PUBLICATIONS
1990

EFFECTS OF BORON ON SEEDLING ESTABLISHMENT OF ANNUAL LEGUMES

G. R. Smith, C. L. Gilbert, and I. J. Pemberton

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 two 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 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 improved maintenance of reseeding 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.

PROCEDURES

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 1380 lbs/ac. Phosphorus and potassium were added as KH_2PO_4 at the rates of 120 and 127 lbs/ac, respectively. The soil was air-dried, screened through a 0.25 in screen, mixed, and weighed into individual 6-in plastic pots, each receiving 4.8 lbs of soil. Mineral amendments were added on a soil weight basis. Soil boron content was analyzed before and after addition of fertilizer boron. In all experiments, boric acid was the boron source.

Experiment 1. Boron (B) was mixed into individual pots at the rate of 0, 1.5, or 3.0 lbs B/ac. Pre-germinated 'Mt. Barker' subterranean clover seed was planted 2 February 1989. Plants were thinned to nine plants per pot after one week. Plants were harvested at 2, 3, or 4 weeks. The 3x3 factorial treatment combinations were arranged in a randomized complete block design (RCB) with 4 replications. Taproot length, number of lateral roots, number of lateral roots over 0.4 in, and number of lateral roots over 1.2 in were recorded at each date. Plants were dried at 140°F 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 1.5 lbs B/ac. Pre-germinated seed of Mt. Barker subterranean (sub) and 'H-18' rose clover was sown on 17 February 1989. Plants were thinned after one week (n = 8 to 10 per pot). Pots were watered to field capacity (5.3 lbs) and maintained at approximately this soil moisture level for ten days. After ten days, half of the pots were designated to receive no water for the remaining course of the study, and the remainder were maintained at field capacity (average pot weight = 5.28 lbs). The 2x2x2 factorial treatment combinations were arranged in a RCB design with 3 replications. Pot weights were recorded periodically and any plant deaths 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 field capacity treatments were also harvested.

Experiment 3. Boron was mixed into the soil on a soil weight basis at the rate of 0, 1.0, 2.0, and 3.0 lbs B/ac. Pre-germinated seed of the legume varieties were sown 27 March 1989. Legume varieties used were 'Dixie' crimson, 'Yuchi' arrowleaf, 'Common' ball, 'Bigbee' berseem, H-18 rose, 'Hairy' vetch, and Mt. Barker sub. The 4x7 factorial treatment combinations were arranged in a RCB design with 4 replications. Plants were thinned after one week (n = 2 to 8 per pot). Pots were watered to maintain field capacity for 28 days at which time the experiment was terminated. Measurements taken at the close of the experiment on four reps were root length, shoot and root dry matter yield. Additional measurements obtained on two reps were number of lateral roots, number of lateral roots over 0.4 in, and number of lateral roots over 1.2 in. Plant shoots and roots were dried at 140°F 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 three weeks old; by four weeks, root dry weights of plants fertilized with 1.5 or 3.0 lbs B/ac were nearly twice that of unfertilized controls. Shoot dry weights at four weeks were 14 and 20 percent greater for plants fertilized with 1.5 or 3.0 lbs B/ac, 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 two weeks for boron fertilized plants and this difference was amplified by four weeks. Taproots of unfertilized plants grew an average of only 0.4 in. in two weeks, while those of plants receiving 1.5 or 3.0 lbs B/ac grew 2.6 and 2.7 in, respectively. The total number of lateral roots was higher in treatments with boron than in minus boron. A similar effect was observed for the number of lateral roots over 0.4 in and over 1.2 in. in length. In most cases, the 3.0 lbs B/ac 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 non-water-stressed plants receiving 1.5 lbs B/ac. Plants not fertilized with boron, but non-water-stressed 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 non-water-stressed 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, 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.

Experiment 3. Boron fertilizer, whether applied at 1.0, 2.0, or 3.0 lbs/ac, 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 1.2 in when fertilized with boron. Except for sub and rose clovers, all clovers fertilized with boron had a greater number of total lateral roots. Rose clover plants fertilized with boron grew significantly fewer lateral roots than unfertilized controls. The number of lateral roots between 0.4 and 1.2 in long 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 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 1.5 lbs/ac 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. These dramatic effects were the result of the correction of soil boron deficiency. The native boron level of less than 0.3 ppm B was corrected to 0.8 - 1.0 ppm B by the addition of 1.5 lbs B/ac (Table 1). Annual clover forage production depends on successful seedling establishment. Correcting boron soil deficiency before planting helps ensure greater seedling survival under drought conditions and improves early seedling growth and establishment.

TABLE 1. EFFECT OF BORON FERTILIZER RATES ON SOIL BORON LEVEL FOR A LILBERT FINE SANDY LOAM SOIL UNDER GREENHOUSE CONDITIONS

Experiment #	Boron† rate	Soil Test Boron 2 week sampling	Soil Test Boron 4 week sampling
	lbs B/ac	ppm B	ppm B
1	0.0	0.300‡	0.234
1	1.5	0.840	0.890
1	3.0	1.410	1.532
3	0.0	---	0.312
3	1.0	---	0.852
3	2.0	---	1.000
3	3.0	---	1.360

†Boric acid was boron source.

‡The following scale is used by TAEX Soil Testing Laboratory to rate soil boron (ppm) levels: 0-0.4 = poor; 0.5-0.9 = fair; 1.0-2.4 = good; 2.4-4.9 = high; and >5.0 = toxic.

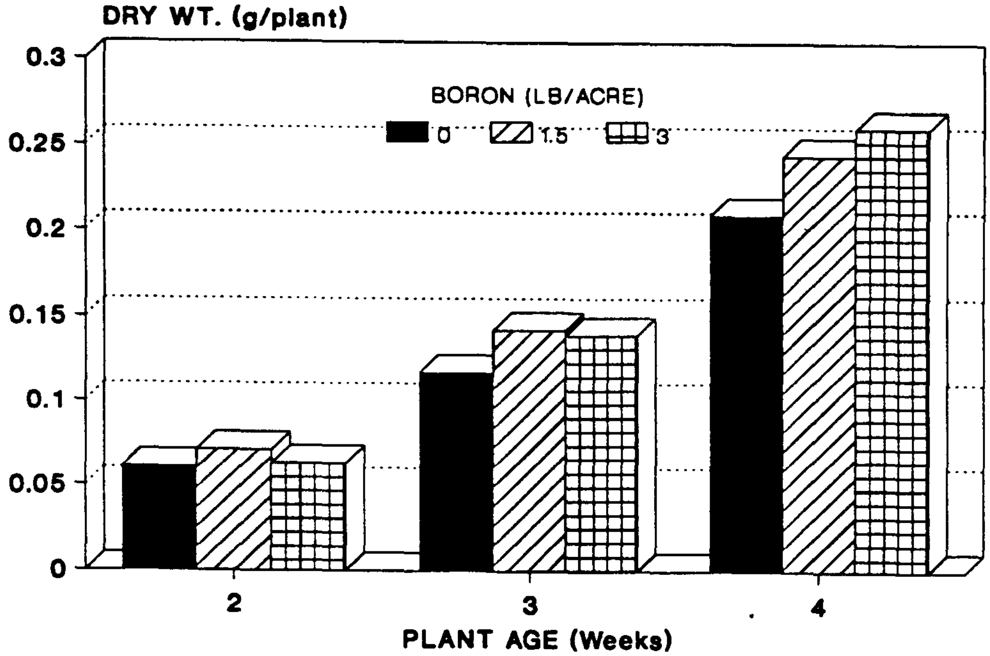

FIGURE 1.b. AVERAGE SHOOT DRY WEIGHT

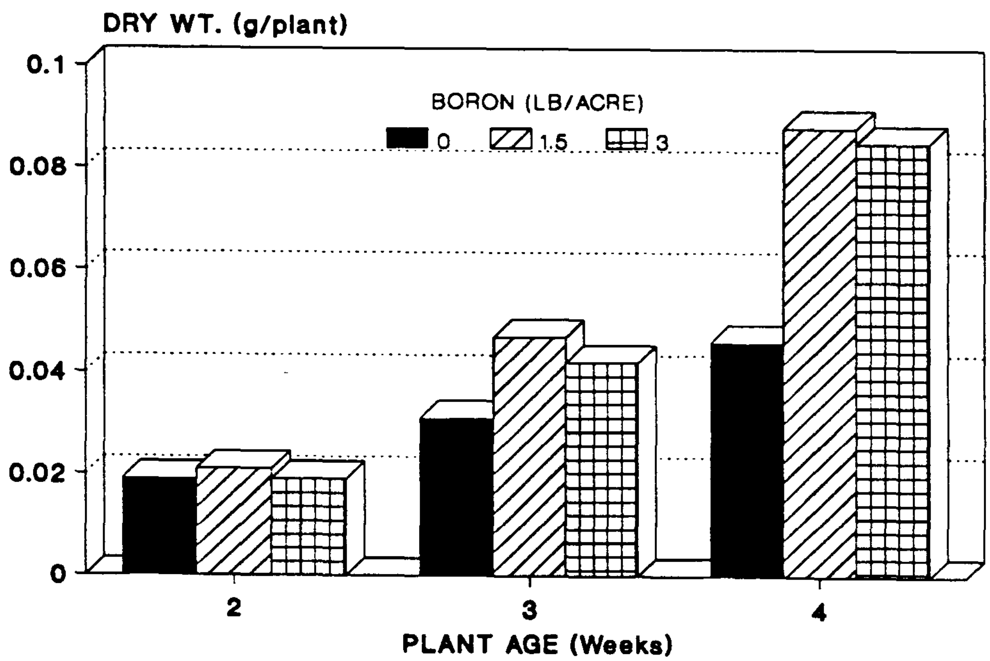

FIGURE 1.a. AVERAGE ROOT DRY WEIGHT

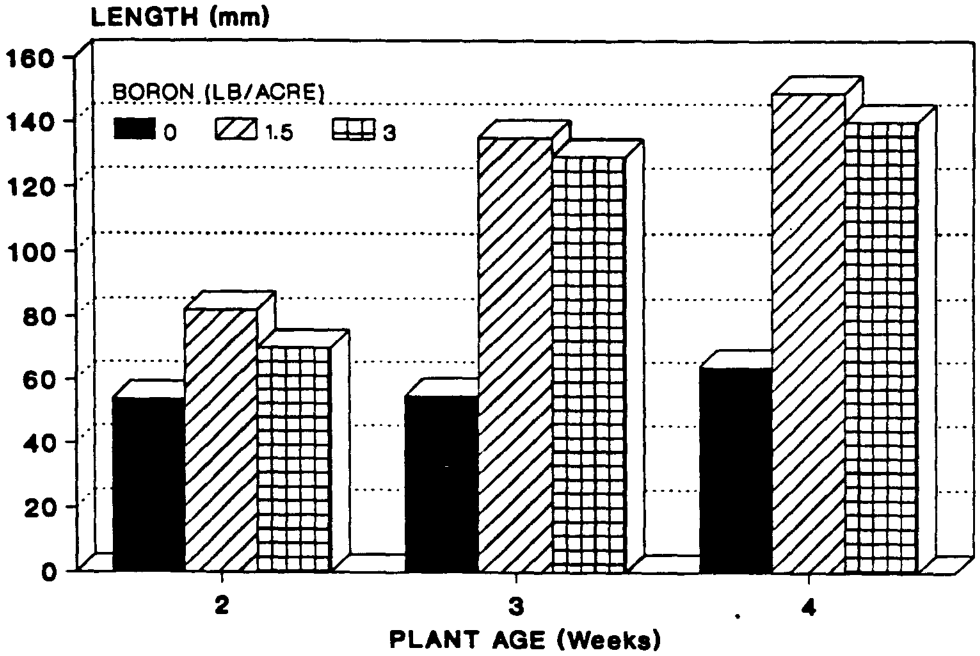

FIGURE 2.a. TAPROOT LENGTH

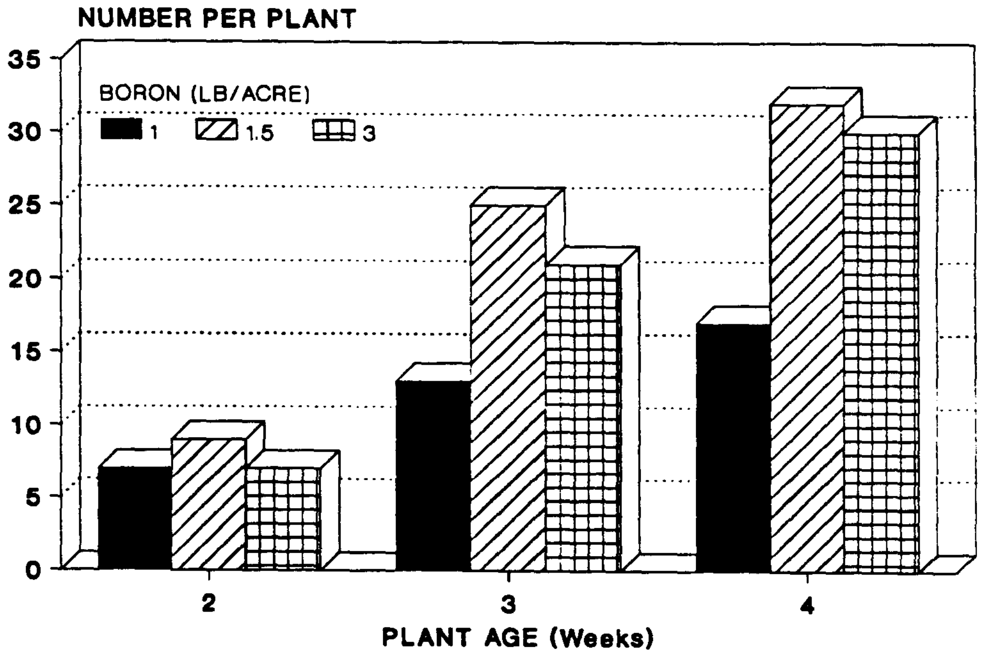

FIGURE 2.b. TOTAL LATERAL ROOTS

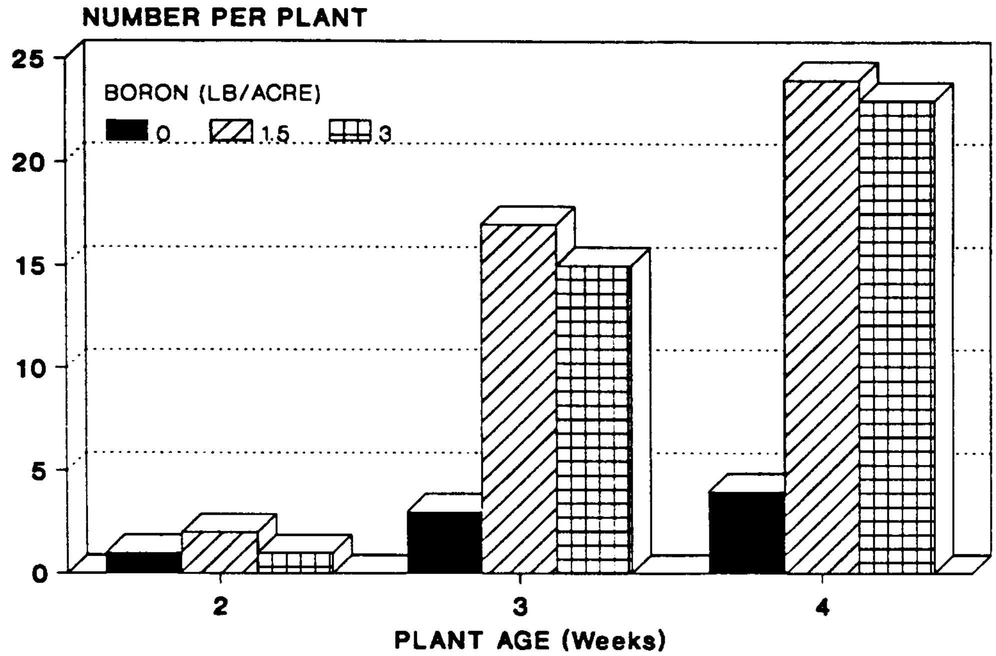

FIGURE 2.c. LATERAL ROOTS › 10 mm

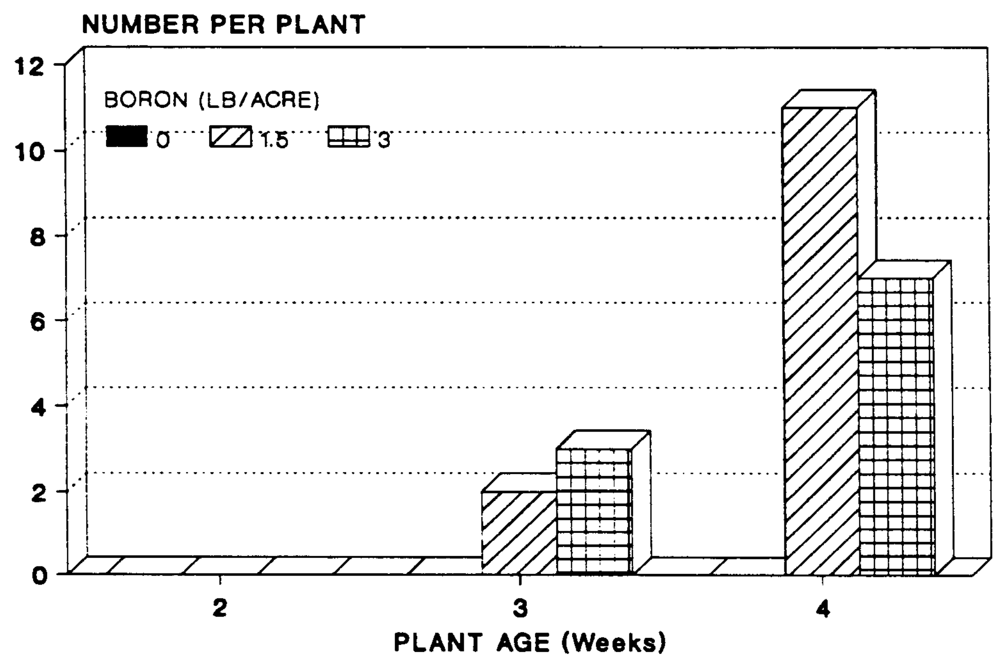

FIGURE 2.d. LATERAL ROOTS › 30 mm

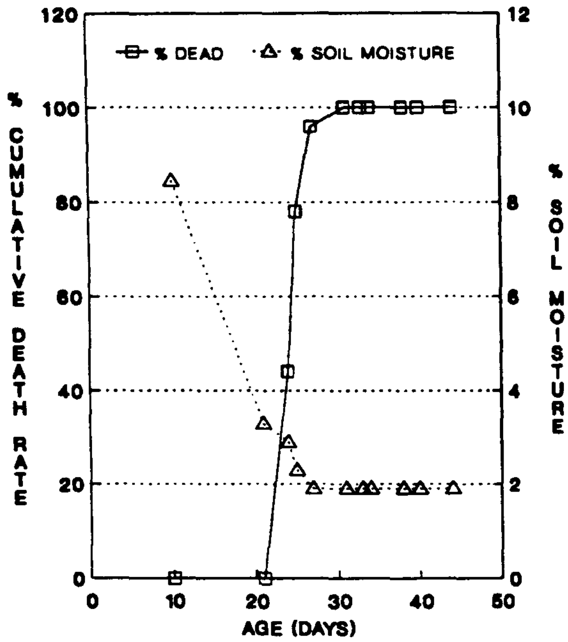

FIGURE 3.a. ROSE CLOVER - BORON 0 LB/AC

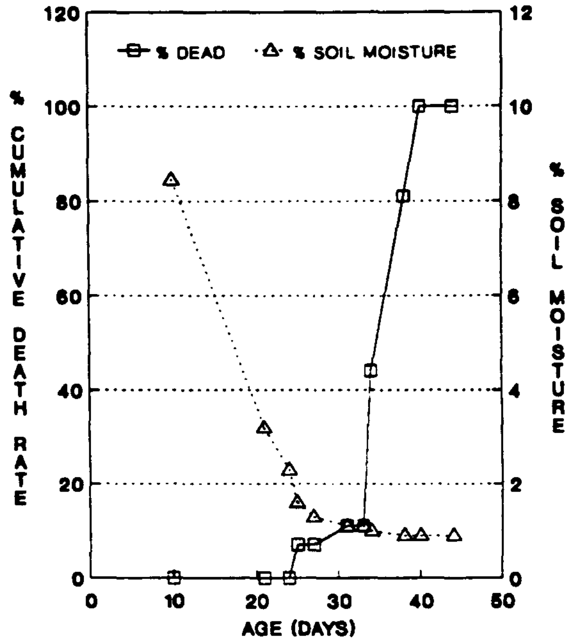

FIGURE 3.b. ROSE CLOVER - BORON 1.5 LB/A

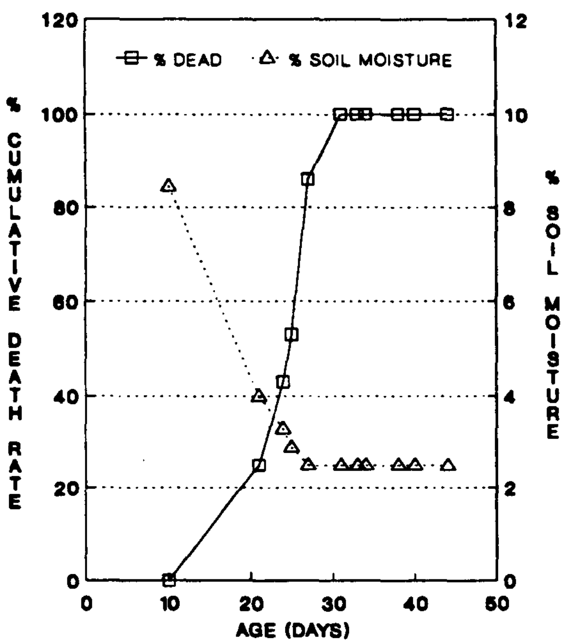

FIGURE 3.c. SUB CLOVER - BORON 0 LB/A

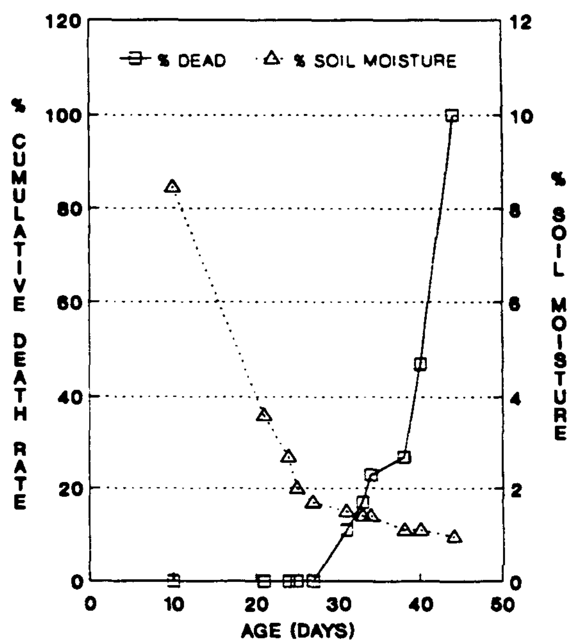

FIGURE 3.d. SUB CLOVER - BORON 1.5 LB/A

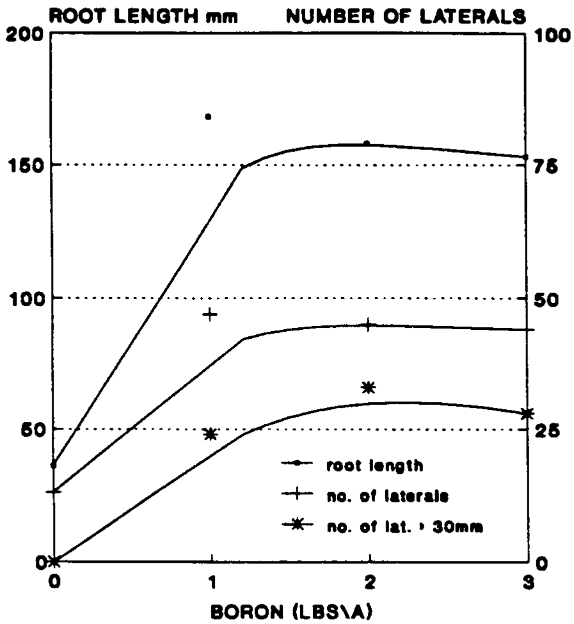

FIG. 4.a. EFFECTS OF BORON ON ROOT GROWTH OF ARROWLEAF CLOVER AT 4 WKS

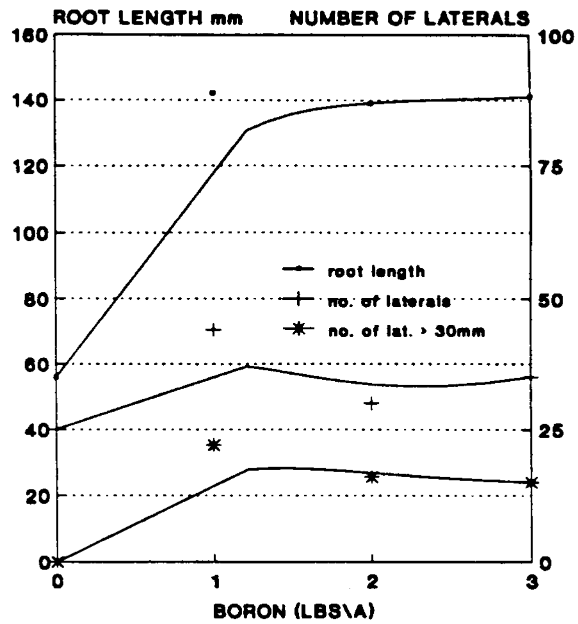

FIG. 4.b. EFFECTS OF BORON ON ROOT GROWTH OF BALL CLOVER AT 4 WEEKS

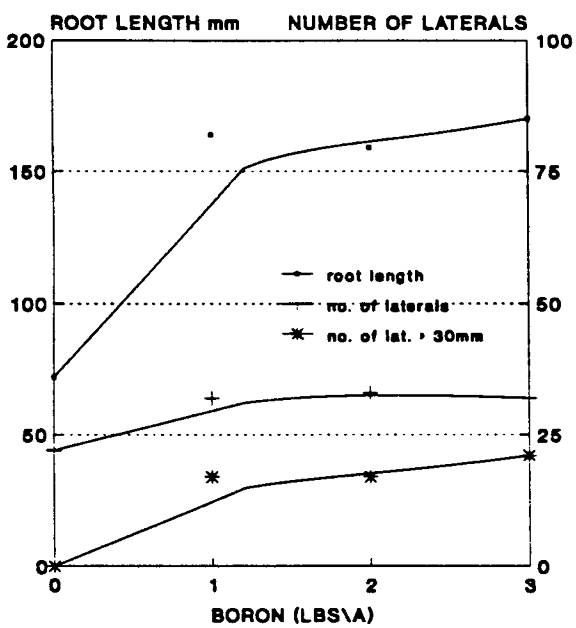

FIG. 4.c. EFFECTS OF BORON ON ROOT GROWTH OF BERSEEM CLOVER AT 4 WEEKS

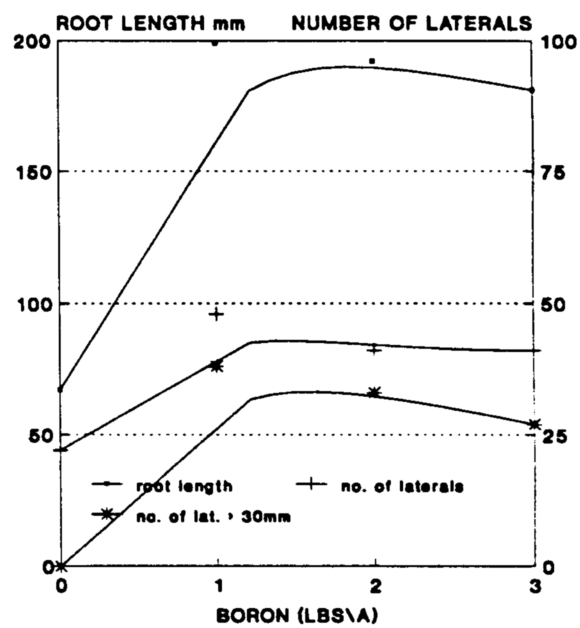

FIG. 4.d. EFFECTS OF BORON ON ROOT GROWTH OF CRIMSON CLOVER AT 4 WEEKS

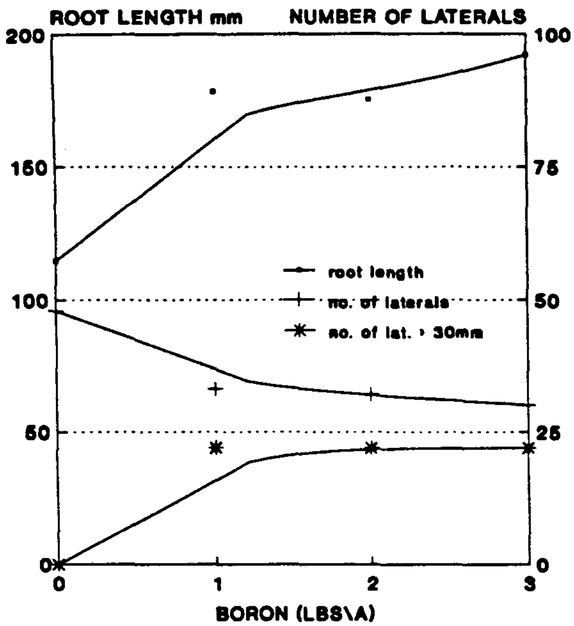

FIG. 4.e. EFFECTS OF BORON ON ROOT GROWTH OF ROSE CLOVER AT 4 WEEKS

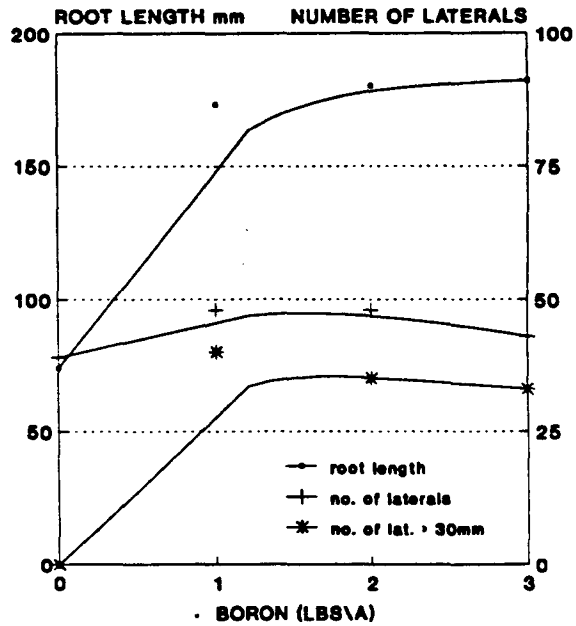

FIG. 4.f. EFFECTS OF BORON ON ROOT GROWTH OF SUB CLOVER AT 4 WEEKS

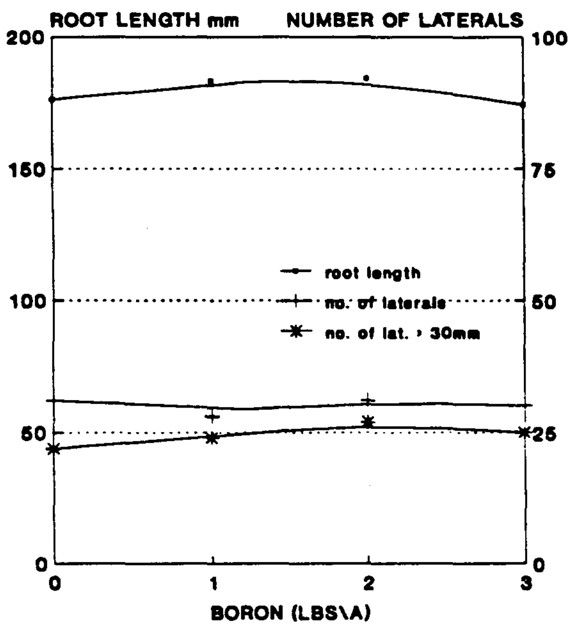

FIG. 4.g. EFFECTS OF BORON ON ROOT GROWTH OF HAIRY VETCH AT 4 WEEKS