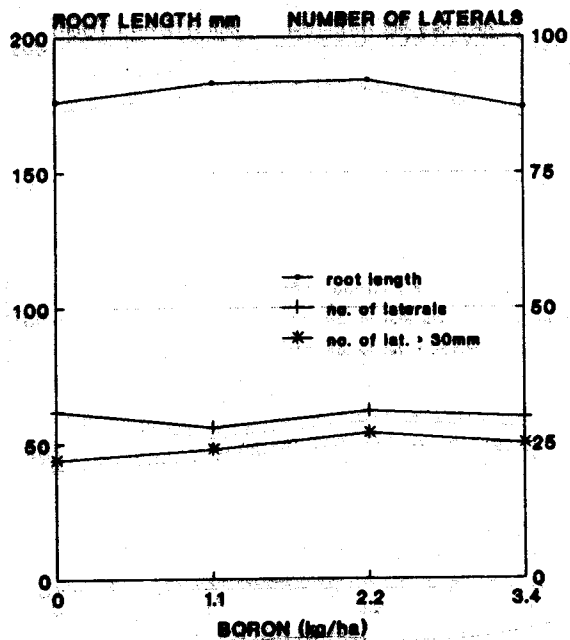


Figure 4.g. Effects of boron on root growth of hairy vetch at 4 weeks.

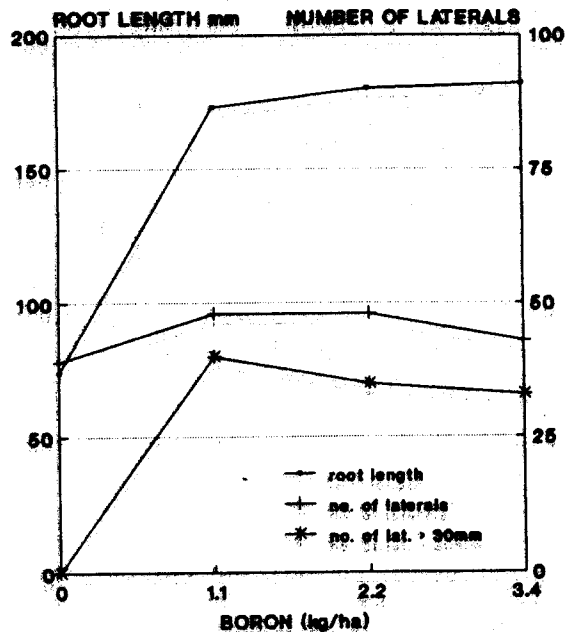


Figure 4.i. Effects of boron on root growth of sub clover at 4 weeks.