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Pressurized Hot Water and DTPA-Sorbitol, Viable Alternatives for Soil Boron Extraction

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PRESSURIZED HOT WATER AND DTPA-SORBITOL,

VIABLE ALTERNATIVES FOR SOIL

BORON EXTRACTION

by

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GRADUATE COMMITTEE APPROVAL

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This thesis has been read by each member of the following graduate committee and by majority vote has been found to be satisfactory.

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ABSTRACT

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Pressurized hot water and DTPA-Sorbitol are two relatively new soil boron (B) extraction methods with potential to replace the cumbersome hot water extraction. The objective of this research is to produce data in support of acceptance or rejection of these two alternative B extractions. The three soil tests were used to extract B from samples of calcareous sand and silt loam and limed, loamy fine sand treated with 10 levels of B and incubated for 7 and 28 d. As B application increased so did extractable B with each extraction method. High correlations (r of 0.977 to 0.999) were observed between extractable B and rate of B application with all three methods. Hot water generally extracted the least and pressurized hot water the most B regardless of soil type, rate of application or duration of incubation. Greenhouse and field experiments were conducted on one limed acid and two alkaline soils naturally low in B to test alfalfa response to B fertilizer. Values from the three soil extraction methods were correlated to yield, B tissue concentration and total B removal of alfalfa. In greenhouse studies with varying levels of soil applied B, highly significant relationships exist between extractable soil B and both tissue B concentration and total B removal. Correlations between yield and extractable soil B were impossible to obtain because of a lack of alfalfa yield responses to applied boron. All three methods accurately predict plant B tissue concentrations and total B removal. The field experiment produced a significant positive relationship between total alfalfa yield and extractable B using hot water and pressurized hot water extractions, but not using DTPA-Sorbitol. The results observed in this research support pressurized hot water extraction as the better of the two alternatives to replace hot water extraction in a broad range of soil types.

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(prepared for submission to Communications in Soil Science and Plant Analysis)

PRESSURIZED HOT WATER AND DTPA-SORBITOL, VIABLE ALTERNATIVES FOR SOIL BORON EXTRACTION. I. BORON-TREATED SOIL INCUBATION AND EFFICIENCY OF EXTRACTION

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ABSTRACT

Serious challenges associated with hot water extraction, the standard extraction method for water soluble boron (B), limit its use in commercial soil testing laboratories. Several alternatives to make B testing more practical have been proposed and studied; none of the alternatives have readily replaced the hot water method. Two relatively new, promising B extraction methods are pressurized hot water and DTPA-Sorbitol. Very little reported work compares B extraction values obtained from the standard hot water extraction method and these two alternative methods. This study was conducted to complete an initial step in validating new procedures – extracting the designated nutrient from fertilized, incubated soils using standard and alternative extraction methods and comparing the resulting values. The three extraction methods were used to extract B from samples of calcareous sand and silt loam soils and limed, loamy fine sand, all which had been treated with 10 levels of B (0 to 8 mg kg^{-1}) and incubated for 7 and 28 d. The amount of B extracted increased as the rate of B application increased with all three soil extraction methods. High correlations (r of 0.977 to 0.999) were observed between extractable B and rate of B application with all three procedures. Correlations between the amount of extractable B using hot water extraction method and the value obtained with an alternative extraction method were similar for both methods (r = 0.89). Hot water generally extracted the least and pressurized hot water the most B regardless of soil type, rate of application or duration of incubation. This study suggests the more easily used methods of pressurized hot water and DTPA-Sorbitol could be recommended as replacements to the cumbersome hot water extraction.

INTRODUCTION

Boron (B) is found in the soil as five major fractions: primary minerals such as tourmaline and B rich micas, secondary minerals within clay lattices, adsorbed on surfaces of clays and organic matter, within organic matter and microbial biomass, and in soil solution as boric acid (1). Total B in soils typically ranges from 20 – 200 mg kg^{-1} (2), the major determining factor being parent material. Although the plant available fraction is small, ranging from 0.4 to 5.0 mg B kg^{-1} (3), these quantities generally meet the needs of agronomic crops. Most agronomic crops exhibit a deficiency response when the soil available concentration is less than 0.4 mg B kg^{-1} and a toxicity response when the concentration exceeds 1.0 mg B kg^{-1} (3, 4). Boron availability is modified by factors such as pH, soil texture, soil moisture, temperature, oxide minerals, clay mineralogy, calcium carbonate and organic matter (5, 6, 7, 8).

As with most other soil tests, i.e. phosphorus, potassium, copper, iron, manganese and zinc, soil B tests must determine nutrient status of the soil relative to plant needs under a wide range of conditions. Soil B tests must estimate both deficient and toxic levels for plant species differing in B requirement or sensitivity. Currently, the standard plant available soil B test is a hot water extraction method (9, 10) that measures water soluble B. This method has various challenges that result in inconsistent or sporadic use by many soil testing laboratories. Some of these challenges include: B contamination from glassware, limited number of samples run at one time, inconsistency in refluxing time and lack of repeatable results. The sporadic use of the hot water extraction method causes B fertilizer application in many cases to be based on estimation of soil B rather than actual assessment. The use of a simpler B extraction would address these problems.

As the factors that limit B availability vary among soils, so does the effectiveness of various soil extraction methods. Different extracting agents in the methods interact with various soil components and release differing fractions of available B. Nable et al. (4) suggested seven soil extracting agents for measuring the plant available fraction of B in soil: ammonium oxalate, saturation extract, hydrochloric acid (HCl), hot water extraction with variation and improvement, calcium chloride ($CaCl_2$), mannitol exchangeable, and ammonium bicarbonate diethylenetriaminepentaacetic acid (AB-DTPA). They also proposed that the three most effective alternative methods for use in laboratories in lieu of the hot water extraction were the hot $CaCl_2$, AB-DTPA and Mehlich-3 methods. The hot $CaCl_2$ method lacks the ability to measure released B in soils of differing characteristics and is more adapted to acid soils (11, 12, 13). Shuman et al. (14) noted that the Mehlich-3 procedure extracted available soil B comparable to the hot water extraction method, making it a more suitable alternative method. The highest correlation values between Mehlich-3 extractable B and hot water extractable B was observed in soils with a low pH. Simard et al. (15) suggested including the soil pH as a coefficient in the Mehlich-3 soil extraction method to predict B fertilizer recommendations of crops. Gestring and Soltanpour (16) proposed using AB-DTPA as a multi-element extraction method for B in arid, calcareous, western soils. This procedure requires the analysis of pH, percent organic matter and percent clay to correlate available soil B to plant growth responses (17). Matsi et al. (18) suggested including cation exchange capacity in the correlation to plant available soil B when using the AB-DTPA extraction method. Requiring additional soil analyses before plant uptake of B can be accurately estimated using the Mehlich-3 and AB-DTPA extraction methods (17, 18) increases time and expense of laboratory analysis.

Two recently introduced, simplified, alternative B extraction methods for use on alkaline soils are DTPA-Sorbitol (19) and pressurized hot water (20). Diethylenetriaminepentaacetic acid (DTPA) is broadly used to extract copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) (21, 22). Saccharides are effective chelators of B (23); hence sorbitol is an effective chelating agent and could be used for B extraction (24). The DTPA-Sorbitol extraction method combines 0.005 M diethylenetriaminepentaacetic acid and 0.2 M sorbitol. It offers multi-element extraction capability and simplicity, but requires monitoring of microbial contamination when used in routine analysis. The pressurized hot water extraction method was proposed for extraction of nitrate, sulfate, potassium, and phosphorus (25, 26) and water soluble B (20). This method extracts B as it forces boiling, pressurized distilled water through soil. It offers the advantages of simplicity, elimination of hazardous chemicals, speed and low cost.

Extraction values from both methods have been initially correlated to extraction values obtained with the hot water extraction method. Miller et al. (19) compared hot water and DTPA-Sorbitol extraction methods on 42 untreated (no B applied) soils ranging in physical and chemical properties and observed consistent, predictable linear relationships (r = 0.98). Webb et al. (20) compared hot water and pressurized hot water extraction methods on 40 untreated alkaline soils and observed predictable linear relationships (r = 0.83) among soil extractable B values obtained using the two methods. Studies of soils treated with levels of B comparing these three extraction methods have not been reported. The objective of this research was to correlate B extraction values obtained from each extraction method in three varied soil types, each type treated with 10 levels of B and incubated for 7 and 28 days in an attempt to validate the two alternative methods.

MATERIALS AND METHODS

Three soils (Hayeston sand, Minidoka silt loam and Darco loamy fine sand) were air dried (25 - 30°C), screened (5-mm) and mixed thoroughly to increase homogeneity. Two-hundred gram samples of Hayeston sand and Minidoka silt loam were placed into forty, 250-ml plastic bottles and then mixed with 0, 0.125, 0.25, 0.5, 1.0, 1.5, 2.0, 4.0, 6.0 and 8.0 mg B kg^{-1} (4 replications) using boric acid as the B source. In a second experiment conducted at a later time two-hundred gram samples of the Darco loamy fine sand were placed into forty, 250-ml plastic bottles, limed at the rate of 1000 mg kg^{-1} $CaCO_3$ $acre^{-1}$ using reagent grade $CaCO_3$ and then mixed with 0, 0.125, 0.25, 0.5, 0.75, 1.0, 1.5, 2.0, 4.0 and 8.0 mg B kg^{-1} (4 replications) using boric acid as the B source.

Following B application in both experiments, all samples were brought to field capacity using distilled water and the samples were placed in an incubator at 30°C for 7 and 28 days. After 7 days approximately half of the soil was removed from each bottle; the remaining sample was returned to the incubator for another 21 days. The subsamples taken after the 7-day incubation and the soil remaining after the 28-day incubation were air dried (25°C), screened (2-mm) and analyzed for available B by the three extraction methods.

Analysis of soil B was accomplished for the three extraction methods as described below. For hot water extraction method: 20 g of soil, 40 ml of distilled water and 0.5 ml of 10% $BaCl_2$ are placed in boiling water in sealed plastic pouches for 14 minutes; the extract is filtered through medium filter paper (9, 10). For pressurized hot water: boiling water (100 ml, 93˚ C) under 0.25 MPa pressure is forced through 5.0 g of soil placed on medium filter paper in the basket of an espresso machine; the extract is collected for 1-2 minutes (20). For DTPA-Sorbitol: 12.5 g soil and 25 ml 0.2 M DTPA-Sorbitol solution are mixed, shaken for two hours, centrifuged and filtered through medium filter paper (19). The filtrate from each extraction method was analyzed using Inductively Coupled Plasma Spectrometer (ICP; Thermo Jerrell Ash Corporation, Franklin, Maryland).

RESULTS AND DISCUSSION

As expected, increased B was extracted with all three methods as the rate of B application increased (Figure 1). Correlation coefficients between extractable B and rate of B application were high with all three procedures in all soil types -- r values ranged from 0.977 to 0.999 for hot water, from 0.994 to 0.999 for pressurized hot water and from 0.995 to 0.999 for DTPA-Sorbitol. The most consistent correlation coefficients among extraction methods were found on the Darco loamy fine sand. Correlations between the amount of extractable B using hot water extraction method and the values obtained with the two alternative extraction methods were similar for both alternative methods ($r = 0.89$).

In general, the hot water extraction method extracted the least B and pressurized hot water the most B regardless of soil type, rate of B application or duration of incubation (Figure 1). The most B extracted was 5.6 mg kg^{-1} with hot water, 8.6 mg kg^{-1} with DTPA-Sorbitol and 15.4 mg kg^{-1} with pressurized hot water. This pattern of extraction among the methods is consistent with past studies conducted (20) on 40 untreated soils in which pressurized hot water always extracted more B than hot water. Pressurized hot water consistently extracted more B than was incorporated into the incubated samples. We have no explanation for the observation, but possible contamination from equipment, errors in application of B during experiment establishment and dilution factors during analysis have been considered. Regardless, the actual amount extracted is less important than the ability to predict the relationships between applied and extractable B and those were exceptional ($r = 0.994$ to 0.999). Miller et al. (19) reported that sorbitol concentration of 0.2 M was optimal for extraction in soils containing 2 mg kg^{-1} or less soil extractable B and suggested higher sorbitol concentrations would be required at high B contents to reach equilibrium. Our results suggest that 0.2 M sorbitol concentration generally extracts more B than the hot water extraction method and may be acceptable. Thus, increasing sorbitol concentration in the extracting solution to test high B soils may be unnecessary for routine analysis.

In all three soil types, the amount of extractable B measured by each of the three extraction methods was significantly different. This is easily visible at high B rates as the slope of the extractions are different for the three methods with pressurized hot water > DTPA-Sorbitol > hot water (Figure 1). In general, B extraction values after 28-days of incubation are significantly lower than after 7-days of incubation in all three soils (Table 1). The Darco loamy fine sand exhibited the most change in extraction values between 7 and 28 days. In this soil, B values from the three extraction methods decrease from those obtained at 7 days, suggesting B fixation occurred during the incubation period. This is likely associated with the actively reacting calcium carbonate initially applied to the samples to raise the pH to a desirable range just prior to incubation (pH change from 4.75 to 7.0). Boron adsorption is usually greater in soils having higher calcium carbonate contents (27, 28). Application of lime to acid soils can result in B deficiency symptoms; this is thought to be attributed to freshly released aluminum hydroxide scavenging soluble B (1), not to the change in pH. The two calcareous soils exhibit less change in extraction values from 7 to 28 days and values for the Hayeston sand do not differ with pressurized hot water and DTPA-Sorbitol. It appears that fewer soil-B reactions are taking place in the calcareous soils over time, especially in the Hayeston sand versus the limed acid soil. Although hot water extraction values decrease over time, pressurized hot water and DTPA-Sorbitol do not change as much or as consistently. Perhaps hot water extraction cannot measure B undergoing reactions, while the other two methods can. This is a promising aspect of the two new methods since hot water extraction is reported to under-extract B from soils (11, 29).

CONCLUSION

Correlation coefficients (r values) between extractable B and rate of B application for pressurized hot water (0.994 to 0.999) and DTPA-Sorbitol (0.995 to 0.999) were comparable to those obtained from hot water extraction (0.977 to 0.999). The correlations between B values obtained using the two alternative extraction methods and hot water were likewise comparable; in both cases r = 0.89. Both alternative procedures tested were similar in relating the amount of extracted versus rate of B application. Due to the ease and relatively rapid nature of extracting soil available B with pressurized hot water and DTPA-Sorbitol, we recommend they be used in lieu of hot water extraction. Further research to correlate pressurized hot water extractable B, plant uptake and yield response is reported elsewhere (30).

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Table 1. P values comparing differences in soil B by three extraction methods for soil samples taken after 7-day and 28-day incubation. NS not significant at $\alpha = 0.05$; *Significant at $\alpha = 0.05$; **Significant at $\alpha = 0.01$.

Extraction Method	Hayeston Sand	Minidoka Silt Loam	Darco Loamy Fine Sand
Hot Water	**	**	**
Pressurized Hot Water	NS	**	**
DTPA-Sorbitol	NS	*	**

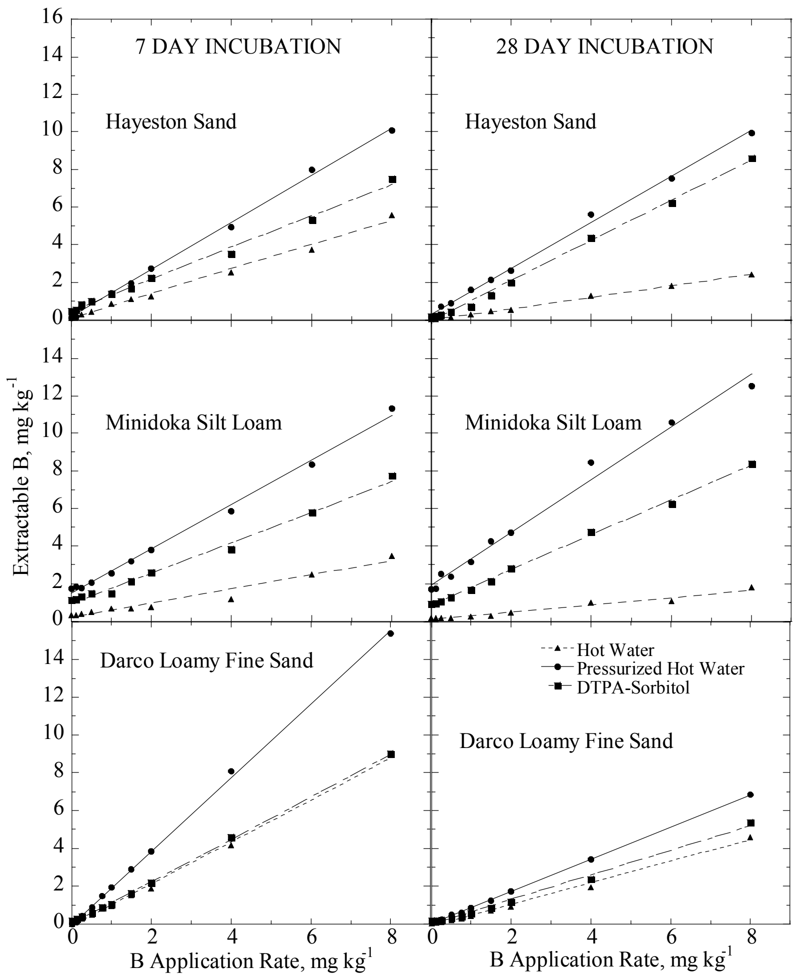

Figure 1. Effects of B application rates on soil B using hot water, pressurized hot water and DTPA-Sorbitol extractions on Hayeston sand, Minidoka silt loam and Darco loamy fine sand incubated for 7 and 28 days.

MANUSCRIPT #2 – PRESSURIZED HOT WATER AND DTPA-SORBITOL, VIABLE ALTERNATIVES FOR SOIL BORON EXTRACTION. II. CORRELATION OF SOIL EXTRACTION TO RESPONSES OF BORON-FERTILIZED ALFALFA

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ABSTRACT

Pressurized hot water and DTPA-Sorbitol are two relatively new, alternative soil boron (B) extraction methods that have initially shown significant correlation with the hot water extraction method in untreated soils as well as soils incubated with various levels of B. No data on yield or nutrient uptake have been reported to further validate the use of the two alternative extraction methods. The objective of the research was to extract soil samples of B-treated soils using all three extraction methods and correlate the obtained values to yield, B tissue concentration and total B removal of alfalfa (*Medicago sativa*). Greenhouse and field experiments on alkaline and limed acid soils naturally low in hot water extractable B were conducted to test alfalfa response to B fertilizer. In the greenhouse, highly significant relationships exist between plant uptake and extractable B with all three methods at varying levels of soil applied B, but no alfalfa yield response was observed. All three methods result in accurate predictions of plant B tissue concentrations and total B removal. The field experiment exhibits a significant positive relationship between total alfalfa yield and extractable B using hot water and pressurized hot water extractions. Extractable B using DTPA-Sorbitol was not related to total alfalfa yield in the field experiment. This work, coupled with the earlier incubation studies, supports the pressurized hot water extraction method as an improvement over hot water in diverse soil types. The lack of relationship in the acid soil supports DTPA-Sorbitol as an improvement over hot water in alkaline soils.

INTRODUCTION

Boron deficiency is the most widespread micronutrient deficiency observed throughout the world and affects almost all major crops. Due to its important plant functions, B is often a critical input for agricultural crops, especially for alfalfa production. Adequate B nutrition is important for high crop yields and quality. These factors and a high response to B fertilizer result in more B application to alfalfa than any other agronomic crop.

The complexity of boron in the plant and soil systems make it challenging to develop a soil B extraction method that can determine nutrient status relative to plant needs under a wide range of soil conditions for various plant species. There is minimal understanding of the role of B in plants due to contradictory results obtained in successive experiments. Clarification is difficult due to the following: plant requirement varies in relation to cell wall composition; mechanisms of B uptake are unclear; and B translocation within the plant varies among species. Boron availability in the soil is modified by numerous soil characteristics such as pH, texture, moisture, temperature, organic matter and clay mineralogy.

Determining B in soils is one of the most demanding and difficult soil tests routinely performed in laboratories (1). Currently, the hot water extraction method is the most widely used soil B test to estimate plant available B (1, 2). Despite numerous modifications (1, 3, 4), this procedure still presents many challenges that promote sporadic use among laboratories. The method is still time consuming and results are variable due to variations in boiling time and water temperature and loss of water during the procedure (5, 6). The sporadic use of the hot water extraction method causes B fertilizer application in many cases to be based on estimation rather than actual assessment. Practitioners desire alternative extraction methods that are easier to use to dissuade application of B fertilizers without a corresponding soil test value to base application rates. Numerous attempts have been made to identify suitable alternatives to hot water extraction – ammonium oxalate, saturation extraction, HCl, calcium chloride, mannitol exchangeable and ammonium bicarbonate-DTPA (7).

Two new alternatives for use in alkaline soils are DTPA-Sorbitol (8) and pressurized hot water (9). Diethylenetriaminepentaacetic acid (DTPA) is currently used in alkaline soils to extract the micronutrients copper, iron, manganese and zinc. Vaughan and Howe (10) demonstrated that sorbitol acts as an effective chelating agent for B and could be used for extraction. The DTPA-Sorbitol extraction method combines 0.005 M DTPA and 0.2 M sorbitol, offering simplicity and multi-element extraction capability. The main drawback of this method is it requires monitoring of DTPA-Sorbitol solution for microbial contamination when used in routine analysis. The pressurized hot water extraction method was developed to extract water soluble elements -- nitrate, sulfate, potassium, phosphorus (11, 12) and boron (9). This method extracts B as it forces boiling, pressurized distilled water through soil. Advantages of this procedure include multi-element extraction, simplicity, no hazardous chemical use, speed and low cost.

To validate DTPA-Sorbitol and pressurized hot water as alternative extraction methods, research is needed to compare them to the standard hot water extraction. Miller et al. (8) compared values from DTPA-Sorbitol extraction method to values using the hot water extraction method on 42 untreated soils, resulting in correlation of $r = 0.98$. Webb et al. (9) compared values from pressurized hot water to hot water in 40 untreated alkaline soils ($r = 0.83$) and developed a regression equation to convert pressurized hot water extraction values to hot water extraction values useable for fertilizer interpretation. Soil incubation experiments provided correlation between the amount of B applied to incubated soils and the amount extracted post-incubation in both limed, acid and arid zone soils ($r = 0.977$ to 0.999; 13). Carter et al. (14) concluded that DTPA-Sorbitol, pressurized hot water and hot water extraction values correlate well to B tissue concentrations of native Utah Rosaceae species. No greenhouse or field work has been reported comparing the three procedures on cultivated soils treated with various rates of B fertilizer. Yield and nutrient uptake correlations need to be obtained for both DTPA-Sorbitol and pressurized hot water extractable B before either extraction method is seriously considered as an alternative to the standard hot water extraction method.

The goal of this research was to compare B extraction from various soil types using three soil test methods (hot water, pressurized hot water and DTPA-Sorbitol) and to correlate the extraction values to yield, B tissue concentration and total B removal of alfalfa. The research is divided into three parts: a) greenhouse experiment conducted with alfalfa grown on two soil types collected in Southeast Idaho known to be low in B, (b) greenhouse experiment conducted with two alfalfa varieties grown on a soil collected in Eastern Texas known to respond to B in field experiments (15) and (c) analysis of soil samples obtained from a long-term experiment in Eastern Texas on which alfalfa yield response has already been correlated to B extraction values using the hot water method (15).

MATERIALS AND METHODS

Greenhouse Alfalfa Experiments

Three soils (Hayeston sand, Minidoka silt loam and Darco loamy fine sand) were air dried (25 - 30°C), screened (5-mm), and mixed thoroughly to increase homogeneity. The two Idaho soils (Hayeston sand and Minidoka silt loam) and the Texas soil (Darco loamy fine sand) were placed in black plastic one-gallon pots, to about 3 cm from the lip of the pots. This volume of soil resulted in an average of 3.2, 2.6 and 3.3 kg pot^{-1} for the Hayeston sand, the Minidoka silt loam and the Darco loamy fine sand, respectively. Soils from the individual pots containing the Hayeston sand and Minidoka silt loam were fertilized with reagent grade materials at the following rates: 15 mg N kg^{-1} from $(NH_4)_2SO_4$, 60 mg P kg^{-1} from $Ca(H_2PO_4)_2 \cdot H_2O$, and 200 mg K kg^{-1} from KCl. Soils from the individual pots containing the Darco loamy fine sand were mixed with the equivalent of 1000 mg kg^{-1} $CaCO_3$ and then fertilized with reagent grade materials at the following rates: 17.5 mg N kg^{-1} from $(NH_4)_2SO_4$, 30 mg P kg^{-1} and 75 mg K kg^{-1} from K_2HPO_4 and 10 mg Mg kg^{-1} from $MgCl_2 \cdot 6H_2O$.

After mixing all soils with the aforementioned basic fertilizers, eight levels of B were applied to the Hayeston sand and Minidoka silt loam samples: 0, 0.125, 0.25, 0.5, 1.0, 2.0, 4.0 and 8.0 mg B kg^{-1} as liquid boric acid (H_3BO_3); 10 levels of B were applied to the Darco loamy fine sand samples: 0, 0.125, 0.25, 0.5, 1.0, 1.5, 2.0, 3.0, 4.0 and 8.0 mg B kg^{-1} as liquid boric acid (H_3BO_3). Each level was replicated four times in all soil types. Shortly after B application a 100 g soil sample was removed from each pot for B analysis using the three extraction methods.

Alfalfa seeds were inoculated with *Rhizobium meliloti* and planted directly into the fertilized soils. The Hayeston sand and Minidoka silt loam were planted with alfalfa var. Nitro Plus; the Darco loamy fine sand was planted with alfalfa var. Nitro Plus and Tahoe 2001. The pots were maintained in a greenhouse (18 - 28°C) and watered with tap water (low in B) as needed. The experimental design was a completely randomized block design; re-randomization occurred every 14 – 21 days. During winter months (October to April), high-pressure sodium supplemental lighting was used to provide 12 hr day lengths.

When the plants reached appropriate size and maturity (a random few to one third of the plants were in bloom), the leaves, petioles and stems were harvested. The plant material was weighed, dried for a minimum of 48 hours (65˚C), weighed again, ground (20-mesh sieve) and analyzed for B. After the final harvest, a 100-g soil sample was taken from each pot, air dried (25°C), screened (2-mm sieve) and analyzed for available B by the three extraction methods.

Field Alfalfa Experiment

A long-term field experiment is underway at Texas A&M University Agricultural Research and Extension Center in Overton, Texas. Fifteen factorial treatments of B and lime were applied to plots 12.5 square meters in size and replicated four times in a completely randomized block design. Three liming rates (0, 2240 and 4480 kg lime ha^{-1}), each with two lime particle sizes (A_3 grade with effective calcium carbonate equivalent of sixty-two and superfine with effective calcium carbonate equivalent of one hundred), were applied three times over the course of a five-year period. Boron was applied annually as Granubor® at three rates (0, 2.24 and 4.48 kg B ha^{-1}). Yield data was collected for alfalfa grown on the plots two years after the final lime application was made (1994). Six cuttings were taken during a single season and soil samples were taken after the final alfalfa harvest.

The soil samples were analyzed at Texas A&M University Agricultural Research and Extension Center Laboratory for B using hot water extraction and colorimetric analysis. Correlation between alfalfa yields and soil extractable B using hot water extraction was positive and significant (15). Soils were sent to Brigham Young University for pressurized hot water and DTPA-Sorbitol extraction. Previously collected yield data was correlated to extractable B measured by these two alternative methods.

Extraction and Analytical Methods

Hot water (1): 20 g of soil mixed with 40 ml of distilled water and 0.5 ml of 10% $BaCl_2$ in plastic pouches; mixture placed in boiling water for 14 minutes; extract filtered through medium filter paper.

Pressurized hot water (9): boiling water (100 ml, 93˚ C) under 0.25 MPa pressure produced by espresso machine is forced through 5.0 g of soil that is placed on medium filter paper and collected in a plastic cup.

DTPA-Sorbitol (8): 12.5 g soil and 25 ml 0.2 M DTPA-Sorbitol solution are shaken for two hours, centrifuged and filtered through medium filter paper.

Plant Tissue Analysis (16): 1.0 g of dry plant material mixed with 5 ml $Ca(OH)_2$, dry ashed at 600˚C for 2 h; dissolved with 15 ml 0.36 N H_2SO_4; filtered through fast filter paper.

Standardization of Samples: Each replicate soil sample was analyzed once, with standard soil samples included every 20 to 32 samples to guarantee good analytical technique; each replicate plant sample was analyzed once, with standard plant samples included every 16 to 20 samples to guarantee good analytical technique.

B Analysis: Filtrate from extractions performed at Texas A&M University Agricultural Research and Extension Center was analyzed for B using colorimetric, azomethane-H procedure (17, 18); filtrate from extractions performed at Brigham Young University was immediately analyzed for B using Inductively Coupled Plasma Spectrometer (ICP; Thermo Jerrell Ash Corporation, Franklin, Maryland).

Statistical Analysis: The soil and plant data were subjected to several statistical analysis procedures using Statistical Analysis Software (SAS Proprietary Release Software 8.2; SAS Institute 2001, Cary, North Carolina), including analysis of variance, correlation and linear, binomial and multiple regression.

RESULTS AND DISCUSSION

The amount of B extracted with each procedure increased as the rate of B application increased in all three soils for the three greenhouse experiments (Figure 1) and the field experiment (Figure 2). Similar results were previously reported in greenhouse and field studies comparing soil extractable B using hot water, 0.05 M HCl, 1.5 M CH_3COOH and hot 0.01 M $CaCl_2$ (19) extractions. With the exception of the field experiment on a limed acid soil where DTPA-Sorbitol extracted the least amount of B, the extraction methods followed trends previously observed in soils incubated with various rates of B; pressurized hot water > DTPA-Sorbitol > hot water (13). Pressurized hot water extracted the most B and hot water generally extracted the least amount of soil B. This is a promising aspect as the hot water extraction method shows inconsistencies in correlation between extractable B values and plant response to B fertilization, primarily due to under extraction of B from soils (5, 20). Previous work on DTPA-Sorbitol extraction reports that 0.2 M sorbitol concentration would be inadequate at extracting B at hot water extraction values greater than 2 mg kg^{-1} (8); but the results of this study suggest 0.2 M sorbitol concentration may be adequate.

In the greenhouse experiments, in all three soils, significantly less B was extracted by each of the three methods at the end of the experiment compared to the beginning (Figure 1; Table 1). This can be explained by B removal by the alfalfa over time (Total B Removal Section) and B inactivation by soil factors over time as shown in previous studies (13). Correlation coefficients associated with extractable B and rate of B application were high with all three procedures in both the greenhouse and field experiments (Table 2) and the best relationships were defined on the data from the Darco loamy fine sand greenhouse experiment. In all experiments, r-values ranged from 0.764 to 0.989 for hot water, from 0.710 to 0.998 for pressurized hot water and from 0.749 to 0.997 for DTPA-Sorbitol. As expected, the poorest defined relationships were under field conditions ($r = 0.710$ to 0.764).

Yield

In the greenhouse experiment with the naturally high pH soils (Minidoka silt loam and Hayeston sand), the total alfalfa yield (summed over the five harvests) varied from 16 – 20 g dry weight pot^{-1}. There was no significant yield response to B treatments for the first four harvests, but a significant difference in yield among treatments was observed for the fifth harvest (α=0.05, data not shown). This relationship observed between yield and applied B was not a normal response curve and little or no correlation between the soil extraction values and total yields existed (Table 3). There was no difference in response to B between the two soils.

In the greenhouse experiment with alfalfa grown on a limed, acid soil (Darco loamy fine sand), total yield over the six harvests varied from 6 – 18 g dry weight pot $^{-1}$. The yields measured in

Harvests 2, 4, 5, 6 and the total yield summed over six harvests significantly differed among B treatment levels (α=0.05; data not shown), but the differences were unrelated to B application rate so there was no distinguishable pattern or relationship. Significant positive correlations exist between the soil extraction values and total yields (Table 3). There was no difference in response to B between the two alfalfa varieties tested.

In an attempt to better define the relationship between total yield in the greenhouse study on limed-acid soil and extractable B for all three extraction methods, stepwise regression was conducted to determine the best-fitting multiple regression model. Stepwise regression systematically chose from the following parameters to determine the most appropriate regression model: extractable B, applied B, seed type, soil pH, organic matter and Mehlich-3 extractable P, K, Cu, Fe, Mn and Zn. The resulting models (results not shown) did little to improve the relationship between total yield and extractable B obtained using the three soil extraction methods. We propose that this is due to only slight initial variation in many of the parameters included in the stepwise procedure in these three soils; the only parameters with considerable variation were extractable B, applied B and seed type. Prior to the experiment, the soil was mixed thoroughly to minimize variation. In a greenhouse study on alfalfa using three soil types more variable in soil pH, organic matter, texture and extractable macro and micronutrients than our soils, the best relationship for predicting yields included soil B, pH, organic matter and percent clay in the models (21). This was for soil B extractions obtained using saturation extract, NH_4HCO_3-DTPA, hot water and mannitol (21). These same soil parameters were needed in regression analysis to improve prediction of B concentration in three native species obtained on 27 highly variable soil samples using hot water, pressurized hot water and DTPA-Sorbitol extractions (14). Thus, a multiple regression equation would be better suited to define relationships between alfalfa yield and soil extractable B in experiments comparing alfalfa grown on more variable soil types or in natural ecosystems.

The lack of predictable yield response in the greenhouse experiments is puzzling. Alfalfa is most prone to B deficiency and receives more B fertilizer than any other economic crop (22). It shows response to B fertilization in over 40 states in the USA and was rated, albeit somewhat subjectively, quite responsive to B application (23). Most agronomic crops exhibit a deficiency response when the soil available concentration is less than 0.4 mg B kg^{-1} and a toxicity response when the concentration exceeds 1.0 mg B kg^{-1} (7, 24). The initial hot water extractable B in all three soils fell well below these values and B treatment rates applied in the greenhouse studies were adequate for inducing deficiency and/or toxicity responses. Gestring and Soultanpour (21) observed similar lack of response in alfalfa experiments applying 0, 1, 3, 5 and 10 μg B g^{-1} soil as sodium borate in greenhouse experiments. Yield remained essentially the same as the B application rate increased, and B contents in alfalfa suggested neither B deficient nor toxic conditions.

Unlike the greenhouse studies, alfalfa yield response was observed in the long-term field experiment in Texas (15). All six of the alfalfa cuttings were affected individually by the amount of lime and B applied to the soil and no significant interactions existed (15). The total yield (sum of six cuttings) was affected by the amount of B and lime applied and the fineness of calcium carbonate but interactions among the treatments were not significant (15). Binomial regression using X^2 proved to be the best approach for comparisons between the amounts of B extracted using the various methods and the alfalfa yields. Correlations between soil extraction values and yields of each cutting and the total are listed in Table 4. The relationships between extractable B for all three methods and total yield are shown in Figure 3. In all regression equations Y = total yield and X = corresponding extractable B values. Significant R-values were generated between hot water and pressurized hot water extractable B and alfalfa yields in all six cuttings and the total yield (ranging from 0.538 to 0.718, all significant at 0.05 level; Table 4). DTPA-Sorbitol extraction failed to predict yield in this limed, acid soil. The original work reporting positive, significant correlation between alfalfa yields and soil extractable B using the hot water extraction (15) needed to include soil pH, soil B, applied B and soil Mn to best explain the variability in alfalfa yield (seventy-six percent of variability explained). The soil extractable B values obtained from the pressurized hot water (DTPA-Sorbitol extraction values are not included because of failure to predict alfalfa yields) were analyzed using multiple regression with the same parameters (soil pH, applied B and soil Mn) and generated slightly higher adjusted R^2 values, indicating that pressurized hot water extraction can better explain the variability in alfalfa yield than hot water extraction. This suggests B values from either hot water or pressurized hot water extraction methods could be used as accurate predictors of alfalfa yields in the field. DTPA-Sorbitol shows no correlation between extractable B and alfalfa yield, suggesting it is not valuable as a yield predictor in this limed, acid soil.

Tissue B Concentration

With the Hayeston sand and the Darco loamy fine sand, a clear increase in B concentration was observed as B application increased with all harvests (Figure 4). The pattern was not as clear in the Minidoka silt loam, although the highest B rate resulted in significantly higher B concentrations than the control (except for harvest 2, Figure 4). As B rates increased, the alfalfa grown in the Hayeston sand had considerably more B in the tissues than the alfalfa grown in either the Darco loamy fine sand or Minidoka silt loam. With the Hayeston sand, alfalfa B tissue concentration was nearly twice as high with high B applications in harvest 1 and 2, than in the alfalfa grown in the other two soils. A general trend for lower B concentrations at later harvests was observed in all soils. This would be expected under conditions where additional B applications were not made, as either the plant could deplete the B added or B could become unavailable for uptake. Boron availability is modified by factors such as pH, soil texture, soil moisture, temperature, oxide minerals, clay mineralogy, calcium carbonate and organic matter (22, 25, 26, 27) and these factors would be expected to exert their influence over time. Excluding harvest 2 in the Minidoka silt loam (which demonstrated negative values), correlations between tissue concentration and extractable B by the three methods were highest for the Hayeston sand (r = 0.824 to 0.985), followed by the Darco loamy fine sand (r = 0.751 to 0.988) and the Minidoka silt loam (r = 0.560 to 0.944) (Table 5). All correlation coefficients for the Hayeston sand and Darco loamy fine sand were significant at $\alpha = 0.05$, but about half were not significant for the Minidoka silt loam. The differences between soil types might be attributed to physical properties of the Minidoka silt loam that could lead to B inactivation, such as higher clay and organic matter contents.

Tissue B concentrations help explain the lack of alfalfa yield response to B application rates in the greenhouse studies. Eaton (28) reported B toxicity occurred when alfalfa B tissue concentrations fell within the range of 516 to 995 mg B kg^{-1}. In the aforementioned experiment showing lack of response in greenhouse alfalfa experiments, Gestring and Soltanpour (21) saw B tissue concentrations in the predicted toxic range, but no resulting decrease in yield. In a second greenhouse experiment by Gestring and Soltanpour (29), higher B application rates were used in an effort to induce toxicity symptoms: 0, 10, 20 and 40 mg B kg^{-1} applied as sodium borate. Once again, deficiency symptoms were not observed at low B rates, but toxicity symptoms and a corresponding reduction in yield were observed by increasing the rate of B applied. Similar to results seen in our studies, tissue B concentrations were highest in alfalfa grown in the soil with the lowest percentage of clay. They estimated critical levels corresponding to B toxicity to be 850 mg B kg^{-1} for the first alfalfa harvest and 975 mg B kg^{-1} for the second harvest (29). These values fall within the B toxicity range reported by Eaton (28). Our observed tissue B concentrations for alfalfa grown in the greenhouse in the Hayeston sand, Minidoka silt loam and Darco loamy fine sand (Figure 4) fell well below this range, perhaps helping to explain the lack of yield reduction due to B toxicity. The highest alfalfa tissue concentration obtained was 441 mg B kg^{-1}, which was observed in the second harvest of the alfalfa grown in the Hayeston sand at the highest B application rate.

Total B Removal

Total B removal was calculated for each individual pot by multiplying the total yield of each harvest by B tissue concentration and summing over all harvests. At low levels of applied B, the amounts of B removed were small but still significantly different among soils. However, as the amount of B applied increased, B removal increased dramatically in the Hayeston sand and Darco loamy fine sand, but only slightly in the Minidoka silt loam (Fig. 5). At the highest rate of B, alfalfa removed more than twice the amount of B from the Hayeston sand than alfalfa grown in the other two soils. This is largely associated with more consistent and larger increases in B tissue concentrations in the alfalfa grown in the Hayeston sand at the higher treatment levels than in the Minidoka silt loam and Darco loamy fine sand at the higher treatment levels (Fig. 4).

The correlations between total B removed and values of soil available B extracted were all significant at $\alpha = 0.05$ for the Darco loamy fine sand and Hayeston sand (Table 6). None of the correlations for the Minidoka silt loam were significant, resulting in r-values much lower than for the other two soil types. The best relationships between soil extractable B and total B removal are observed with the Darco loamy fine sand and with the pressurized hot water extraction method (Figure 6; Table 6). At the low values of extractable B in the Darco loamy fine sand, the total B removal increases as extractable B increases and once extractable B reaches approximately 2 mg kg^{-1}, B removal plateaus. Relationships between total B removal and extractable B in the other two soil types are more difficult to define. The differences observed between soils suggest that B chemically interacted with the Minidoka silt loam soil causing B fixation. The reduced availability due to fixation impacted B concentration in plant tissue and reduced total B removal compared to the other two soils with lower clay percentages. The lower correlation between extraction values obtained by all three methods and total B removal in the Minidoka silt loam illustrates the three extraction methods are better predictors of total B removal in the two sandy soils.

CONCLUSION

Most of the work completed in the greenhouse, on alfalfa B content and uptake, would support adopting either DTPA-Sorbitol or pressurized hot water in lieu of the hot water extraction method. Although yield relationships were not established in greenhouse experiments, both DTPA-Sorbitol and pressurized hot water extraction values related effectively to tissue B concentration and total B removal. The lone deficiency of DTPA-Sorbitol was in the field study on a limed acid soil where both hot water and pressurized hot water B values could be used to predict yield of alfalfa, but DTPA-Sorbitol could not. Consequently, this research supports accepting DTPA-Sorbitol at an alternative extraction method in alkaline soils and accepting pressurized hot water as an alternative extraction method in both acid and alkaline soils.

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Table 1. P values of paired t-test comparing differences in soil B by three extraction methods for soil samples taken before planting and after final alfalfa harvest in greenhouse experiments. *Significant at $\alpha = 0.05$; **Significant at $\alpha = 0.01$.

Extraction Method	Hayeston Sand	Minidoka Silt Loam	Darco Loamy Fine Sand
Hot Water	**	**	**
Pressurized Hot Water	**	**	**
DTPA-Sorbitol	*	**	**

Table 2. Correlation coefficients relating B application rates and soil B by three extraction methods. Soils in greenhouse experiments were sampled immediately before planting and after final alfalfa harvest. Soils in field experiment were sampled after final alfalfa harvest. *Significant at α =0.05; **Significant at α = 0.01.

r-Values							
	Greenhouse Experiments						Field Experiment
	Minidoka Silt Loam		Hayeston Sand		Darco Loamy Fine Sand		Darco Loamy
Extraction Method	Before	After	Before	After	Before	After	Fine Sand
Hot Water	0.842**	0.792*	0.868**	0.842**	0.989**	0.989**	0.764**
Pressurized Hot Water	0.833*	0.868**	0.907**	0.845**	0.998**	0.993**	0.710**
DTPA-Sorbitol	0.872**	0.853**	0.888**	0.868**	0.997**	0.991**	0.749**

Table 3. Correlation coefficients relating total alfalfa yield and soil B by three extraction methods. Soils in greenhouse experiments were sampled immediately before planting and after final alfalfa harvest. No asterisk not significant at α =0.05; *Significant at α = 0.05; **Significant at α = 0.01.

	r-Values					
	Minidoka Silt Loam		Hayeston Sand		Darco Loamy Fine Sand	
Extraction Method	Before	After	Before	After	Before	After
Hot Water	0.001	0.045	-0.048	-0.037	0.758**	0.768**
Pressurized Hot Water	0.010	0.052	0.005	-0.05	0.731**	0.663**
DTPA-Sorbitol	0.066	0.029	-0.022	-0.031	0.685**	0.697**

Table 4. Correlation coefficients relating alfalfa yield and soil B by three extraction methods in Texas field experiment. No asterisk not significant at α =0.05; *Significant at α =0.05; **Significant at α = 0.01.

	R-Values						
Extraction Method	Cutting 1	Cutting 2	Cutting 3	Cutting 4	Cutting 5	Cutting 6	Total Yield
Hot Water	0.591*	0.552*	0.538*	0.571*	0.578*	0.615*	0.590*
Pressurized Hot Water	0.691**	0.623*	0.666**	0.706**	0.718**	0.702**	0.701**
DTPA-Sorbitol	0.063	-0.007	-0.02	0.03	0.049	0.074	0.046

Table 5. Correlation coefficients (r-values) relating alfalfa tissue concentration and soil B by three extraction methods. Soils in greenhouse experiments were sampled immediately before planting and after final alfalfa harvest (latter data not shown). No asterisk not significant at α =0.05; *Significant at α = 0.05; **Significant at α = 0.01.

Extraction Method	Harvest 1	Harvest 2	Harvest 3	Harvest 4	Harvest 5	Harvest 6
	Minidoka silt loam					
Hot Water Before Planting	0.682	-0.678	0.599	0.944**	0.763**	--
Pressurized Hot Water Before Planting	0.712*	-0.646	0.606	0.929**	0.744**	--
DTPA-Sorbitol Before Planting	0.678	-0.694	0.560	0.926**	0.716**	--
	Hayeston sand					
Hot Water Before Planting	0.985**	0.968**	0.862**	0.824*	0.960**	--
Pressurized Hot Water Before Planting	0.973**	0.948**	0.881**	0.855**	0.928**	--
DTPA-Sorbitol Before Planting	0.978**	0.960**	0.869**	0.845**	0.943**	--
	Darco loamy fine sand					
Hot Water Before Planting	0.751*	0.919**	0.981**	0.917**	0.868**	0.910**
Pressurized Hot Water Before Planting	0.763*	0.939**	0.988**	0.940**	0.884**	0.933**
DTPA-Sorbitol Before Planting	0.765*	0.929**	0.984**	0.928**	0.878**	0.919**

Table 6. Correlation coefficients relating total B removed by the alfalfa in all harvests and soil B by three extraction methods. Soils in greenhouse experiments were sampled immediately before planting and after final alfalfa harvest. No asterisk not significant at α =0.05; *Significant at α =0.05; **Significant at α = 0.01.

	r-Values					
	Minidoka Silt Loam		Hayeston Sand		Darco Loamy Fine Sand	
Extraction Method	Before	After	Before	After	Before	After
Hot Water	0.627	0.687	0.980*	0.980*	0.979**	0.981**
Pressurized Hot Water	0.640	0.592	0.980*	0.983*	0.989**	0.986**
DTPA-Sorbitol	0.586	0.603	0.981*	0.981*	0.983**	0.976**

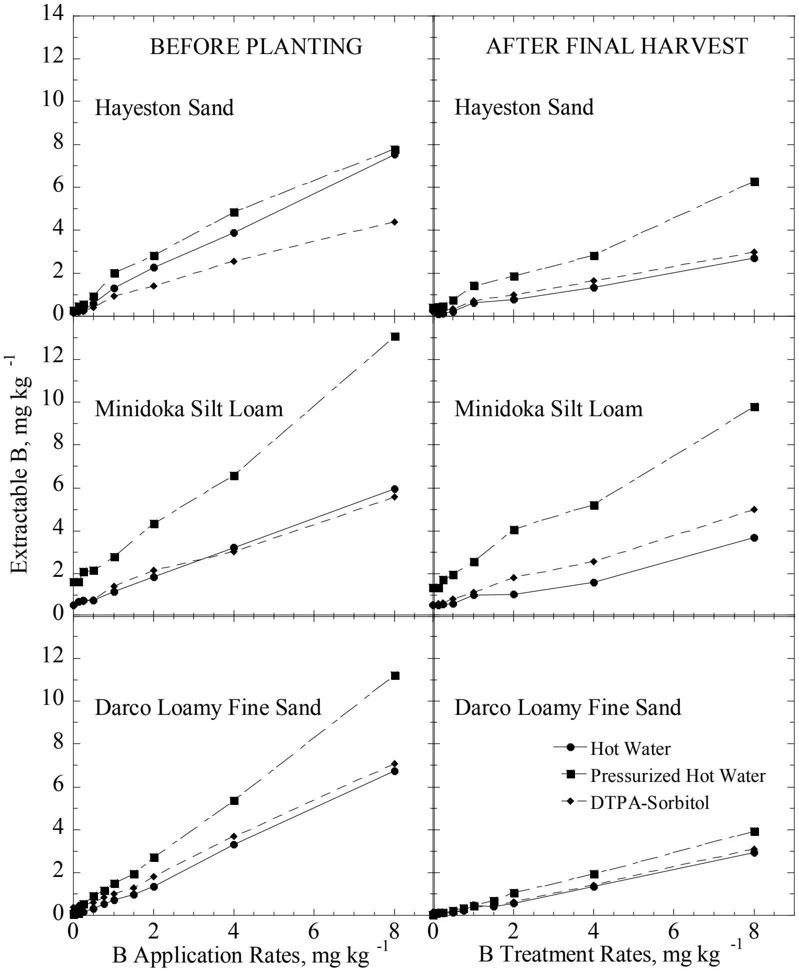

Figure 1. Effects of B application rates on soil B using hot water, pressurized hot water and DTPA-Sorbitol extractions on Hayeston sand, Minidoka silt loam and Darco loamy fine sand. Soils were sampled immediately before planting and after final alfalfa harvest.

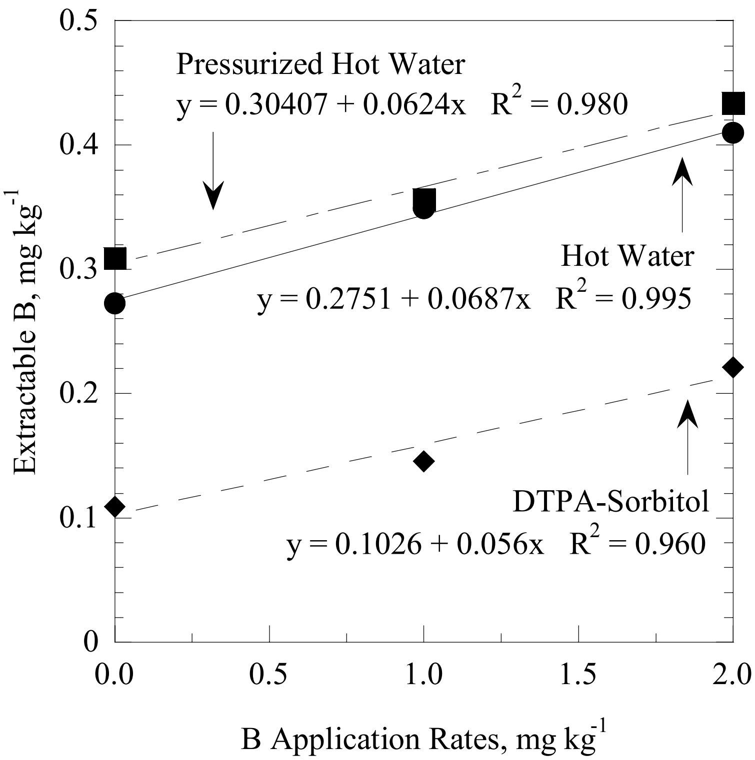

Figure 2. Relationships between B application rates and soil B using hot water, pressurized hot water and DTPA-Sorbitol extractions in the Texas field experiment on Darco loamy fine sand.

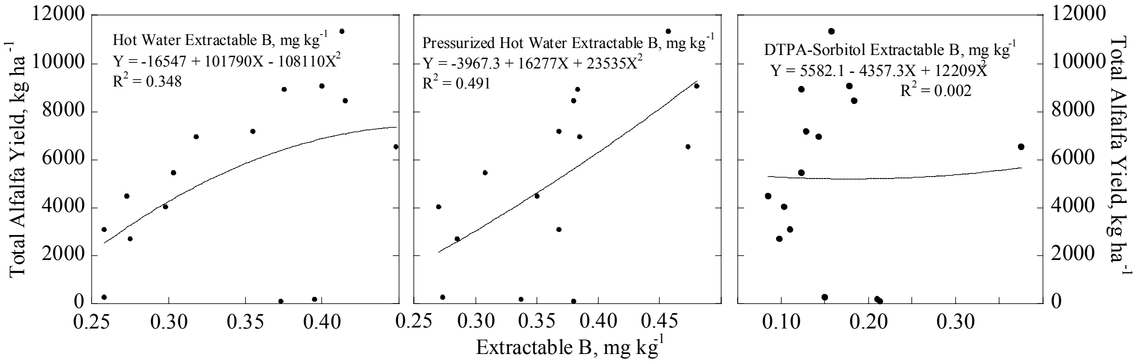

Figure 3. Relationships between total alfalfa yield and soil B using hot water, pressurized hot water, and DTPA-Sorbitol extractions in the Texas field experiment on Darco loamy fine sand.

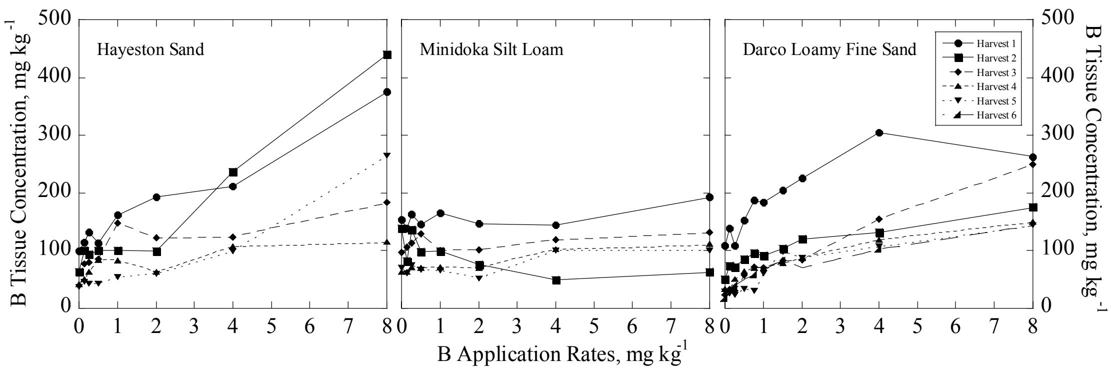

Figure 4. Effects of B application rates on alfalfa tissue concentration in greenhouse experiments grown on Hayeston sand, Minidoka silt loam and Darco loamy fine sand.

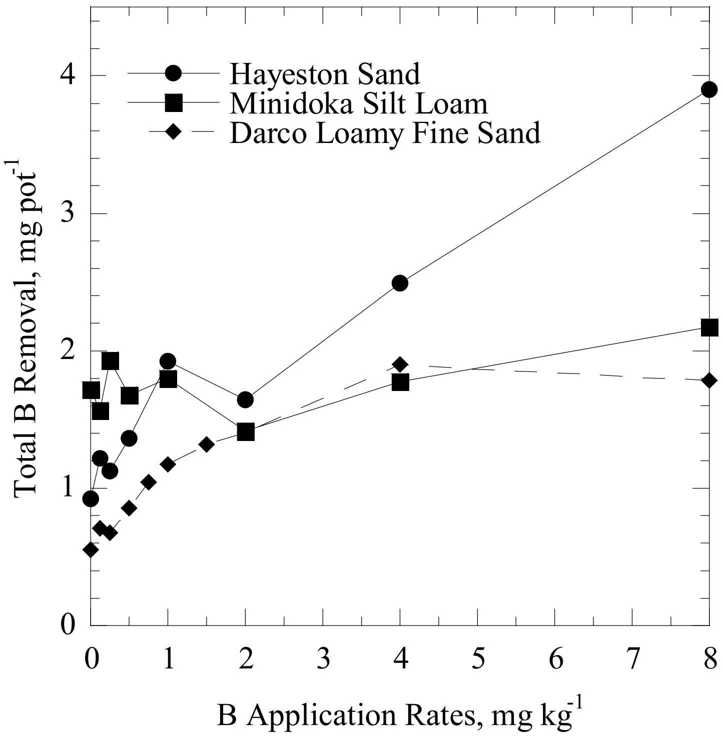

Figure 5. Effects of B application rates on total B removed by the alfalfa (total of all harvests) in greenhouse experiments grown on Hayeston sand, Minidoka silt loam and Darco loamy fine sand.

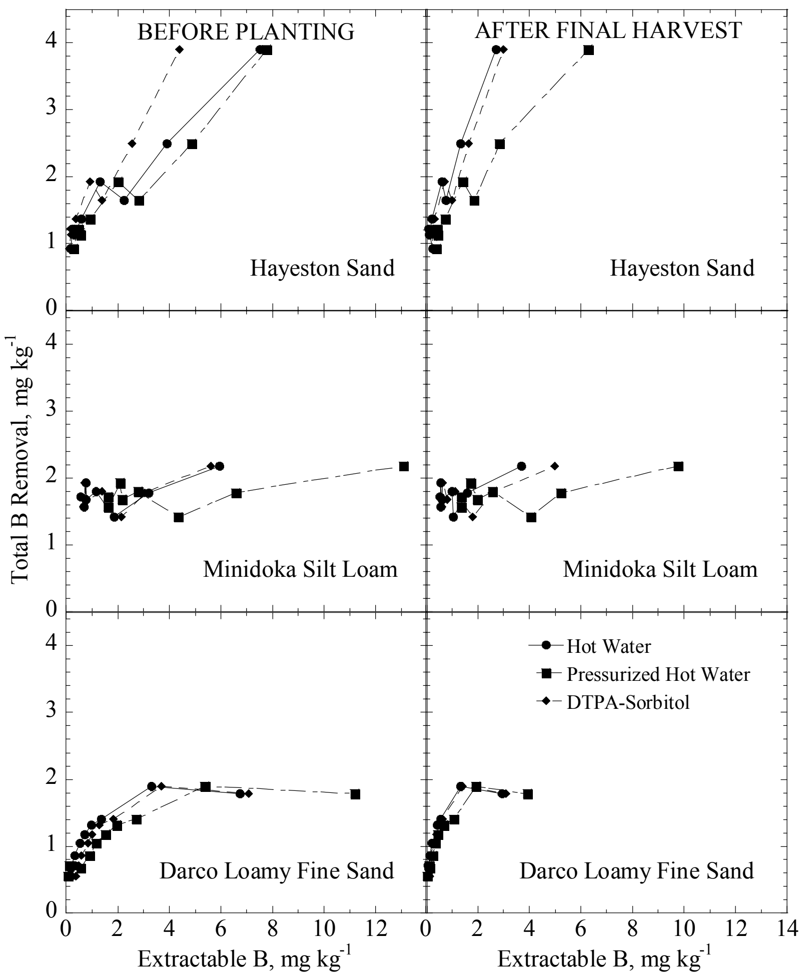

Figure 6. Effects of soil B using hot water, pressurized hot water and DTPA-Sorbitol extractions on total B removed by the alfalfa (total of all harvests). Soils in greenhouse experiments were sampled immediately before planting and after final alfalfa harvest.

APPENDIX A

LITERATURE REVIEW

The role of boron (B) in plants and the related plant-soil interactions are among the least understood of the essential nutrients. Boron is essential to vascular plants, diatoms and some species of green algae and is obtained exclusively from the soil (1). The role of B in plants is complicated and controversial. For years the most widely accepted theory of membrane transport was passive transport; recent research on physiological characteristics indicates involvement of active transport. Boron was originally thought to be immobile in plants and involved in a long list of plant functions. Recent research has discovered that B has restricted mobility in some plant species and total mobility in others. Now there is increasing evidence that B involvement in plant nutrition is a 'cascade effect', with primary roles in cell wall biosynthesis and structure, and plasma membrane integrity. Obtaining B from the soil is complicated too. Numerous factors are involved in sorption reactions in the soil, affecting B availability; pH, organic matter and clay content are three components in boron sorption reactions. The complexity of boron in both the plant and the soil system make it challenging to develop a soil B extraction method that can determine nutrient status relative to plant needs under a wide range of soil conditions and plant species. These complexities necessitate a thorough review of all aspects of B previously mentioned – plant functions, soil interactions and soil extraction methods.

Roots absorb B from the soil solution mainly as undissociated boric arid, $B(OH)_3$, a form potentially permeable to plant cells. It is unclear whether boric acid is diffused through the lipid bilayer or if B uptake occurs by a membrane protein-mediated process. Bingham et al. (2) investigated B absorption in barley roots and found that boric acid absorption was unaffected by solution pH, ranging from 3.0 to 7.0. They also showed that boric acid was not accumulated in the tissue and that addition of metabolic inhibitors or exposure to low temperatures had no influence on absorption. Hence, it was hypothesized that B absorption was a physical process, which resulted from the diffusion of undissociated boric acid across the lipid bilayer of the root-cell plasma membrane. A few years later, Oertli and Grgurevic (3) came to the same conclusion following an investigation into the relative importance of the two forms of boric acid, $B(OH)_3$ and $B(OH)_4^{-1}$, for B absorption. They found that relative B uptake decreased with increasing pH value of the uptake solution. This was consistent with the decrease of the fraction of undissociated boric acid at more alkaline pH values. They proposed that B in the plant tissue rapidly approaches diffusive equilibrium with B in the soil solution, and this equilibrium is governed by the concentration of undissociated boric acid in the soil solution.

On the other hand, to describe the uptake of boric acid exclusively in terms of passive transport raises doubts. Kochian (4) pointed out that if B uptake is due solely to passive diffusion across the lipid bilayer then it is the only plant nutrient for which this is the case and it is difficult to conceptualize how plants would regulate B uptake by this transport mechanism. Membrane permeability differs greatly between species and genotypes in response to environmental factors; it is unclear whether these modifications to the membrane are adequate to regulate uptake of B.

In 1997, Dannel et al. (5) repeated the same kind of experiment as Oertli and Grgurevic (3) but used an intact root system supplied with much lower concentrations of boric acid. They found convincing evidence in support of an active component in the uptake process at low levels of B.

At a marginal supply of B, a concentration mechanism was found to build up a gradient against the nutrient solution to satisfy the B demand of the plant (5).

After reviewing the varied and conflicting results on B uptake carried out over the past 30 years, supporting both passive and active transport, Hu and Brown (6) highlight important difficulties in studying B uptake by plants. These include:

- the ability of boric acid to form complexes with a variety of compounds including polysaccharides, sugar alcohols etc. both in the cell wall and the cytoplasm;
- the large variations in membrane permeability between species and even between genotypes;
- the fact that uptake studies based on transmembrane electrical gradients, analysis of absorption kinetics and measurements of electrical changes in ion uptake do not readily apply to studies on B.

Hu and Brown (6) suggest that although the B uptake mechanism is not completely understood, uptake can best be explained as a passive diffusion of free boric acid into the cell followed by rapid formation of B complexes within the cytoplasm and cell walls. The fall in boric acid concentration within the cell as B complexes form allows for further absorption of B from the external soil solution. Therefore, B uptake is seen as a passive process acting in response to external boric acid concentration, membrane permeability, internal complex formation and transpiration rate.

Until recently, B was thought to be immobile in plants, translocated only in the xylem. In most plant species, B distribution between plant organs and the symptoms of B deficiency and toxicity support restricted mobility of B. In plants, long distance translocation of nutrients takes place in the vascular system. Primary xylem translocation is directed mainly to the sites of highest transpiration (the largest sink being leaves), which do not usually have the highest demand for nutrients. Phloem translocation is independent of transpiration and supplies nutrients to actively growing areas, such as young leaves, fruits and seeds – organs that do not lose water readily. Restricted mobility of a nutrient indicates that the nutrient is translocated through the xylem; toxicity symptoms appear in the older tissue, while deficiency symptoms appear in the young tissues.

Recently it was discovered that when species produce significant amounts of polyols in source leaves, boron is transferred from the xylem and readily translocated in the phloem as the result of B-polyol complex formations. Brown and Hu (7) suggested that B should be phloem mobile in any species for which sorbitol, mannitol, or dulcitol are the primary photosynthates since these polyols can effectively complex B. Subsequently, this hypothesis was verified through the isolation and characterization of B-polyol complexes from celery and peach (8). This makes B unique among essential plant nutrients in that it has restricted mobility in some plant species and total mobility in others (9).

There is long list of postulated roles of B (10): sugar transport, cell wall synthesis and structure, lignification, carbohydrate metabolism, nucleic acid metabolism, respiration, indole acetic acid (IAA) metabolism, phenol metabolism and membrane structure and stability. There is increasing evidence that B is involved in a 'cascade effect' and in a primary role in cell wall biosynthesis and structure, and plasma membrane integrity.

Gauch and Dugger (11) found evidence to support one essential role of B in plants. Their data suggests that it is directly involved with transport of sugars. A reaction of B with sugar forms an ionizable sugar-boron complex, which moves through cellular membranes more readily than non-borated, non-ionized sugar molecules. However, this idea became unacceptable as research discovered boric acid reacts only weakly with sucrose, the major sugar translocated within higher plants, and the concentration of B is low in phloem, the main translocation route for sucrose. This lead to the belief that the influence of B on sugar translocation is usually interpreted as an indirect response due to reduction in growth or manipulation of auxin biosynthesis (12).

There are varied theories on the role of B in cell wall synthesis. Dugger and Palmer (13, 14) proposed that B deficiency inhibits the activity of UDPG-pyrophosphorylase, which would result in a reduction in the availability of UDPG for cellulose synthesis. However, according to Hu et al. (15), cell wall synthesis, which occurs in the symplasm, is not depressed by B deficiency. It is obvious that B plays an important role in the structural arrangement of the cell wall components in the apoplast.

The chemical composition and structure of cell walls are quickly affected by a lack of B in the plant. Primary cell walls lose smoothness and are characterized by irregular deposits of vesicular aggregates and membranous material. Hemicellular and pectic substances increase and a high proportion of glucose is incorporated into β 1-3 glucan, the main component of callose, which blocks sieve cells and inhibits phloem transport. The dramatic and rapid responses associated with lack of B are not surprising, as B is believed to play a key role in the structure and integrity of cell walls. Boron complexes strongly with cell wall constituents such as hemicellulose and pectic polysaccharides. These complexes are required for structural integrity due to the formation of borate-ester cross-links. Matoh (16) suggests the boron—RG II (rhamnogalacturonan II) complex may be the exclusive polysaccharide-binding compound in cell walls. Apoplastic B also functions in stabilizing certain cell wall constituents by acting in a structural role together with Ca (17).

Tissue B concentration varies between plants depending on plant characteristics. Plant species grown in the same soil vary considerably in their plant tissue B concentration (18). Graminaceous species contain 5 – 10 mg B kg^{-1} on a dry weight basis and most dicots contain 20 – 70 mg B kg^{-1}. In latex bearing plants, the B content may be as high as 80 – 100 mg B kg^{-1} (18). The distinct differences in B demand, particularly between monocotyledonous and dicotyledonous species, are most likely related to the differences in their cell wall composition. Hu et al, (15) discovered that plants with higher pectin cell wall content have high B requirements and plants with a lower pectin cell wall content have low B requirements. In Graminous species the primary cell walls contain very little pectic material.

There is limited literature available on the role of B in lignification and carbohydrate metabolism. Parish (19) suggested that B might facilitate the attachment of peroxidase to the cell wall. The bound peroxidases catalyze the polymerization of phenols to lignin. It has been found that the relative proportion of trytophan-derived glucosinolates in plants was increased by B deficiency, whereas a major methionine-derived glucosinolate declined, perhaps as a result of competition for limited UDGP.

A decrease in RNA and DNA content and DNA synthesis is documented when B is withheld from plants -- implying involvement in nucleic acid metabolism. Decrease in RNA levels precedes cessation in cell division and could be the result of both inhibited RNA synthesis and higher RNAase activity. Support for the involvement of B in RNA metabolism comes from the work of Birnbaum et al. (20) in which certain nucleotides such as uracil can delay symptoms of B deficiency. Depending on which literature is read, inhibition of DNA synthesis is considered either a primary (21) or secondary (22, 23) effect of B deficiency.

An initial increase in the rate of respiration from B deficiency is followed by a decline as deficiency symptoms become evident. There appears to be a shift in the substrate flux from glycolysis into the pentose phosphate pathway (24). Research supports its mediation by the formation of reversible or irreversible diolborate complexes of different stabilities with substrates and/or enzymes (24). Gomez-Rodriguez et al. (25) found that the activity of glucose-6-phosphate dehydrogenase, the first committed step of the pentose phosphate pathway, was more consistently increased in sunflower leaves in response to low B than was 6-phosphogluconate dehydrogenase activity. This suggests that the action of B is on the former enzyme and the effect on the latter enzyme is a result of increased substrate level.

Many contradictory results on relationships between B, indole acetic acid (IAA), and phenol metabolism are caused by different experimental conditions and have lead to considerable controversy. It is proposed that B acts by reducing auxin concentrations to levels that are not inhibitory to root growth, but in other experiments auxin levels are higher than normal in B deficient plants. High concentrations of IAA induce anatomical changes in the root tips similar to those caused by B deficiency. This has lead to the misinterpretation that B deficiency symptoms are a reflection of increased auxin levels. In reality the structural changes brought about by B deficiency and excessive IAA levels are quite different. It might be that interactions between B and IAA and tissue differentiation are secondary events caused by primary effects of B on phenol metabolism (26).

Accumulation of phenols is a feature common in B deficient plants and most likely related to the function of B in the formation of *cis*-diol complexes with certain sugars and phenols. Under B deficiency the substrate flux is shifted towards the pentose phosphate cycle and, thus, enhanced phenol biosynthesis. Accordingly, under B deficiency, phenols accumulate and polyphenol oxidase activity increases. The accumulation of phenols and the increase in polyphenol oxidase activity lead to the formation of highly reactive intermediates such as caffeic quinone in the cell walls. These quinones are very effective in producing superoxide radicals that are capable of damaging membranes by lipid peroxidation. Differences between monocotyledonous and dicotyledonous species in phenol metabolism and in the pathway of lignin biosynthesis present differences in the risk of oxidative damage of the plasma membrane of the species. These differences may be in part responsible for the differences in B demand between these two groups of plants (27).

There is increasing evidence for a particular role for B on plasma membrane function. This evidence comes from the dramatic effects in increased membrane permeability in isolated leaves corresponding with B deficiency. It is suggested that B stabilizes the structure of the plasma membrane by complexing membrane compounds containing *cis*-diol groups such as glycoproteins and glycolipids to keep channels or enzymes at optimum conformation within the membrane (28). The binding of B to polyhydroxyl groups of membranes is seen as maintaining the structure and integrity of membranes and a major reason for the stimulatory effects of B on membrane-bound ATPase activity and for controlling permeability of plasma membranes (29).

From the published research regarding the role of B in cell wall biosynthesis, phenol metabolism, and plasma membrane integrity, it can be concluded that B exerts its primary influence in the cell wall and at the plasma membrane—cell wall interface in higher plants. Changes in the cell wall and at this interface are considered as primary effects of B deficiency leading to the cascade of secondary effects on metabolism, growth and plant composition.

Soil B is categorized into five major fractions: primary minerals such as tourmaline and B rich micas, secondary minerals within clay lattices, adsorbed on surfaces of clays and organic matter, within organic matter and microbial biomass, and in soil solution as boric acid (30). The first two categories constitute fixed B, the next two adsorbed B and the last plant available B (31). Based upon extraction criteria, B in soils is categorized as acid-soluble, water-soluble and total B (32). Total B in soils typically ranges from 20 – 200 mg kg^{-1} (33), the major determining factor being parent material. Although the plant available fraction, or water-soluble B is small, ranging from 0.4 to 5.0 mg B kg^{-1} (34), these quantities generally meet the needs of agronomic crops.

Compared to other essential nutrient elements, the chemistry of B in soils is simple. The fraction of soil B classified as water-soluble is the fraction available for plant uptake. The two common forms of B in soil solution are undissociated boric acid, $B(OH)_3$, and the borate anion, $B(OH)_4^{-1}$. Boric acid is a very weak monobasic acid that acts as a Lewis acid by accepting a hydroxyl ion to form the borate anion. The B concentration in the soil solution is generally controlled by adsorption reactions. Since plants only respond to the B activity in soil solution, the amount of water-soluble B available for plant uptake is also generally controlled by B adsorption reactions. Boron does not undergo oxidation-reduction or volatilization reactions (30), causing availability to be modified by factors such as pH, soil texture, soil moisture, temperature, oxide minerals, clay mineralogy, calcium carbonate and organic matter (31, 35, 36, 37).

Of the factors affecting B availability in soil solution, pH is one of the most important. With increasing soil solution pH, B becomes less available to plants. Boron adsorption onto soil constituents increased as function of solution pH in the range of pH 3 to 9 (38, 39, 40, 41, 42) and decreased in the range of pH 10 to 11.5 (43). At a pH of less than 7, $B(OH)_3$ is the dominant solution form. Boric acid has a low affinity for clay minerals but as pH increases above 7, the concentration of $B(OH)_4^{-1}$ increases and this form has a high affinity for clay minerals (6). Application of lime to acid soils can therefore result in B deficiency symptoms; this is thought to be attributed to freshly released aluminum hydroxide scavenging soluble B (31), not to the change in pH.

The availability of B in soils is also greatly influenced by soil texture and parent material. Adsorbed B, dependent on soil texture, increases with increasing clay content (44, 45) with a maximum occurring at pH 8 to 10 (30). Coarse-textured soils contain less total and water-soluble B, and as a result, B deficiency occurs more frequently on these soils than fine-textured, less freely drained types (31). Boron deficiency also occurs commonly on highly weathered soils due to a loss of B reserves held by clay minerals (31).

Boron reaches plant roots through diffusion; diffusivity of B decreases with decreasing water content because drying reduces soil solution mobility and increases the diffusion path length (46). As soils dry B availability generally decreases, making deficiency more likely and causing plants to extract B from lower depths (47). Boron adsorption increases with increasing soil temperature, perhaps due to an interactive effect of soil temperature with soil moisture (30). Wetting and drying cycles can greatly increase B fixation (48) with the greatest increase occurring during the first wet-dry cycle (49).

Soil adsorption sites may act as a pool from which B is supplied to solution (source) or B is removed by adsorption (sink). Adsorbed B may buffer B concentration in soil solution (50). The constant capacitance model explains the B adsorption envelope very well (51). There is a gradual rise in adsorption as pH rises above 7, a broad maximum near pH 9 and finally a sharp decline in adsorption at higher pH levels. The characteristics reflect competition for hydrogen ions between the soil adsorbent and borate ion which protonates significantly at pH values less than 9.2. The principal adsorption mechanism is ligand exchange with surface hydroxyl groups (51). The manner of B adsorption on these surfaces is more similar to that of cations causing B to be more strongly sorbed than other anions (52). The sorption strength may be derived from inner-sphere surface complexation formed in conjunction with the ligand exchange mechanism (51).

Oxides, clays, calcium carbonate and organic matter are the common B adsorbing surfaces in soils. Aluminum and iron oxides are significant variables in multiple regression equations explaining the variance of adsorbed, soluble and total B in soils (45). Ions such as silicate, sulfate, phosphate and oxalate compete with B for adsorption sites (30) and consequently can increase B availability. The effect of the competing ions can be slight (sulfate) or substantial (phosphate) (30). As mentioned previously, clay minerals exhibit increasing B adsorption with increasing solution pH with maximum occurring at pH 8 to 10 (30). Boron initially is adsorbed onto particle edges. Subsequently it migrates and incorporates structurally into tetrahedral sites replacing structural silicon and aluminum (30). Illite clays adsorb the greatest amount of B with montmorillonite and kaolinite adsorbing lesser amounts, respectively. Goldberg and Forster (53) indicate calcium carbonate acts as an important sink for B adsorption in calcareous soils. The mechanism of adsorption could be exchange with carbonate groups (30). Organic matter has the ability to complex large amounts of B, usually more than mineral soil constituents (30) but can also replenish soil solution B through mineralization (31).

Most agronomic crops exhibit a deficiency response when the soil available concentration is less than 0.4 mg B kg^{-1} and a toxicity response when the concentration exceeds 1.0 mg B kg^{-1} (34, 50). Lack of B results in predictable plant deficiency symptoms including irregular thickening of cells walls and distorted growth (16). Development of deficiency symptoms generally reduces crop quality and yield even if appropriate amounts of B are applied to compensate for the deficiency (34). Toxicity symptoms are similar to those exhibited under deficient conditions – reduced growth, cupping of leaves, leaf burn, chlorotic and/or necrotic patches at leaf margins and tips of older leaves (50). Consequently, it is critical to predict the availability of soil B before symptoms develop. Soil B tests hold a key to such prediction. However, soil B tests must determine nutrient status relative to plant needs under a wide range of conditions including estimation of deficient and toxic levels for different plant species.

Determining hot water extractable B in soils is one of the most demanding and difficult soil tests routinely performed in laboratories (54). The widely used soil B test was developed by Berger and Truog (55). In 1947 Rogers (56) discovered the hot water extraction could identify soils where positive responses to B fertilizer could be expected. Gupta et al. (57) suggest hot water extraction extracts B from soluble inorganic, organic and adsorbed inorganic pools within the soil. Many modifications have been developed attempting to simplify the original procedure. A batch handling technique was developed in 1973 (58) to reduce the time requirements associated with the hot water technique. The modification called for heating 50-ml Pyrex tubes weathered in concentrated HCl over blocks, allowing numerous samples to be run at a give time. The weathering in HCl was done to reduce the amount of B released into the sample by the borosilicate glassware. Mahler et al. (54) suggested the use of sealable, disposable plastic pouches as an alternative to glassware in an attempt to reduce the cost involved with purchasing, cleaning and storing glassware. It was agreed (54, 59) that less error was observed if samples were refluxed for a longer period than indicated versus stopping the refluxing too early. Increasing refluxing time from 5 to 7 minutes reduced the error among samples significantly.

Despite modifications, this procedure has various challenges that promote sporadic use among laboratories. It still shows inconsistencies in correlation between extractable B values and plant response to B fertilization, primarily due to under extraction of B from soils (56, 60). The method is still time consuming and results are variable due to variations in refluxing times, water temperatures and loss of water during the procedure (60, 61). Due to the challenges involved with the procedure and inconsistencies observed with results, clientele and testing laboratories often see little need to incur extra costs associated with B testing. This leads to estimating B needs rather than assessment. Numerous attempts have been made to identify more reliable alternatives.

Nable et al. (50) suggested seven soil extraction agents for measuring the plant available fraction of B in soil: ammonium oxalate, saturation extract, hydrochloric acid (HCl), hot water extraction with variation and improvement, calcium chloride ($CaCl_2$), mannitol exchangeable, and ammonium bicarbonate diethylenetriaminepentaacetic acid (AB-DTPA). As the factors that limit B availability vary among soils, so does the effectiveness of various soil extraction methods. The different extracting agents attack specified soil components and release differing fractions of available B. Nable et al. (50) proposes that the three most effective alternatives to the HWB method for use in laboratories are the hot calcium chloride ($CaCl_2$), ammonium bicarbonate diethylenetriaminepentacetic acid (AB-DTPA) and Mehlich-3.

The hot $CaCl_2$ lacks the ability to measure released B in soils of differing characteristics and is more adapted to acid soils (60, 61, 62). Shuman et al. (63) noted that the Mehlich-3 procedure extracted available soil B, comparable to the HWB method, making this a more universal extractant for laboratories. It showed the highest correlation between values for Mehlich-3 extractable B and hot water extractable B in soils with a low pH. Simard et al. (64) suggested including the soil pH as a coefficient in the soil test for B to predict B fertilizer recommendations of crops for B. Gestring and Soltanpour (65) proposed using AB-DTPA as a multi-extraction procedure for B in arid, calcareous soils of the West. This procedure requires the analysis of pH, percent organic matter and percent clay to correlate available soil B to plant growth responses (66). Matsi et al. (67) suggests including cation exchange capacity in the correlation to plant available soil B when using the AB-DTPA method. The Mehlich-3 and AB-DTPA methods require additional soil analysis procedures before plant uptake of B can be accurately estimated (66, 67), increasing time spent on laboratory analysis of B.

Two recently introduced, plausible alternatives for use in arid soils are DTPA-Sorbitol (68) and pressurized hot water (69). Both methods have initially been correlated to extraction values obtained with the hot water method.

Miller et al. (68) compared hot water and DTPA-Sorbitol extractions on 42 untreated (no B applied) soils ranging in physical and chemical properties and observed consistent, predictable linear relationships ($r^2 = 0.97$). Diethylenetriamine-pentaacetic acid (DTPA) is broadly used to extract copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) (70, 71). Literature shows (72) that saccharides are effective chelates of B. Vaughan and Howe (73) demonstrated that sorbitol acts as an effective chelating agent for B and could be used for extraction. The DTPA-Sorbitol extraction method combines DTPA and 0.2 M sorbitol. It offers multi element extraction capability and simplicity, but requires monitoring of microbial contamination when used in routine analysis.

The pressurized hot water method was proposed for extraction of nitrate, sulfate, potassium, and phosphorus (74, 75) and plant available B (69). This method extracts B as it forces boiling, pressurized distilled water through soil. It offers simplicity, no hazardous chemical use, speed and low cost. Webb et al. (69) compared hot water and pressurized hot water extractions on 40 untreated arid soils and observed predictable linear relationships ($r^2 = 0.68$) among soil extractable B values obtained using the two methods. A linear regression equation $y = 0.12271 + 0.21155x$ (y is mg kg^{-1} boiling hot water extractable B and x is mg kg^{-1} pressurized hot water B; $r^2 = 0.68$) allows conversion of pressurized hot water B to hot water B values for which yield correlations are already available (69). Yield correlations need to be obtained for both DTPA-Sorbitol and pressurized hot water extraction values before either extraction method is seriously considered as an alternative to hot water extraction.

Little work has been done that compares more than one of these procedures with another. As mentioned, Miller et al. (68) compared extraction values from forty-two untreated soils obtained by DTPA-Sorbitol and Webb et al. (69) compared values from forty untreated soils by pressurized hot water to conventional hot water extraction of soil B. Carter et al. (76) were the first to compare the three methods when they compared DTPA-Sorbitol, pressurized hot water and hot water extraction values to B tissue concentrations of native Utah species. No work has been reported comparing the three procedures on cultivated soils treated with various rates of B fertilizer.

There is a need to develop a more efficient and reliable B extraction method, especially one suitable for arid and semi-arid zone soils. The alternative methods suggested earlier are either not suited for varying soil types or do not significantly reduce laboratory analysis time or costs. Both the DTPA-Sorbitol and pressurized hot water methods are plausible alternatives to the hot water extraction for Western United States soil types. The initial correlations observed between their extractable B values and the hot water extraction are very promising. Once the methods are correlated with plant uptake their use has the potential to increase significantly.

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APPENDIX B

PROCEDURE FOR HOT WATER BORON EXTRACTION

1. Fill a 4000 ml metal beaker with about 8-cm depth of water.

2. Ignite a Bunsen burner and place the beaker on a stand over the flame allowing the water to come to a boil. Monitor the intensity of the flame and water, so water does not overflow the beaker when it begins to boil.

3. Use plastic heat sealable pouches and seal to create a seam to contain soil sample.

4. Weigh 20.0 g of the soil to be analyzed into plastic pouch. Add 40 ml of distilled water and 0.5 ml of 10% $BaCl_2$ to a plastic pouch with soil then seal the top of the pouch. Seal the top of the pouch with the sealer. Use caution with the sealer. If the bags are kept in the sealer for too short of time the seal will be weak and will not hold. If they are left in the sealer too long the seal will melt.

5. Hand shake sealed pouch to mix the contents until water is evenly distributed throughout the soil sample and place carefully in the beaker of boiling water. Just leave enough space between the pouches so they can move easily by one another. Place a weight on top of the beaker to keep samples submerged in boiling water.

6. As soon as the water returns to a boil, begin timing. Allow the pouches to stand in the boiling water for exactly 14 minutes.

7. Remove the pouches from the beaker of boiling water and allow cooling in a cold-water bath. Use caution when removing the pouches, the contents are hot and can easily burn the skin.

8. Cut the top corner of the pouch and then filter the extract through 11 cm, medium filter paper into plastic bottles.

9. Run the extract directly on the ICP (Inductively Coupled Plasma Spectrometer, Thermo Jerrell Ash Corporation, Franklin, Maryland). No dilution is necessary.

10. Calculate the boron concentration as follows:
    Boron in the soil, mg kg^{-1} = (ICP reading, μg B ml^{-1}) * [(40.0 ml dH_2O) / (20.0 g soil)].

Reagents

1. 10% $BaCL_2$: Weight 24.43 g of $BaCl_2 \cdot 2H_2O$ into a one-liter volumetric flask and bring to volume with distilled water.

2. Stock Solution
   a. Boron 1000 μg ml^{-1}: Weight 5.720g of H_3BO_3 into one-liter volumetric flask and bring to volume with distilled water.

3. Working Standards for ICP
   a. High standard: 1.0 μg B ml^{-1}
   b. Check standard: 0.5 μg B ml^{-1}.

PROCEDURE FOR PRESSURIZED HOT WATER BORON EXTRACTION

NOTE: These instructions are designed for use on the MAXIM® EX-450 (Salton/Maxin Housewares, Inc., Mt. Prospect, Illinois) espresso machine only.

1. Plug in the espresso machine.

2. Fill a 100 ml volumetric flask with distilled water and pour in into the water reservoir. Screw the lid on tightly.

3. Place the metal filter cup securely in the designated position on the espresso machine.

4. Place a disposable plastic cup under the percolation opening of the attached metal filter cup.

5. Turn the black knob on the left side of the machine to “brew”. A red light found next to the knob will illuminate.

6. When the water stops dripping from the attached metal filter cup into the disposable plastic cup, turn the knob on left side of espresso machine to “steam release” indicated by four white dots and a picture of the steam releasing.

7. After the steam stops, turn the knob to “off” and unscrew the water reservoir lid on top of the espresso machine. Now the machine is at the correct operating temperature and ready to run test samples. It is not necessary to save the water from the initial run through.

8. Remove the metal filter cup. Place one 5.5 cm, medium-slow filter paper in the bottom of the metal filter cup. Make sure the filter paper covers all of the holes on the bottom and fits up against the sides of the metal filter cup. If the seal formed by the filter paper is not adequate, soil will leak around the filter paper and cloud the extract.

9. Weigh 5 g of the soil to be analyzed and place in the center of the metal filter cup on the filter paper.

10. Put the metal filter cup back in the proper position on the espresso machine, making sure it locks in place.

11. Place a disposable plastic cup under the metal filter cup, percolation opening.

12. Unscrew the lid of the water reservoir. Refill with 100 ml of distilled water. Screw the lid on tightly.

13. Turn the black knob on the left side of the machine to “brew”. A red light found next to the knob will illuminate.

14. Once dripping from the percolation opening on the metal filter cup into the plastic cup stops, release the steam by turning the black knob on the left side to “steam release”. Save the filtrate in the plastic cups.

15. Remove the metal filter cup and discard the filter paper and soil and remove the plastic cup with collected filtrate. Rinse the metal filter cup out three times with distilled water.

16. Repeat steps 8 – 15 with each new sample. After performing the extraction, there should be no standing water in the metal filter cup and the soil should be relatively dry. If there is standing water or if the extract looks muddy, the sample should be weighed and run again. Fine textured soils will be more likely to leak than sandy soils.

17. Pour the sample into a 100 ml plastic tube, stopper and allow sample to cool and suspended soil particles to settle before reading sample on the ICP. Run the extract directly on the ICP (Inductively Coupled Plasma Spectrometer, Thermo Jerrell Ash Corporation, Franklin, Maryland). No dilution is necessary.

18. Calculate the boron concentration as follows:
    Boron in the soil, mg kg^{-1} = (ICP reading, μg B ml^{-1}) * [(100ml dH_2O) / (5.0g soil)].

Reagents

1. Stock Solution
   a. Boron 1000 μg ml^{-1}: Weight 5.720g of H_3BO_3 into one-liter volumetric flask and bring to volume with distilled water.

2. Working Standards for ICP
   a. High standard: 1.0 μg B ml^{-1}
   b. Check standard: 0.5 μg B ml^{-1}.

PROCEDURE FOR DTPA-SORBITOL BORON EXTRACTION

NOTE: Store the DTPA-Sorbitol solution for no longer than two weeks. If it is stored longer than this, check it for bacterial growth on a regular basis. Wash all labware used in this procedure with bleach when finished.

1. Weigh 12.5 g of soil to be analyzed into a 50 ml plastic centrifuge tube.

2. Add 25 ml of DTPA-Sorbitol extracting solution and cap tightly.

3. Shake for exactly 2 hours on a reciprocating shaker set on a low speed. Samples should not be shaken for less or more than 2 hours or the readings will be affected.

4. After removing from the shaker, centrifuge the tubes for approximately two minutes at 3000 rpm.

5. Remove the tubes from the centrifuge and filter the liquid from the sample through 11-cm medium filter paper into a plastic bottle.

6. Determine the concentration of B on the ICP (Inductively Coupled Plasma Spectrometer, Thermo Jerrell Ash Corporation, Franklin, Maryland). No dilution is necessary.

7. Calculate the boron concentration as follows:
   Boron in the soil, mg kg^{-1} = (ICP reading, μg B ml^{-1}) * [(25ml DTPA-Sorbitol) / (12.5g soil)]

Reagents

1. DTPA-Sorbitol extracting solution: Weigh 36.434 g of Sorbitol ($C_6H_{14}O_6$) and 1.96 g of DTPA [$(HOCOCH_2)_2$ $(NCH_2DH_2)_2$ NCH_2COOH] into a one liter volumetric flask. Add 14.92 g of TEA (triethanolamine buffer). Bring the volume to approximately 950 ml with distilled water. Add 1.46 g of calcium chloride ($CaCl_2{\cdot}H2O$). Bring the volume to one liter with distilled water while adjusting the pH to exactly 7.3 with 6 N HCL or 6 N NaOH. The final concentration will be 0.005 M DTPA, 0.2 M Sorbitol, 0.1 M TEA, and 0.01 M $CaCl_2$.

2. Stock Solution
   a. Boron 1000 μg ml^{-1}: Dissolve 5.720 g of H_3BO_3 into one-liter volumetric flask and bring to volume with distilled water.

3. Working standards for ICP
   a. High standard: 1.0 μg B ml^{-1}
   b. Check standard: 0.5 μg B ml^{-1}.

APPENDIX C

INCUBATION EXPERIMENTS DATA

A01 -- Soil Incubation Experiment with Hayeston Sand and Minidoka Silt Loam
Harvest 1, Soil (16 April 2001)

			HWB		PHWB		DTPA-Sorbitol	
Soil	Trt	Sample	ICP reading	B ppm soil	ICP reading	B ppm soil	ICP reading	B ppm soil
sandy	0	1	0.0442	0.088	0.0033	0.066	0.2311	0.462
sandy	0	2	0.0627	0.125	0.0084	0.168	0.2236	0.447
sandy	0	3	0.0515	0.103	0.0037	0.074	0.2227	0.445
sandy	0	4	0.0496	0.099	0.0053	0.106	0.2249	0.450
sandy	0.125	5	0.1000	0.200	0.0087	0.174	0.2646	0.529
sandy	0.125	6	0.1024	0.205	0.0109	0.218	0.2725	0.545
sandy	0.125	7	0.0941	0.188	0.0080	0.160	0.2534	0.507
sandy	0.125	8	0.0735	0.147	0.0074	0.148	0.2623	0.525
sandy	0.25	9	0.1638	0.328	0.0374	0.748	0.4254	0.851
sandy	0.25	10	0.1360	0.272	0.0352	0.704	0.3910	0.782
sandy	0.25	11	0.1360	0.272	0.0331	0.662	0.3996	0.799
sandy	0.25	12	0.1443	0.289	0.0294	0.588	0.4023	0.805
sandy	0.5	13	0.1987	0.397	0.0492	0.984	0.4910	0.982
sandy	0.5	14	0.2015	0.403	0.0457	0.914	0.4945	0.989
sandy	0.5	15	0.1633	0.327	0.0523	1.046	0.4841	0.968
sandy	0.5	16	0.2565	0.513	0.0477	0.954	0.4821	0.964
sandy	1	17	0.3609	0.722	0.0783	1.566	0.6942	1.388
sandy	1	18	0.4325	0.865	0.0697	1.394	0.6870	1.374
sandy	1	19	0.4735	0.947	0.0745	1.490	0.7128	1.426
sandy	1	20	0.4342	0.868	0.0642	1.284	0.6945	1.389
sandy	1.5	21	0.5075	1.015	0.1131	2.262	0.8304	1.661
sandy	1.5	22	0.5900	1.180	0.0933	1.866	0.8407	1.681
sandy	1.5	23	0.6263	1.253	0.0983	1.966	0.8502	1.700
sandy	1.5	24	0.4524	0.905	0.0863	1.726	0.7948	1.590
sandy	2	25	0.5209	1.042	0.1348	2.696	1.1750	2.350
sandy	2	26	0.7488	1.498	0.1586	3.172	1.1540	2.308
sandy	2	27	0.6067	1.213	0.1305	2.610	1.2340	2.468
sandy	2	28	0.6186	1.237	0.1233	2.466	0.9001	1.800
sandy	4	29	0.8239	1.648	0.2603	5.206	1.7260	3.452
sandy	4	30	0.9398	1.880	0.2028	4.056	1.7830	3.566
sandy	4	31	1.3760	2.752	0.2632	5.264	1.6930	3.386
sandy	4	32	1.8880	3.776	0.2581	5.162	1.7930	3.586
sandy	6	33	1.4130	2.826	0.4374	8.748	2.5420	5.084
sandy	6	34	2.3770	4.754	0.3739	7.478	2.6930	5.386
sandy	6	35	1.6040	3.208	0.3946	7.892	2.7580	5.516
sandy	6	36	2.0850	4.170	0.3907	7.814	2.6720	5.344
sandy	8	37	2.5460	5.092	0.5309	10.618	3.4750	6.950
sandy	8	38	2.8160	5.632	0.4778	9.556	3.7450	7.490
sandy	8	39	2.5360	5.072	0.5622	11.244	3.8730	7.746
sandy	8	40	3.2230	6.446	0.4447	8.894	3.9120	7.824

A01 -- Soil Incubation Experiment with Hayeston Sand and Minidoka Silt Loam
Harvest 1, Soil (16 April 2001)

			HWB		PHWB		DTPA-Sorbitol	
Soil	Trt	Sample	ICP reading	B ppm soil	ICP reading	B ppm soil	ICP reading	B ppm soil
silt loam	0	41	0.2495	0.499	0.0843	1.686	0.5881	1.176
silt loam	0	42	0.1899	0.380	0.0839	1.678	0.5774	1.155
silt loam	0	43	0.1054	0.211	0.0882	1.764	0.5699	1.140
silt loam	0	44	0.1244	0.249	0.0939	1.878	0.5623	1.125
silt loam	0.125	45	0.1132	0.226	0.1069	2.138	0.6100	1.220
silt loam	0.125	46	0.2165	0.433	0.0976	1.952	0.6363	1.273
silt loam	0.125	47	0.1235	0.247	0.0905	1.810	0.4642	0.928
silt loam	0.125	48	0.1842	0.368	0.0771	1.542	0.6143	1.229
silt loam	0.25	49	0.2203	0.441	0.0816	1.632	0.6693	1.339
silt loam	0.25	50	0.1823	0.365	0.0931	1.862	0.6752	1.350
silt loam	0.25	51	0.1711	0.342	0.0946	1.892	0.6517	1.303
silt loam	0.25	52	0.2013	0.403	0.0836	1.672	0.6464	1.293
silt loam	0.5	53	0.2086	0.417	0.1019	2.038	0.7337	1.467
silt loam	0.5	54	0.2494	0.499	0.0904	1.808	0.7294	1.459
silt loam	0.5	55	0.2785	0.557	0.1137	2.274	0.7513	1.503
silt loam	0.5	56	0.2706	0.541	0.1085	2.170	0.7411	1.482
silt loam	1	57	0.3434	0.687	0.1452	2.904	0.7442	1.488
silt loam	1	58	0.3702	0.740	0.1173	2.346	0.7625	1.525
silt loam	1	59	0.3241	0.648	0.1313	2.626	0.6927	1.385
silt loam	1	60	0.2970	0.594	0.1176	2.352	0.7577	1.515
silt loam	1.5	61	0.2105	0.421	0.1815	3.630	1.0750	2.150
silt loam	1.5	62	0.3480	0.696	0.1552	3.104	1.0950	2.190
silt loam	1.5	63	0.3093	0.619	0.1567	3.134	1.0300	2.060
silt loam	1.5	64	0.4493	0.899	0.1470	2.940	1.0730	2.146
silt loam	2	65	0.3307	0.661	0.2158	4.316	1.2870	2.574
silt loam	2	66	0.3120	0.624	0.1680	3.360	1.2750	2.550
silt loam	2	67	0.4326	0.865	0.1995	3.990	1.3420	2.684
silt loam	2	68	0.3770	0.754	0.1741	3.482	1.2920	2.584
silt loam	4	69	0.6448	1.290	0.2965	5.930	1.8370	3.674
silt loam	4	70	0.6576	1.315	0.3222	6.444	2.0630	4.126
silt loam	4	71	0.4460	0.892	0.2963	5.926	1.9040	3.808
silt loam	4	72	0.6129	1.226	0.2555	5.110	1.8650	3.730
silt loam	6	73	1.5230	3.046	0.4603	9.206	2.8840	5.768
silt loam	6	74	0.9208	1.842	0.3956	7.912	2.9540	5.908
silt loam	6	75	1.0290	2.058	0.4423	8.846	2.8360	5.672
silt loam	6	76	1.4890	2.978	0.3690	7.380	2.8680	5.736
silt loam	8	77	1.9110	3.822	0.6223	12.446	3.6760	7.352
silt loam	8	78	1.9680	3.936	0.5533	11.066	3.9070	7.814
silt loam	8	79	1.4300	2.860	0.5755	11.510	3.9100	7.820
silt loam	8	80	1.6130	3.226	0.5158	10.316	3.9860	7.972

A01 -- Soil Incubation Experiment with Hayeston Sand and Minidoka Silt Loam
Harvest 2, Soil (7 May 2001)

			HWB		PHWB		DTPA-Sorbitol	
Soil	Trt	Sample	ICP reading	B ppm soil	ICP reading	B ppm soil	ICP reading	B ppm soil
sandy	0	1	0.0065	0.013	0.0108	0.216	0.0961	0.192
sandy	0	2	0.0093	0.019	0.0065	0.130	0.0804	0.161
sandy	0	3	0.0077	0.015	0.0017	0.034	0.0776	0.155
sandy	0	4	0.0092	0.018	0.0111	0.222	0.0708	0.142
sandy	0.125	5	0.0247	0.049	0.0147	0.294	0.0960	0.192
sandy	0.125	6	0.0222	0.044	0.0117	0.234	0.1016	0.203
sandy	0.125	7	0.0201	0.040	0.0078	0.156	0.1184	0.237
sandy	0.125	8	0.0242	0.048	0.0078	0.156	0.1023	0.205
sandy	0.25	9	0.0529	0.106	0.0172	0.344	0.1342	0.268
sandy	0.25	10	0.0802	0.160	0.0519	1.038	0.1379	0.276
sandy	0.25	11	0.0519	0.104	0.0382	0.764	0.1528	0.306
sandy	0.25	12	0.0586	0.117	0.0332	0.664	0.1452	0.290
sandy	0.5	13	0.0651	0.130	0.0425	0.850	0.2109	0.422
sandy	0.5	14	0.0804	0.161	0.0458	0.916	0.2111	0.422
sandy	0.5	15	0.0605	0.121	0.0427	0.854	0.2153	0.431
sandy	0.5	16	0.0735	0.147	0.0461	0.922	0.2105	0.421
sandy	1	17	0.1103	0.221	0.0812	1.624	0.3517	0.703
sandy	1	18	0.1474	0.295	0.0762	1.524	0.3550	0.710
sandy	1	19	0.1244	0.249	0.0807	1.614	0.3608	0.722
sandy	1	20	0.1470	0.294	0.0783	1.566	0.3570	0.714
sandy	1.5	21	0.1689	0.338	0.1139	2.278	0.4645	0.929
sandy	1.5	22	0.2240	0.448	0.1014	2.028	0.7085	1.417
sandy	1.5	23	0.2218	0.444	0.1065	2.130	0.7018	1.404
sandy	1.5	24	0.2922	0.584	0.1020	2.040	0.7615	1.523
sandy	2	25	0.2442	0.488	0.1158	2.316	0.9615	1.923
sandy	2	26	0.2754	0.551	0.1381	2.762	0.9891	1.978
sandy	2	27	0.2263	0.453	0.1338	2.676	1.0000	2.000
sandy	2	28	0.3067	0.613	0.1384	2.768	1.0090	2.018
sandy	4	29	0.7107	1.421	0.2903	5.806	2.1790	4.358
sandy	4	30	0.5887	1.177	0.2849	5.698	2.2600	4.520
sandy	4	31	0.6035	1.207	0.2957	5.914	2.0440	4.088
sandy	4	32	0.6478	1.296	0.2497	4.994	2.2300	4.460
sandy	6	33	0.8690	1.738	0.4061	8.122	3.2060	6.412
sandy	6	34	0.9919	1.984	0.3914	7.828	2.7710	5.542
sandy	6	35	0.7860	1.572	0.3553	7.106	3.2900	6.580
sandy	6	36	0.9770	1.954	0.3532	7.064	3.1490	6.298
sandy	8	37	1.0550	2.110	0.4925	9.850	4.4460	8.892
sandy	8	38	1.2430	2.486	0.4749	9.498	4.1600	8.320
sandy	8	39	1.1220	2.244	0.4912	9.824	4.0860	8.172
sandy	8	40	1.3710	2.742	0.5310	10.620	4.4990	8.998

A01 -- Soil Incubation Experiment with Hayeston Sand and Minidoka Silt Loam
Harvest 2, Soil (7 May 2001)

			HWB		PHWB		DTPA-Sorbitol	
Soil	Trt	Sample	ICP reading	B ppm soil	ICP reading	B ppm soil	ICP reading	B ppm soil
silt loam	0	41	0.0820	0.164	0.0969	1.938	0.4723	0.945
silt loam	0	42	0.0644	0.129	0.0887	1.774	0.4522	0.904
silt loam	0	43	0.0749	0.150	0.0756	1.512	0.4431	0.886
silt loam	0	44	0.1222	0.244	0.0812	1.624	0.4630	0.926
silt loam	0.125	45	0.1158	0.232	0.0842	1.684	0.4906	0.981
silt loam	0.125	46	0.1194	0.239	0.0890	1.780	0.4819	0.964
silt loam	0.125	47	0.0424	0.085	0.0829	1.658	0.4732	0.946
silt loam	0.125	48	0.0933	0.187	0.0884	1.768	0.4827	0.965
silt loam	0.25	49	0.1104	0.221	0.1465	2.930	0.5360	1.072
silt loam	0.25	50	0.0791	0.158	0.1369	2.738	0.5453	1.091
silt loam	0.25	51	0.0820	0.164	0.0939	1.878	0.5351	1.070
silt loam	0.25	52	0.1054	0.211	0.0000	0.000	0.5287	1.057
silt loam	0.5	53	0.0747	0.149	0.1207	2.414	0.6315	1.263
silt loam	0.5	54	0.0814	0.163	0.1101	2.202	0.6326	1.265
silt loam	0.5	55	0.0788	0.158	0.1186	2.372	0.6321	1.264
silt loam	0.5	56	0.1050	0.210	0.1260	2.520	0.6368	1.274
silt loam	1	57	0.1210	0.242	0.1717	3.434	0.8259	1.652
silt loam	1	58	0.0776	0.155	0.1472	2.944	0.8515	1.703
silt loam	1	59	0.1120	0.224	0.1643	3.286	0.8027	1.605
silt loam	1	60	0.1850	0.370	0.1479	2.958	0.8278	1.656
silt loam	1.5	61	0.1805	0.361	0.2137	4.274	1.0490	2.098
silt loam	1.5	62	0.1455	0.291	0.1946	3.892	1.0430	2.086
silt loam	1.5	63	0.1594	0.319	0.2381	4.762	1.1560	2.312
silt loam	1.5	64	0.1060	0.212	0.2027	4.054	1.0100	2.020
silt loam	2	65	0.1771	0.354	0.2444	4.888	1.4070	2.814
silt loam	2	66	0.2251	0.450	0.2567	5.134	1.4260	2.852
silt loam	2	67	0.2626	0.525	0.1990	3.980	1.3950	2.790
silt loam	2	68	0.2499	0.500	0.2465	4.930	1.3960	2.792
silt loam	4	69	0.5319	1.064	0.3926	7.852	2.4820	4.964
silt loam	4	70	0.5646	1.129	0.4232	8.464	2.2280	4.456
silt loam	4	71	0.4676	0.935	0.4578	9.156	2.3710	4.742
silt loam	4	72	0.3930	0.786	0.4186	8.372	2.4220	4.844
silt loam	6	73	0.5547	1.109	0.5182	10.364	3.0670	6.134
silt loam	6	74	0.5180	1.036	0.5121	10.242	3.0140	6.028
silt loam	6	75	0.4527	0.905	0.5716	11.432	3.3470	6.694
silt loam	6	76	0.6292	1.258	0.5141	10.282	3.0650	6.130
silt loam	8	77	0.9390	1.878	0.6224	12.448	4.1280	8.256
silt loam	8	78	1.0950	2.190	0.5457	10.914	4.1710	8.342
silt loam	8	79	0.8168	1.634	0.7154	14.308	4.2280	8.456
silt loam	8	80	0.7498	1.500	0.6232	12.464	4.2110	8.422

C03 -- Soil Incubation Experiment with Darco Loamy Fine Sand
Harvest 1, Soil (10 April 2003)

		HWB		PHWB		DTPA-Sorbitol	
Trt	Sample	ICP reading	B ppm soil	ICP reading	B ppm soil	ICP reading	B ppm soil
0	1	0.0138	0.028	0.0039	0.078	0.0767	0.153
0	2	0.0105	0.021	0.0000	0.000	0.0885	0.177
0	3	0.0095	0.019	0.0000	0.000	0.0811	0.162
0	4	0.0093	0.019	0.0000	0.000	0.0913	0.183
0.125	5	0.0614	0.123	0.0063	0.126	0.1255	0.251
0.125	6	0.0659	0.132	0.0083	0.166	0.1390	0.278
0.125	7	0.0815	0.163	0.0060	0.120	0.1478	0.296
0.125	8	0.0815	0.163	0.0048	0.096	0.1341	0.268
0.25	9	0.1385	0.277	0.0284	0.568	0.1961	0.392
0.25	10	0.1344	0.269	0.0227	0.454	0.2019	0.404
0.25	11	0.1337	0.267	0.0187	0.374	0.1958	0.392
0.25	12	0.1489	0.298	0.0183	0.366	0.1757	0.351
0.5	13	0.2399	0.480	0.0394	0.788	0.2966	0.593
0.5	14	0.2618	0.524	0.0437	0.874	0.3101	0.620
0.5	15	0.2304	0.461	0.0434	0.868	0.2914	0.583
0.5	16	0.2811	0.562	0.0486	0.972	0.2964	0.593
0.75	17	0.3769	0.754	0.0653	1.306	0.4265	0.853
0.75	18	0.4324	0.865	0.0826	1.652	0.4643	0.929
0.75	19	0.4077	0.815	0.0722	1.444	0.4332	0.866
0.75	20	0.4000	0.800	0.0782	1.564	0.4299	0.860
1	21	0.5032	1.006	0.0926	1.852	0.4986	0.997
1	22	0.4620	0.924	0.0968	1.936	0.5254	1.051
1	23	0.4904	0.981	0.0921	1.842	0.5251	1.050
1	24	0.4746	0.949	0.1055	2.110	0.5447	1.089
1.5	25	0.7596	1.519	0.1433	2.866	0.7874	1.575
1.5	26	0.7626	1.525	0.1539	3.078	0.7850	1.570
1.5	27	0.8018	1.604	0.1436	2.872	0.8724	1.745
1.5	28	0.7519	1.504	0.1417	2.834	0.8325	1.665
2	29	1.0390	2.078	0.1987	3.974	1.1250	2.250
2	30	0.8689	1.738	0.1836	3.672	1.1240	2.248
2	31	0.9979	1.996	0.1753	3.506	1.0190	2.038
2	32	0.8656	1.731	0.2111	4.222	1.1410	2.282
4	33	2.3880	4.776	0.4291	8.582	2.2900	4.580
4	34	2.1200	4.240	0.4192	8.384	2.3240	4.648
4	35	2.0540	4.108	0.3947	7.894	2.2830	4.566
4	36	1.7800	3.560	0.3746	7.492	2.2520	4.504
8	37	4.8950	9.790	0.7290	14.580	4.4930	8.986
8	38	4.2160	8.432	0.8401	16.802	4.3960	8.792
8	39	4.7950	9.590	0.7518	15.036	4.6370	9.274
8	40	3.9980	7.996	0.7562	15.124	4.4520	8.904

C03 -- Soil Incubation Experiment with Darco Loamy Fine Sand
Harvest 2, Soil (1 May 2003)

		HWB		PHWB		DTPA-Sorbitol	
Trt	Sample	ICP reading	B ppm soil	ICP reading	B ppm soil	ICP reading	B ppm soil
0	1	0.0238	0.048	0.0000	0.000	0.0871	0.174
0	2	0.0236	0.047	0.0080	0.160	0.0786	0.157
0	3	0.0139	0.028	0.0079	0.158	0.0834	0.167
0	4	0.0180	0.036	0.0082	0.164	0.0858	0.172
0.125	5	0.0241	0.048	0.0079	0.158	0.1188	0.238
0.125	6	0.0270	0.054	0.0094	0.188	0.0879	0.176
0.125	7	0.0393	0.079	0.0081	0.162	0.0791	0.158
0.125	8	0.0362	0.072	0.0090	0.180	0.0908	0.182
0.25	9	0.0617	0.123	0.0125	0.250	0.1109	0.222
0.25	10	0.0490	0.098	0.0133	0.266	0.1129	0.226
0.25	11	0.0509	0.102	0.0139	0.278	0.1138	0.228
0.25	12	0.0508	0.102	0.0142	0.284	0.1076	0.215
0.5	13	0.1251	0.250	0.0266	0.532	0.1919	0.384
0.5	14	0.1003	0.201	0.0229	0.458	0.1486	0.297
0.5	15	0.0997	0.199	0.0256	0.512	0.1512	0.302
0.5	16	0.0931	0.186	0.0235	0.470	0.1596	0.319
0.75	17	0.1147	0.229	0.0276	0.552	0.1622	0.324
0.75	18	0.1489	0.298	0.0272	0.544	0.1897	0.379
0.75	19	0.1403	0.281	0.0290	0.580	0.1987	0.397
0.75	20	0.1851	0.370	0.0343	0.686	0.2196	0.439
1	21	0.2098	0.420	0.0389	0.778	0.2661	0.532
1	22	0.2109	0.422	0.0380	0.760	0.2453	0.491
1	23	0.1976	0.395	0.0445	0.890	0.2910	0.582
1	24	0.2401	0.480	0.0455	0.910	0.3292	0.658
1.5	25	0.3462	0.692	0.0602	1.204	0.4267	0.853
1.5	26	0.3937	0.787	0.0656	1.312	0.4528	0.906
1.5	27	0.3744	0.749	0.0600	1.200	0.4177	0.835
1.5	28	0.3182	0.636	0.0633	1.266	0.3987	0.797
2	29	0.4631	0.926	0.0769	1.538	0.5453	1.091
2	30	0.5050	1.010	0.0942	1.884	0.6007	1.201
2	31	0.5253	1.051	0.0910	1.820	0.6090	1.218
2	32	0.3892	0.778	0.0846	1.692	0.5489	1.098
4	33	0.9361	1.872	0.1793	3.586	1.2030	2.406
4	34	0.9852	1.970	0.1788	3.576	1.1730	2.346
4	35	0.8437	1.687	0.1437	2.874	1.0910	2.182
4	36	1.1430	2.286	0.1805	3.610	1.2540	2.508
8	37	2.2590	4.518	0.3275	6.550	2.8620	5.724
8	38	2.4800	4.960	0.3577	7.154	2.7360	5.472
8	39	2.0440	4.088	0.3357	6.714	2.3980	4.796
8	40	2.3860	4.772	0.3519	7.038	2.7170	5.434

GREENHOUSE ALFALFA EXPERIMENTS DATA

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand

Harvest 1, Soil (10 September 2001)

			HWB		PHWB		DTPA-Sorbitol	
Soil	Trt	Sample	ICP reading	B ppm soil	ICP reading	B ppm soil	ICP reading	B ppm soil
silt loam	0	1	0.3016	0.603	0.0734	1.468	0.2940	0.588
silt loam	0	2	0.2659	0.532	0.0998	1.996	0.2694	0.539
silt loam	0	3	0.3018	0.604	0.0727	1.454	0.2868	0.574
silt loam	0	4	0.2365	0.473	0.0788	1.576	0.2741	0.548
silt loam	0.125	5	0.2402	0.480	0.0841	1.682	0.3211	0.642
silt loam	0.125	6	0.2342	0.468	0.0667	1.334	0.3215	0.643
silt loam	0.125	7	0.5462	1.092	0.0668	1.336	0.3296	0.659
silt loam	0.125	8	0.3718	0.744	0.1081	2.162	0.3357	0.671
silt loam	0.25	9	0.3882	0.776	0.0913	1.826	0.3687	0.737
silt loam	0.25	10	0.4394	0.879	0.0928	1.856	0.3543	0.709
silt loam	0.25	11	0.3735	0.747	0.1213	2.426	0.3540	0.708
silt loam	0.25	12	0.3395	0.679	0.1138	2.276	0.3494	0.699
silt loam	0.5	13	0.4070	0.814	0.1075	2.150	0.4160	0.832
silt loam	0.5	14	0.3762	0.752	0.1362	2.724	0.3857	0.771
silt loam	0.5	15	0.3777	0.755	0.0928	1.856	0.4008	0.802
silt loam	0.5	16	0.3806	0.761	0.0968	1.936	0.4018	0.804
silt loam	1	17	0.6575	1.315	0.1538	3.076	0.7948	1.590
silt loam	1	18	0.5471	1.094	0.1362	2.724	0.7182	1.436
silt loam	1	19	0.4803	0.961	0.1305	2.610	0.5316	1.063
silt loam	1	20	0.6281	1.256	0.1386	2.772	0.7560	1.512
silt loam	2	21	0.8642	1.728	0.1988	3.976	1.1290	2.258
silt loam	2	22	0.9175	1.835	0.2035	4.070	0.9976	1.995
silt loam	2	23	1.0130	2.026	0.2431	4.862	1.0640	2.128
silt loam	2	24	0.9046	1.809	0.2220	4.440	1.0980	2.196
silt loam	4	25	1.3270	2.654	0.2970	5.940	1.5000	3.000
silt loam	4	26	1.7740	3.548	0.3265	6.530	1.4290	2.858
silt loam	4	27	1.3380	2.676	0.3245	6.490	1.3060	2.612
silt loam	4	28	1.9770	3.954	0.3670	7.340	1.8260	3.652
silt loam	8	29	2.6400	5.280	0.5769	11.538	2.6950	5.390
silt loam	8	30	2.7920	5.584	0.6399	12.798	2.6370	5.274
silt loam	8	31	2.7710	5.542	0.6466	12.932	2.6730	5.346
silt loam	8	32	3.6790	7.358	0.7499	14.998	3.1850	6.370

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand

Harvest 1, Soil (10 September 2001)

			HWB		PHWB		DTPA-Sorbitol	
Soil	Trt	Sample	ICP reading	B ppm soil	ICP reading	B ppm soil	ICP reading	B ppm soil
sandy	0	33	0.1107	0.221	0.0209	0.418	0.0599	0.120
sandy	0	34	0.0831	0.166	0.0121	0.242	0.0556	0.111
sandy	0	35	0.0924	0.185	0.0158	0.316	0.0472	0.094
sandy	0	36	0.0724	0.145	0.0070	0.140	0.0567	0.113
sandy	0.125	37	0.1670	0.334	0.0315	0.630	0.1074	0.215
sandy	0.125	38	0.1068	0.214	0.0246	0.492	0.0824	0.165
sandy	0.125	39	0.1069	0.214	0.0209	0.418	0.0850	0.170
sandy	0.125	40	0.1008	0.202	0.0178	0.356	0.0896	0.179
sandy	0.25	41	0.1680	0.336	0.0251	0.502	0.0923	0.185
sandy	0.25	42	0.1436	0.287	0.0340	0.680	0.1052	0.210
sandy	0.25	43	0.1375	0.275	0.0217	0.434	0.1112	0.222
sandy	0.25	44	0.1319	0.264	0.0290	0.580	0.1096	0.219
sandy	0.5	45	0.2858	0.572	0.0371	0.742	0.1688	0.338
sandy	0.5	46	0.2995	0.599	0.0454	0.908	0.1839	0.368
sandy	0.5	47	0.3209	0.642	0.0495	0.990	0.2020	0.404
sandy	0.5	48	0.2587	0.517	0.0520	1.040	0.2296	0.459
sandy	1	49	0.7377	1.475	0.1037	2.074	0.4563	0.913
sandy	1	50	0.5380	1.076	0.0997	1.994	0.4618	0.924
sandy	1	51	0.6799	1.360	0.1002	2.004	0.4494	0.899
sandy	1	52	0.6378	1.276	0.0982	1.964	0.4739	0.948
sandy	2	53	1.2870	2.574	0.1417	2.834	0.8061	1.612
sandy	2	54	1.0900	2.180	0.1459	2.918	0.7823	1.565
sandy	2	55	1.2630	2.526	0.1456	2.912	0.6202	1.240
sandy	2	56	0.8665	1.733	0.1310	2.620	0.5830	1.166
sandy	4	57	1.9420	3.884	0.2504	5.008	1.3890	2.778
sandy	4	58	2.2000	4.400	0.2476	4.952	1.3530	2.706
sandy	4	59	1.9930	3.986	0.2565	5.130	1.1750	2.350
sandy	4	60	1.6360	3.272	0.2175	4.350	1.2010	2.402
sandy	8	61	4.9730	9.946	0.4578	9.156	2.4960	4.992
sandy	8	62	3.1060	6.212	0.3130	6.260	1.8820	3.764
sandy	8	63	3.9760	7.952	0.4584	9.168	2.5490	5.098
sandy	8	64	2.9690	5.938	0.3257	6.514	1.8300	3.660

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand
Harvest 1, Soil (10 September 2001)

			pH	NaHCO3 - P			NaHCO3 - K	
Soil	Trt	Sample	Sat. Paste	% Trans	P ppm solution	P ppm soil	A.A. Reading	K ppm soil
silt loam	0	1	7.7	62.3	1.267	25.348	0.71	227.20
silt loam	0	2	7.7	57.7	1.473	29.469	0.70	224.00
silt loam	0	3	7.7	59.3	1.400	28.000	0.64	204.80
silt loam	0	4	7.7	66.8	1.080	21.601	0.58	185.60
silt loam	0.125	5	7.7	63.1	1.233	24.663	0.58	185.60
silt loam	0.125	6	7.7	36.7	2.689	53.780	0.56	179.20
silt loam	0.125	7	7.7	64.9	1.158	23.152	0.49	156.80
silt loam	0.125	8	7.7	68.1	1.028	20.566	0.51	163.20
silt loam	0.25	9	7.7	61.7	1.293	25.868	0.85	272.00
silt loam	0.25	10	7.7	62.4	1.263	25.262	0.72	230.40
silt loam	0.25	11	7.7	67.8	1.040	20.803	0.59	188.80
silt loam	0.25	12	7.7	54.6	1.622	32.436	0.63	201.60
silt loam	0.5	13	7.7	60.3	1.355	27.101	0.70	224.00
silt loam	0.5	14	7.7	66.2	1.104	22.086	0.67	214.40
silt loam	0.5	15	7.7	62.0	1.280	25.608	0.68	217.60
silt loam	0.5	16	7.7	53.0	1.702	34.034	0.62	198.40
silt loam	1	17	7.7	67.4	1.056	21.121	0.68	217.60
silt loam	1	18	7.7	58.9	1.418	28.363	0.66	211.20
silt loam	1	19	7.7	47.8	1.979	39.582	0.40	128.00
silt loam	1	20	7.7	63.8	1.203	24.070	0.70	224.00
silt loam	2	21	7.7	54.2	1.642	32.831	0.71	227.20
silt loam	2	22	7.7	65.9	1.116	22.330	0.54	172.80
silt loam	2	23	7.7	62.5	1.259	25.176	0.75	240.00
silt loam	2	24	7.7	63.8	1.203	24.070	0.81	259.20
silt loam	4	25	7.7	66.5	1.092	21.843	0.77	246.40
silt loam	4	26	7.7	64.2	1.187	23.734	0.79	252.80
silt loam	4	27	7.7	39.6	2.485	49.694	0.88	281.60
silt loam	4	28	7.7	62.8	1.246	24.919	0.85	272.00
silt loam	8	29	7.7	67.2	1.064	21.280	0.59	188.80
silt loam	8	30	7.7	58.4	1.441	28.821	0.61	195.20
silt loam	8	31	7.7	45.3	2.123	42.469	0.75	240.00
silt loam	8	32	7.7	49.4	1.891	37.813	0.77	246.40

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand
Harvest 1, Soil (10 September 2001)

			pH	NaHCO3 - P			NaHCO3 - K	
Soil	Trt	Sample	Sat. Paste	% Trans	P ppm solution	P ppm soil	A.A. Reading	K ppm soil
sandy	0	33	7.2	50.9	1.810	36.206	0.86	275.20
sandy	0	34	7.2	55.9	1.559	31.172	0.64	204.80
sandy	0	35	7.2	57.4	1.487	29.749	0.73	233.60
sandy	0	36	7.2	62.8	1.246	24.919	0.56	179.20
sandy	0.125	37	7.2	61.4	1.307	26.130	0.56	179.20
sandy	0.125	38	7.2	60.9	1.328	26.569	0.60	192.00
sandy	0.125	39	7.2	54.6	1.622	32.436	0.66	211.20
sandy	0.125	40	7.2	60.9	1.328	26.569	0.62	198.40
sandy	0.25	41	7.2	57.1	1.502	30.031	0.59	188.80
sandy	0.25	42	7.2	53.7	1.666	33.329	0.70	224.00
sandy	0.25	43	7.2	61.3	1.311	26.218	0.59	188.80
sandy	0.25	44	7.2	54.7	1.617	32.338	0.57	182.40
sandy	0.5	45	7.2	59.5	1.391	27.819	0.66	211.20
sandy	0.5	46	7.2	57.0	1.506	30.125	0.65	208.00
sandy	0.5	47	7.2	65.4	1.137	22.739	0.69	220.80
sandy	0.5	48	7.2	64.6	1.170	23.400	0.65	208.00
sandy	1	49	7.2	64.3	1.183	23.651	0.45	144.00
sandy	1	50	7.2	61.6	1.298	25.955	0.61	195.20
sandy	1	51	7.2	64.5	1.174	23.484	0.63	201.60
sandy	1	52	7.2	59.0	1.414	28.272	0.62	198.40
sandy	2	53	7.2	66.1	1.108	22.167	0.53	169.60
sandy	2	54	7.2	63.7	1.208	24.154	0.56	179.20
sandy	2	55	7.2	62.8	1.246	24.919	0.53	169.60
sandy	2	56	7.2	63.0	1.237	24.748	0.53	169.60
sandy	4	57	7.2	64.9	1.158	23.152	0.57	182.40
sandy	4	58	7.2	56.1	1.549	30.980	0.69	220.80
sandy	4	59	7.2	59.8	1.377	27.549	0.65	208.00
sandy	4	60	7.2	55.5	1.578	31.558	0.75	240.00
sandy	8	61	7.2	60.9	1.328	26.569	0.62	198.40
sandy	8	62	7.2	62.5	1.259	25.176	0.48	153.60
sandy	8	63	7.2	61.7	1.293	25.868	0.65	208.00
sandy	8	64	7.2	58.6	1.432	28.638	0.62	198.40

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand

Harvest 2, Soil (13 June 2002)

			HWB		PHWB		DTPA-Sorbitol	
Soil	Trt	Sample	ICP reading	B ppm soil	ICP reading	B ppm soil	ICP reading	B ppm soil
silt loam	0	1	0.3528	0.706	0.0589	1.178	0.2781	0.556
silt loam	0	2	0.3015	0.603	0.0727	1.454	0.2935	0.587
silt loam	0	3	0.1921	0.384	0.0747	1.494	0.2675	0.535
silt loam	0	4	0.2262	0.452	0.0653	1.306	0.2971	0.594
silt loam	0.125	5	N/A	.	N/A	.	N/A	.
silt loam	0.125	6	0.2684	0.537	0.0593	1.186	0.3034	0.607
silt loam	0.125	7	0.2312	0.462	0.0700	1.400	0.2968	0.594
silt loam	0.125	8	0.3307	0.661	0.0743	1.486	0.3061	0.612
silt loam	0.25	9	N/A	.	N/A	.	N/A	.
silt loam	0.25	10	0.2062	0.412	0.0880	1.760	0.3293	0.659
silt loam	0.25	11	0.2303	0.461	0.0828	1.656	0.3027	0.605
silt loam	0.25	12	0.4198	0.840	0.0870	1.740	0.3396	0.679
silt loam	0.5	13	N/A	.	N/A	.	N/A	.
silt loam	0.5	14	0.2352	0.470	0.0947	1.894	0.4077	0.815
silt loam	0.5	15	0.3664	0.733	0.1013	2.026	0.4058	0.812
silt loam	0.5	16	0.3028	0.606	0.1020	2.040	0.4301	0.860
silt loam	1	17	0.3095	0.619	0.1160	2.320	0.5012	1.002
silt loam	1	18	0.5851	1.170	0.1414	2.828	0.6326	1.265
silt loam	1	19	0.4043	0.809	0.1183	2.366	0.4971	0.994
silt loam	1	20	0.6874	1.375	0.1375	2.750	0.6217	1.243
silt loam	2	21	0.4283	0.857	0.1790	3.580	0.7846	1.569
silt loam	2	22	0.4380	0.876	0.1822	3.644	0.7832	1.566
silt loam	2	23	0.6384	1.277	0.2305	4.610	1.0610	2.122
silt loam	2	24	0.5901	1.180	0.2169	4.338	0.9771	1.954
silt loam	4	25	N/A	.	N/A	.	N/A	.
silt loam	4	26	0.7516	1.503	0.2289	4.578	1.1180	2.236
silt loam	4	27	0.7577	1.515	0.2334	4.668	1.1600	2.320
silt loam	4	28	0.8858	1.772	0.3189	6.378	1.5670	3.134
silt loam	8	29	1.9320	3.864	0.4380	8.760	2.3450	4.690
silt loam	8	30	2.0150	4.030	0.5128	10.256	2.6300	5.260
silt loam	8	31	1.7030	3.406	0.4604	9.208	2.3180	4.636
silt loam	8	32	1.7340	3.468	0.5428	10.856	2.6770	5.354

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand

Harvest 2, Soil (13 June 2002)

			HWB		PHWB		DTPA-Sorbitol	
Soil	Trt	Sample	ICP reading	B ppm soil	ICP reading	B ppm soil	ICP reading	B ppm soil
sandy	0	33	0.0447	0.089	0.0234	0.468	0.1914	0.383
sandy	0	34	0.3850	0.770	0.0179	0.358	0.1119	0.224
sandy	0	35	0.0370	0.074	0.0176	0.352	0.0971	0.194
sandy	0	36	0.0407	0.081	0.0198	0.396	0.1047	0.209
sandy	0.125	37	0.0471	0.094	0.0256	0.512	0.1178	0.236
sandy	0.125	38	0.0437	0.087	0.0198	0.396	0.1080	0.216
sandy	0.125	39	0.0458	0.092	0.0212	0.424	0.1121	0.224
sandy	0.125	40	0.0522	0.104	0.0223	0.446	0.1197	0.239
sandy	0.25	41	0.0710	0.142	0.0240	0.480	0.1213	0.243
sandy	0.25	42	0.0647	0.129	0.0240	0.480	0.1339	0.268
sandy	0.25	43	0.0616	0.123	0.0190	0.380	0.1121	0.224
sandy	0.25	44	0.0673	0.135	0.0249	0.498	0.1280	0.256
sandy	0.5	45	N/A	.	N/A	.	N/A	.
sandy	0.5	46	0.1112	0.222	0.0445	0.890	0.1539	0.308
sandy	0.5	47	0.1123	0.225	0.0334	0.668	0.1626	0.325
sandy	0.5	48	0.1081	0.216	0.0318	0.636	0.1713	0.343
sandy	1	49	N/A	.	N/A	.	N/A	.
sandy	1	50	0.3869	0.774	0.0922	1.844	0.4110	0.822
sandy	1	51	0.3336	0.667	0.0838	1.676	0.4077	0.815
sandy	1	52	0.1992	0.398	0.0365	0.730	0.2431	0.486
sandy	2	53	N/A	.	N/A	.	N/A	.
sandy	2	54	0.2829	0.566	0.0712	1.424	0.3542	0.708
sandy	2	55	0.3956	0.791	0.1003	2.006	0.4747	0.949
sandy	2	56	0.4692	0.938	0.1073	2.146	0.6689	1.338
sandy	4	57	0.4086	0.817	0.0821	1.642	0.4492	0.898
sandy	4	58	0.9317	1.863	0.2033	4.066	1.1230	2.246
sandy	4	59	0.7541	1.508	0.1681	3.362	0.9769	1.954
sandy	4	60	0.5522	1.104	0.1138	2.276	0.7223	1.445
sandy	8	61	N/A	.	N/A	.	N/A	.
sandy	8	62	0.7258	1.452	0.1829	3.658	0.9779	1.956
sandy	8	63	1.4990	2.998	0.3759	7.518	1.6780	3.356
sandy	8	64	1.8290	3.658	0.3844	7.688	1.8120	3.624

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand
Harvest 2, Soil (13 June 2002)

			pH	O.M.	NaHCO3 - P			NaHCO3 - K	
Soil	Trt	Sample	Sat. Paste		% Trans	P ppm solution	P ppm soil	A.A. Reading	K ppm soil
silt loam	0	1	7.7	1.186	86.1	0.398	7.965	0.25	80.00
silt loam	0	2	7.7	1.211	84.4	0.452	9.036	0.29	92.80
silt loam	0	3	7.7	1.173	86.5	0.386	7.716	0.28	89.60
silt loam	0	4	7.7	1.179	86.0	0.401	8.027	0.25	80.00
silt loam	0.125	5	7.7	1.324	86.2	0.395	7.903	0.27	86.40
silt loam	0.125	6	7.7	1.236	86.5	0.386	7.716	0.28	89.60
silt loam	0.125	7	7.7	1.261	87.4	0.358	7.160	0.25	80.00
silt loam	0.125	8	7.7	1.268	86.3	0.392	7.840	0.28	89.60
silt loam	0.25	9	7.7	1.211	73.6	0.820	16.393	0.30	96.00
silt loam	0.25	10	7.7	1.287	87.2	0.364	7.283	0.24	76.80
silt loam	0.25	11	7.7	1.261	86.4	0.389	7.778	0.27	86.40
silt loam	0.25	12	7.7	1.249	86.4	0.389	7.778	0.26	83.20
silt loam	0.5	13	7.7	1.186	78.9	0.633	12.657	0.28	89.60
silt loam	0.5	14	7.7	1.255	87.1	0.367	7.345	0.26	83.20
silt loam	0.5	15	7.7	1.230	85.0	0.433	8.656	0.30	96.00
silt loam	0.5	16	7.7	1.104	87.1	0.367	7.345	0.26	83.20
silt loam	1	17	7.7	1.287	86.5	0.386	7.716	0.24	76.80
silt loam	1	18	7.7	1.331	85.8	0.408	8.152	0.28	89.60
silt loam	1	19	7.7	1.186	87.4	0.358	7.160	0.28	89.60
silt loam	1	20	7.7	1.312	87.0	0.370	7.406	0.25	80.00
silt loam	2	21	7.7	1.318	86.2	0.395	7.903	0.27	86.40
silt loam	2	22	7.7	1.242	85.5	0.417	8.341	0.24	76.80
silt loam	2	23	7.7	1.224	87.0	0.370	7.406	0.21	67.20
silt loam	2	24	7.7	1.211	86.1	0.398	7.965	0.23	73.60
silt loam	4	25	7.7	1.148	81.3	0.552	11.047	0.27	86.40
silt loam	4	26	7.7	1.217	85.0	0.433	8.656	0.30	96.00
silt loam	4	27	7.7	1.242	87.0	0.370	7.406	0.23	73.60
silt loam	4	28	7.7	1.299	87.4	0.358	7.160	0.23	73.60
silt loam	8	29	7.7	1.249	82.7	0.506	10.130	0.26	83.20
silt loam	8	30	7.7	1.242	87.4	0.358	7.160	0.22	70.40
silt loam	8	31	7.7	1.255	85.7	0.411	8.215	0.23	73.60
silt loam	8	32	7.7	1.224	86.0	0.401	8.027	0.23	73.60

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand
Harvest 2, Soil (13 June 2002)

			pH	O.M.	NaHCO3 - P			NaHCO3 - K	
Soil	Trt	Sample	Sat. Paste		% Trans	P ppm solution	P ppm soil	A.A. Reading	K ppm soil
sandy	0	33	7.2	0.593	79.0	0.629	12.589	0.14	44.80
sandy	0	34	7.2	0.580	77.3	0.688	13.758	0.13	41.60
sandy	0	35	7.2	0.593	79.3	0.619	12.385	0.14	44.80
sandy	0	36	7.2	0.587	73.9	0.809	16.174	0.18	57.60
sandy	0.125	37	7.2	0.568	84.3	0.455	9.100	0.10	32.00
sandy	0.125	38	7.2	0.580	76.9	0.702	14.036	0.16	51.20
sandy	0.125	39	7.2	0.555	81.3	0.552	11.047	0.12	38.40
sandy	0.125	40	7.2	0.599	76.0	0.733	14.669	0.18	57.60
sandy	0.25	41	7.2	0.580	79.7	0.606	12.115	0.14	44.80
sandy	0.25	42	7.2	0.705	74.3	0.794	15.884	0.21	67.20
sandy	0.25	43	7.2	0.611	77.2	0.691	13.827	0.23	73.60
sandy	0.25	44	7.2	0.674	79.5	0.612	12.250	0.20	64.00
sandy	0.5	45	7.2	0.593	77.6	0.677	13.549	0.15	48.00
sandy	0.5	46	7.2	0.505	72.2	0.871	17.425	0.23	73.60
sandy	0.5	47	7.2	0.649	74.5	0.787	15.740	0.18	57.60
sandy	0.5	48	7.2	0.599	73.1	0.838	16.759	0.29	92.80
sandy	1	49	7.2	0.605	51.5	1.779	35.577	0.31	99.20
sandy	1	50	7.2	0.574	76.2	0.726	14.528	0.32	102.40
sandy	1	51	7.2	0.549	79.5	0.612	12.250	0.13	41.60
sandy	1	52	7.2	0.587	75.1	0.765	15.309	0.15	48.00
sandy	2	53	7.2	0.630	51.7	1.768	35.368	0.24	76.80
sandy	2	54	7.2	0.487	78.0	0.664	13.273	0.14	44.80
sandy	2	55	7.2	0.661	77.7	0.674	13.480	0.15	48.00
sandy	2	56	7.2	0.618	76.9	0.702	14.036	0.16	51.20
sandy	4	57	7.2	0.636	75.5	0.751	15.023	0.16	51.20
sandy	4	58	7.2	0.605	75.9	0.737	14.740	0.18	57.60
sandy	4	59	7.2	0.593	76.9	0.702	14.036	0.22	70.40
sandy	4	60	7.2	0.636	73.8	0.812	16.247	0.19	60.80
sandy	8	61	7.2	0.549	58.0	1.460	29.191	0.21	67.20
sandy	8	62	7.2	0.530	72.6	0.856	17.128	0.24	76.80
sandy	8	63	7.2	0.518	76.7	0.709	14.176	0.17	54.40
sandy	8	64	7.2	0.618	72.0	0.879	17.574	0.22	70.40

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand
Harvest 2, Soil (13 June 2002)

			DTPA - Copper		DTPA - Iron		DTPA - Manganese		DTPA - Zinc	
Soil	Trt	Sample	ICP	Cu ppm soil	ICP	Fe ppm soil	ICP	Mn ppm soil	ICP	Zn ppm soil
silt loam	0	1	2.2690	4.538	0.5653	1.131	2.9250	5.850	1.1490	2.298
silt loam	0	2	7.2870	14.574	0.5500	1.100	4.2400	8.480	2.4140	4.828
silt loam	0	3	1.1560	2.312	0.5382	1.076	3.1620	6.324	0.8869	1.774
silt loam	0	4	1.5400	3.080	0.5396	1.079	3.0730	6.146	0.9602	1.920
silt loam	0.125	5	1.1240	2.248	0.5547	1.109	3.1180	6.236	0.8910	1.782
silt loam	0.125	6	1.1830	2.366	0.5100	1.020	3.1430	6.286	1.1350	2.270
silt loam	0.125	7	1.0250	2.050	0.4818	0.964	2.9590	5.918	1.0170	2.034
silt loam	0.125	8	1.0180	2.036	0.5035	1.007	2.8190	5.638	0.8596	1.719
silt loam	0.25	9	0.9843	1.969	0.5070	1.014	3.0410	6.082	0.8573	1.715
silt loam	0.25	10	0.9459	1.892	0.5085	1.017	3.0480	6.096	0.8699	1.740
silt loam	0.25	11	0.8273	1.655	0.5492	1.098	3.0220	6.044	0.8067	1.613
silt loam	0.25	12	0.9257	1.851	0.5815	1.163	3.6510	7.302	0.8940	1.788
silt loam	0.5	13	1.2530	2.506	0.5327	1.065	3.2080	6.416	0.9765	1.953
silt loam	0.5	14	1.0550	2.110	0.5839	1.168	3.0730	6.146	0.9952	1.990
silt loam	0.5	15	0.9442	1.888	0.6036	1.207	3.7270	7.454	1.0400	2.080
silt loam	0.5	16	0.9732	1.946	0.5630	1.126	3.2790	6.558	1.0840	2.168
silt loam	1	17	0.9365	1.873	0.5716	1.143	2.9640	5.928	1.0360	2.072
silt loam	1	18	0.9744	1.949	0.5651	1.130	3.0730	6.146	0.8667	1.733
silt loam	1	19	0.8988	1.798	0.5288	1.058	2.7740	5.548	0.8651	1.730
silt loam	1	20	0.9266	1.853	0.5402	1.080	2.7400	5.480	0.3952	0.790
silt loam	2	21	0.7946	1.589	0.5567	1.113	2.6310	5.262	0.7685	1.537
silt loam	2	22	0.7703	1.541	0.5560	1.112	2.7200	5.850	0.8683	1.737
silt loam	2	23	0.7462	1.492	0.5328	1.066	2.7770	8.480	0.8146	1.629
silt loam	2	24	0.7239	1.448	0.6655	1.331	2.5350	6.324	0.7961	1.592
silt loam	4	25	0.7076	1.415	0.6562	1.312	2.4150	6.146	0.7674	1.535
silt loam	4	26	0.8033	1.607	0.7049	1.410	2.4500	6.236	0.8026	1.605
silt loam	4	27	0.7371	1.474	0.6776	1.355	2.7230	6.286	0.8504	1.701
silt loam	4	28	0.7663	1.533	0.6907	1.381	2.8720	5.918	0.8772	1.754
silt loam	8	29	0.7635	1.527	0.6287	1.257	2.4100	5.638	0.8125	1.625
silt loam	8	30	0.7573	1.515	0.6175	1.235	2.6500	6.082	0.8179	1.636
silt loam	8	31	0.7631	1.526	0.6354	1.271	2.7360	6.096	0.5845	1.169
silt loam	8	32	0.7255	1.451	0.6029	1.206	2.3870	6.044	0.8197	1.639

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand
Harvest 2, Soil (13 June 2002)

			DTPA - Copper		DTPA - Iron		DTPA - Manganese		DTPA - Zinc	
Soil	Trt	Sample	ICP	Cu ppm soil	ICP	Fe ppm soil	ICP	Mn ppm soil	ICP	Zn ppm soil
sandy	0	33	0.6180	1.236	3.4620	6.924	2.1150	4.230	0.6823	1.365
sandy	0	34	0.5403	1.081	3.2060	6.412	1.8950	3.790	0.7228	1.446
sandy	0	35	0.5650	1.130	3.1900	6.380	1.8150	3.630	0.7751	1.550
sandy	0	36	0.5333	1.067	2.7490	5.498	1.4080	2.816	0.7282	1.456
sandy	0.125	37	0.5889	1.178	3.4270	6.854	1.7330	3.466	0.6752	1.350
sandy	0.125	38	0.5572	1.114	2.9580	5.916	1.6920	3.384	0.6938	1.388
sandy	0.125	39	0.5403	1.081	3.1360	6.272	1.7550	3.510	0.7751	1.550
sandy	0.125	40	0.5760	1.152	3.0670	6.134	1.8060	3.612	0.6969	1.394
sandy	0.25	41	0.6101	1.220	3.1550	6.310	1.8890	3.778	0.7027	1.405
sandy	0.25	42	0.5650	1.130	2.9810	5.962	1.6710	3.342	0.6791	1.358
sandy	0.25	43	0.5009	1.002	2.7770	5.554	2.2050	4.410	0.8529	1.706
sandy	0.25	44	0.9877	1.975	2.9760	5.952	2.0770	4.154	0.8808	1.762
sandy	0.5	45	0.6183	1.237	2.8800	5.760	1.5070	3.014	0.7459	1.492
sandy	0.5	46	1.0290	2.058	2.4920	4.984	2.1180	4.236	0.9656	1.931
sandy	0.5	47	0.6065	1.213	3.5800	7.160	2.3600	4.720	0.9747	1.949
sandy	0.5	48	0.6502	1.300	5.0580	10.116	1.8810	3.762	0.9802	1.960
sandy	1	49	0.5958	1.192	3.7980	7.596	1.3320	2.664	0.8776	1.755
sandy	1	50	0.6386	1.277	2.8880	5.776	2.3770	4.754	1.2750	2.550
sandy	1	51	0.6430	1.286	4.8310	9.662	2.2120	4.424	0.9717	1.943
sandy	1	52	0.6774	1.355	7.0650	14.130	1.5600	3.120	0.8288	1.658
sandy	2	53	0.7904	1.581	6.5590	13.118	1.6000	3.200	0.8899	1.780
sandy	2	54	0.7278	1.456	7.3050	14.610	1.5970	3.194	0.8445	1.689
sandy	2	55	0.6701	1.340	6.2540	12.508	1.9490	3.898	0.9018	1.804
sandy	2	56	0.7111	1.422	6.1250	12.250	2.3800	4.760	0.9881	1.976
sandy	4	57	0.8327	1.665	7.0680	14.136	2.4400	4.880	0.8823	1.765
sandy	4	58	0.6237	1.247	4.6380	9.276	2.2410	4.482	0.9255	1.851
sandy	4	59	0.7279	1.456	4.4730	8.946	2.2490	4.498	0.9960	1.992
sandy	4	60	0.7847	1.569	6.9590	13.918	2.3200	4.640	0.8995	1.799
sandy	8	61	0.8355	1.671	6.6460	13.292	2.4990	4.998	0.8584	1.717
sandy	8	62	0.7454	1.491	7.0980	14.196	2.2520	4.504	0.9007	1.801
sandy	8	63	0.7154	1.431	5.3460	10.692	2.2020	4.404	1.0200	2.040
sandy	8	64	0.7227	1.445	6.0050	12.010	2.4110	4.822	1.0580	2.116

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand
Harvest 1, Plant (19 December 2001)

						[B] Tissue	
Sample	Alfalfa Var.	Soil Type	Trt	Wet Wt. (g)	Dry Wt. (g)	ICP	[B]
1	Nitro Plus	Silt Loam	0	12.000	1.850	3.522	158.490
2	Nitro Plus	Silt Loam	0	6.000	1.720	3.446	155.070
3	Nitro Plus	Silt Loam	0	6.000	2.270	3.337	150.165
4	Nitro Plus	Silt Loam	0	6.000	1.890	3.378	152.010
5	Nitro Plus	Silt Loam	0.125	6.000	1.560	.	.
6	Nitro Plus	Silt Loam	0.125	8.000	1.630	3.018	135.810
7	Nitro Plus	Silt Loam	0.125	6.000	1.750	2.991	134.595
8	Nitro Plus	Silt Loam	0.125	6.000	1.830	3.250	146.250
9	Nitro Plus	Silt Loam	0.25	6.000	1.500	3.527	158.715
10	Nitro Plus	Silt Loam	0.25	8.000	1.910	4.207	189.315
11	Nitro Plus	Silt Loam	0.25	6.000	1.910	4.056	182.520
12	Nitro Plus	Silt Loam	0.25	6.000	2.010	2.700	121.500
13	Nitro Plus	Silt Loam	0.5	8.000	1.730	3.805	171.225
14	Nitro Plus	Silt Loam	0.5	8.000	1.810	3.294	148.230
15	Nitro Plus	Silt Loam	0.5	6.000	1.280	2.859	128.655
16	Nitro Plus	Silt Loam	0.5	4.000	1.280	2.937	132.165
17	Nitro Plus	Silt Loam	1	8.000	2.060	3.692	166.140
18	Nitro Plus	Silt Loam	1	8.000	1.930	3.349	150.705
19	Nitro Plus	Silt Loam	1	4.000	1.900	3.805	171.225
20	Nitro Plus	Silt Loam	1	6.000	1.830	3.885	174.825
21	Nitro Plus	Silt Loam	2	6.000	1.620	3.457	155.565
22	Nitro Plus	Silt Loam	2	8.000	1.910	3.232	145.440
23	Nitro Plus	Silt Loam	2	6.000	1.770	3.031	136.395
24	Nitro Plus	Silt Loam	2	6.000	1.910	3.289	148.005
25	Nitro Plus	Silt Loam	4	8.000	1.540	3.847	173.115
26	Nitro Plus	Silt Loam	4	8.000	1.690	3.763	169.335
27	Nitro Plus	Silt Loam	4	4.000	1.620	2.404	108.180
28	Nitro Plus	Silt Loam	4	6.000	1.860	2.861	128.745
29	Nitro Plus	Silt Loam	8	6.000	1.670	4.780	215.100
30	Nitro Plus	Silt Loam	8	8.000	1.930	4.258	191.610
31	Nitro Plus	Silt Loam	8	4.000	1.730	3.715	167.175
32	Nitro Plus	Silt Loam	8	4.000	1.610	4.395	197.775

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand
Harvest 1, Plant (19 December 2001)

						[B] Tissue	
Sample	Alfalfa Var.	Soil Type	Trt	Wet Wt. (g)	Dry Wt. (g)	ICP	[B]
33	Nitro Plus	Sand	0	8.000	1.410	2.437	109.665
34	Nitro Plus	Sand	0	6.000	1.250	2.285	102.825
35	Nitro Plus	Sand	0	4.000	1.330	2.129	95.805
36	Nitro Plus	Sand	0	4.000	1.300	1.969	88.605
*37	Nitro Plus	Sand	0.125	6.000	0.930	1.840	165.600
38	Nitro Plus	Sand	0.125	6.000	1.270	2.250	101.250
39	Nitro Plus	Sand	0.125	2.000	1.260	2.266	101.970
40	Nitro Plus	Sand	0.125	6.000	1.390	1.922	86.490
41	Nitro Plus	Sand	0.25	6.000	1.480	2.432	109.440
42	Nitro Plus	Sand	0.25	8.000	1.140	3.061	137.745
43	Nitro Plus	Sand	0.25	4.000	1.350	2.705	121.725
*44	Nitro Plus	Sand	0.25	2.000	1.050	1.748	157.320
45	Nitro Plus	Sand	0.5	10.000	1.320	2.331	104.895
46	Nitro Plus	Sand	0.5	6.000	1.090	2.431	109.395
47	Nitro Plus	Sand	0.5	6.000	1.320	2.535	114.075
48	Nitro Plus	Sand	0.5	4.000	1.290	2.745	123.525
*49	Nitro Plus	Sand	1	4.000	0.960	2.182	196.380
50	Nitro Plus	Sand	1	6.000	1.280	3.006	135.270
*51	Nitro Plus	Sand	1	4.000	1.140	1.843	165.870
52	Nitro Plus	Sand	1	6.000	1.630	3.268	147.060
53	Nitro Plus	Sand	2	6.000	1.240	3.104	139.680
*54	Nitro Plus	Sand	2	8.000	1.250	2.632	236.880
55	Nitro Plus	Sand	2	4.000	1.190	5.788	260.460
56	Nitro Plus	Sand	2	6.000	1.600	2.991	134.595
57	Nitro Plus	Sand	4	6.000	1.310	3.867	174.015
58	Nitro Plus	Sand	4	6.000	1.500	4.208	189.360
*59	Nitro Plus	Sand	4	4.000	1.300	2.122	190.980
60	Nitro Plus	Sand	4	6.000	1.420	6.486	291.870
*61	Nitro Plus	Sand	8	6.000	1.160	2.980	268.200
*62	Nitro Plus	Sand	8	4.000	1.200	2.450	220.500
*63	Nitro Plus	Sand	8	4.000	1.300	5.898	530.820
64	Nitro Plus	Sand	8	6.000	1.490	10.740	483.300

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand
Harvest 2, Plant (19 February 2002)

						[B] Tissue	
Sample	Alfalfa Var.	Soil Type	Trt	Wet Wt. (g)	Dry Wt. (g)	ICP	[B]
1	Nitro Plus	Silt Loam	0	14.000	2.280	3.516	158.220
2	Nitro Plus	Silt Loam	0	14.000	2.450	3.308	148.860
3	Nitro Plus	Silt Loam	0	14.000	2.710	3.196	143.820
4	Nitro Plus	Silt Loam	0	14.000	2.650	2.300	103.500
5	Nitro Plus	Silt Loam	0.125	16.000	2.760	1.654	74.430
6	Nitro Plus	Silt Loam	0.125	14.000	2.580	1.892	85.140
7	Nitro Plus	Silt Loam	0.125	16.000	2.810	1.647	74.115
8	Nitro Plus	Silt Loam	0.125	12.000	2.550	2.050	92.250
9	Nitro Plus	Silt Loam	0.25	14.000	2.520	2.669	120.105
10	Nitro Plus	Silt Loam	0.25	16.000	2.840	2.149	96.705
11	Nitro Plus	Silt Loam	0.25	18.000	3.400	3.331	149.895
12	Nitro Plus	Silt Loam	0.25	14.000	2.420	3.915	176.175
13	Nitro Plus	Silt Loam	0.5	18.000	2.990	2.638	118.710
14	Nitro Plus	Silt Loam	0.5	14.000	2.530	2.551	114.795
15	Nitro Plus	Silt Loam	0.5	8.000	1.930	2.280	102.600
16	Nitro Plus	Silt Loam	0.5	14.000	2.560	1.267	57.015
17	Nitro Plus	Silt Loam	1	16.000	2.940	2.940	132.300
18	Nitro Plus	Silt Loam	1	16.000	2.560	2.400	108.000
19	Nitro Plus	Silt Loam	1	14.000	2.550	1.999	89.955
20	Nitro Plus	Silt Loam	1	16.000	2.850	1.437	64.665
21	Nitro Plus	Silt Loam	2	16.000	2.900	2.614	117.630
22	Nitro Plus	Silt Loam	2	16.000	2.770	2.295	103.275
23	Nitro Plus	Silt Loam	2	14.000	2.840	1.082	48.690
24	Nitro Plus	Silt Loam	2	16.000	2.930	0.757	34.065
25	Nitro Plus	Silt Loam	4	12.000	2.370	1.246	56.070
26	Nitro Plus	Silt Loam	4	16.000	2.840	1.767	79.515
27	Nitro Plus	Silt Loam	4	18.000	2.780	0.960	43.196
28	Nitro Plus	Silt Loam	4	18.000	3.130	0.456	20.507
29	Nitro Plus	Silt Loam	8	14.000	2.530	0.704	31.680
30	Nitro Plus	Silt Loam	8	18.000	3.050	1.684	75.780
31	Nitro Plus	Silt Loam	8	14.000	2.480	1.969	88.605
32	Nitro Plus	Silt Loam	8	16.000	2.900	1.235	55.575

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand
Harvest 2, Plant (19 February 2002)

						[B] Tissue	
Sample	Alfalfa Var.	Soil Type	Trt	Wet Wt. (g)	Dry Wt. (g)	ICP	[B]
33	Nitro Plus	Sand	0	16.000	2.610	1.084	48.780
34	Nitro Plus	Sand	0	14.000	2.250	1.748	78.660
35	Nitro Plus	Sand	0	14.000	2.380	1.393	62.685
36	Nitro Plus	Sand	0	12.000	2.180	1.412	63.540
*37	Nitro Plus	Sand	0.125	18.000	2.960	2.434	109.530
38	Nitro Plus	Sand	0.125	10.000	1.560	2.884	129.780
39	Nitro Plus	Sand	0.125	16.000	2.810	1.788	80.460
40	Nitro Plus	Sand	0.125	16.000	2.300	1.855	83.475
41	Nitro Plus	Sand	0.25	14.000	2.350	2.064	92.880
42	Nitro Plus	Sand	0.25	12.000	2.370	2.013	90.585
43	Nitro Plus	Sand	0.25	10.000	1.570	2.075	93.375
*44	Nitro Plus	Sand	0.25	12.000	1.970	2.163	97.335
45	Nitro Plus	Sand	0.5	18.000	2.680	2.160	97.200
46	Nitro Plus	Sand	0.5	12.000	2.080	2.308	103.860
47	Nitro Plus	Sand	0.5	16.000	2.880	1.913	86.085
48	Nitro Plus	Sand	0.5	14.000	2.650	2.495	112.275
*49	Nitro Plus	Sand	1	14.000	2.150	2.657	119.565
50	Nitro Plus	Sand	1	14.000	2.220	2.277	102.465
*51	Nitro Plus	Sand	1	14.000	2.160	2.226	100.170
52	Nitro Plus	Sand	1	14.000	2.870	1.736	78.120
53	Nitro Plus	Sand	2	16.000	2.140	2.800	126.000
*54	Nitro Plus	Sand	2	14.000	2.110	2.209	99.405
55	Nitro Plus	Sand	2	16.000	2.150	1.849	83.205
56	Nitro Plus	Sand	2	18.000	2.950	1.917	86.265
57	Nitro Plus	Sand	4	18.000	2.980	4.150	186.750
58	Nitro Plus	Sand	4	12.000	2.070	5.198	233.910
*59	Nitro Plus	Sand	4	16.000	2.700	6.983	314.235
60	Nitro Plus	Sand	4	18.000	2.830	4.737	213.165
*61	Nitro Plus	Sand	8	18.000	2.710	11.850	533.250
*62	Nitro Plus	Sand	8	14.000	2.180	11.500	517.500
*63	Nitro Plus	Sand	8	14.000	2.180	7.239	325.755
64	Nitro Plus	Sand	8	12.000	1.910	8.593	386.685

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand
Harvest 3, Plant (1 April 2002)

						[B] Tissue	
Sample	Alfalfa Var.	Soil Type	Trt	Wet Wt. (g)	Dry Wt. (g)	ICP	[B]
1	Nitro Plus	Silt Loam	0	22.000	5.880	1.834	82.530
2	Nitro Plus	Silt Loam	0	14.000	3.460	2.030	91.350
3	Nitro Plus	Silt Loam	0	14.000	3.890	2.460	110.700
4	Nitro Plus	Silt Loam	0	20.000	5.020	2.319	104.355
5	Nitro Plus	Silt Loam	0.125	22.000	5.430	2.728	122.760
6	Nitro Plus	Silt Loam	0.125	18.000	4.240	2.263	101.835
7	Nitro Plus	Silt Loam	0.125	16.000	4.570	2.263	101.835
8	Nitro Plus	Silt Loam	0.125	18.000	5.000	2.564	115.380
9	Nitro Plus	Silt Loam	0.25	26.000	6.190	1.985	89.325
10	Nitro Plus	Silt Loam	0.25	18.000	4.450	2.454	110.430
11	Nitro Plus	Silt Loam	0.25	16.000	4.500	2.391	107.595
12	Nitro Plus	Silt Loam	0.25	20.000	5.300	2.694	121.230
13	Nitro Plus	Silt Loam	0.5	24.000	5.830	2.142	96.390
14	Nitro Plus	Silt Loam	0.5	14.000	3.480	3.236	145.620
15	Nitro Plus	Silt Loam	0.5	18.000	4.480	2.948	132.660
16	Nitro Plus	Silt Loam	0.5	18.000	4.460	2.455	110.475
17	Nitro Plus	Silt Loam	1	22.000	5.170	2.592	116.640
18	Nitro Plus	Silt Loam	1	18.000	4.160	1.674	75.330
19	Nitro Plus	Silt Loam	1	18.000	4.770	2.409	108.405
20	Nitro Plus	Silt Loam	1	20.000	5.160	2.229	100.305
21	Nitro Plus	Silt Loam	2	16.000	4.050	2.360	106.200
22	Nitro Plus	Silt Loam	2	16.000	3.980	2.285	102.825
23	Nitro Plus	Silt Loam	2	20.000	5.170	2.420	108.900
24	Nitro Plus	Silt Loam	2	20.000	5.440	1.958	88.110
25	Nitro Plus	Silt Loam	4	24.000	5.620	2.324	104.580
26	Nitro Plus	Silt Loam	4	14.000	3.160	3.130	140.850
27	Nitro Plus	Silt Loam	4	18.000	4.700	2.553	114.885
28	Nitro Plus	Silt Loam	4	18.000	4.570	2.225	100.125
29	Nitro Plus	Silt Loam	8	20.000	4.700	3.310	148.950
30	Nitro Plus	Silt Loam	8	16.000	4.190	2.969	133.605
31	Nitro Plus	Silt Loam	8	18.000	4.330	2.512	113.040
32	Nitro Plus	Silt Loam	8	18.000	4.700	2.949	132.705

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand
Harvest 3, Plant (1 April 2002)

Sample	Alfalfa Var.	Soil Type	Trt	Wet Wt. (g)	Dry Wt. (g)	[B] Tissue	
						ICP	[B]
33	Nitro Plus	Sand	0	14.000	3.490	1.165	52.425
34	Nitro Plus	Sand	0	16.000	3.980	1.283	57.735
35	Nitro Plus	Sand	0	18.000	4.310	1.369	61.605
36	Nitro Plus	Sand	0	18.000	4.220	1.723	77.535
*37	Nitro Plus	Sand	0.125	18.000	4.620	1.990	89.550
38	Nitro Plus	Sand	0.125	14.000	3.550	2.024	91.080
39	Nitro Plus	Sand	0.125	20.000	4.970	1.684	75.780
40	Nitro Plus	Sand	0.125	16.000	4.080	1.209	54.405
41	Nitro Plus	Sand	0.25	14.000	3.390	1.952	87.840
42	Nitro Plus	Sand	0.25	14.000	3.450	1.679	75.555
43	Nitro Plus	Sand	0.25	12.000	3.180	1.544	69.480
*44	Nitro Plus	Sand	0.25	18.000	4.560	1.908	85.860
45	Nitro Plus	Sand	0.5	22.000	5.420	1.363	61.335
46	Nitro Plus	Sand	0.5	16.000	4.030	2.023	91.035
47	Nitro Plus	Sand	0.5	16.000	4.290	1.661	74.745
48	Nitro Plus	Sand	0.5	12.000	3.090	2.025	91.125
*49	Nitro Plus	Sand	1	24.000	5.600	2.919	131.355
50	Nitro Plus	Sand	1	20.000	4.830	3.366	151.470
*51	Nitro Plus	Sand	1	16.000	4.420	3.341	150.345
52	Nitro Plus	Sand	1	20.000	5.560	3.122	140.490
53	Nitro Plus	Sand	2	26.000	5.970	2.964	133.380
*54	Nitro Plus	Sand	2	14.000	3.210	2.881	129.645
55	Nitro Plus	Sand	2	16.000	4.230	2.627	118.215
56	Nitro Plus	Sand	2	16.000	4.550	2.682	120.690
57	Nitro Plus	Sand	4	16.000	4.760	2.510	112.950
58	Nitro Plus	Sand	4	16.000	4.150	2.660	119.700
*59	Nitro Plus	Sand	4	20.000	5.160	3.400	153.000
60	Nitro Plus	Sand	4	20.000	5.090	2.444	109.980
*61	Nitro Plus	Sand	8	24.000	5.630	2.636	118.620
*62	Nitro Plus	Sand	8	18.000	4.370	3.466	155.970
*63	Nitro Plus	Sand	8	20.000	5.230	4.171	187.695
64	Nitro Plus	Sand	8	14.000	3.810	4.634	208.530

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand
Harvest 4, Plant (15 May 2002)

						[B] Tissue	
Sample	Alfalfa Var.	Soil Type	Trt	Wet Wt. (g)	Dry Wt. (g)	ICP	[B]
1	Nitro Plus	Silt Loam	0	24.000	7.500	1.396	62.820
2	Nitro Plus	Silt Loam	0	12.000	4.710	1.441	64.845
3	Nitro Plus	Silt Loam	0	12.000	4.240	1.603	72.135
4	Nitro Plus	Silt Loam	0	20.000	5.510	1.171	52.695
5	Nitro Plus	Silt Loam	0.125	14.000	5.030	1.361	61.245
6	Nitro Plus	Silt Loam	0.125	16.000	5.210	1.535	69.075
7	Nitro Plus	Silt Loam	0.125	14.000	5.490	1.319	59.355
8	Nitro Plus	Silt Loam	0.125	20.000	6.050	1.384	62.280
9	Nitro Plus	Silt Loam	0.25	18.000	7.190	1.427	64.215
10	Nitro Plus	Silt Loam	0.25	16.000	6.750	1.273	57.285
11	Nitro Plus	Silt Loam	0.25	14.000	4.920	1.608	72.360
12	Nitro Plus	Silt Loam	0.25	16.000	5.160	1.915	86.175
13	Nitro Plus	Silt Loam	0.5	16.000	5.910	1.438	64.710
14	Nitro Plus	Silt Loam	0.5	12.000	4.610	1.794	80.730
15	Nitro Plus	Silt Loam	0.5	16.000	4.810	1.502	67.590
16	Nitro Plus	Silt Loam	0.5	20.000	6.320	1.358	61.110
17	Nitro Plus	Silt Loam	1	14.000	5.610	1.442	64.890
18	Nitro Plus	Silt Loam	1	12.000	4.470	1.940	87.300
19	Nitro Plus	Silt Loam	1	24.000	6.500	1.402	63.090
20	Nitro Plus	Silt Loam	1	24.000	7.000	1.588	71.460
21	Nitro Plus	Silt Loam	2	16.000	5.660	1.795	80.775
22	Nitro Plus	Silt Loam	2	16.000	6.490	1.455	65.475
23	Nitro Plus	Silt Loam	2	20.000	6.640	1.523	68.535
24	Nitro Plus	Silt Loam	2	22.000	6.820	1.459	65.655
25	Nitro Plus	Silt Loam	4	14.000	4.620	2.829	127.305
26	Nitro Plus	Silt Loam	4	10.000	4.320	3.120	140.400
27	Nitro Plus	Silt Loam	4	20.000	6.290	1.784	80.280
28	Nitro Plus	Silt Loam	4	18.000	6.060	2.197	98.865
29	Nitro Plus	Silt Loam	8	18.000	5.510	2.787	125.415
30	Nitro Plus	Silt Loam	8	22.000	7.400	2.104	94.680
31	Nitro Plus	Silt Loam	8	18.000	6.100	2.355	105.975
32	Nitro Plus	Silt Loam	8	22.000	6.250	2.728	122.760

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand
Harvest 4, Plant (15 May 2002)

						[B] Tissue	
Sample	Alfalfa Var.	Soil Type	Trt	Wet Wt. (g)	Dry Wt. (g)	ICP	[B]
33	Nitro Plus	Sand	0	26.000	6.380	1.015	45.675
34	Nitro Plus	Sand	0	24.000	6.190	0.967	43.533
35	Nitro Plus	Sand	0	22.000	6.480	0.965	43.430
36	Nitro Plus	Sand	0	18.000	5.710	0.964	43.394
*37	Nitro Plus	Sand	0.125	24.000	7.550	1.367	61.515
38	Nitro Plus	Sand	0.125	14.000	5.430	1.099	49.455
39	Nitro Plus	Sand	0.125	24.000	6.920	1.042	46.890
40	Nitro Plus	Sand	0.125	16.000	4.700	1.106	49.770
41	Nitro Plus	Sand	0.25	28.000	8.200	1.155	51.975
42	Nitro Plus	Sand	0.25	14.000	4.570	1.592	71.640
43	Nitro Plus	Sand	0.25	12.000	4.030	1.613	72.585
*44	Nitro Plus	Sand	0.25	18.000	5.470	1.226	55.170
45	Nitro Plus	Sand	0.5	14.000	5.800	1.549	69.705
46	Nitro Plus	Sand	0.5	18.000	5.640	1.746	78.570
47	Nitro Plus	Sand	0.5	18.000	4.710	1.859	83.655
48	Nitro Plus	Sand	0.5	16.000	4.920	2.027	91.215
*49	Nitro Plus	Sand	1	16.000	5.800	2.546	114.570
50	Nitro Plus	Sand	1	18.000	6.260	2.310	103.950
*51	Nitro Plus	Sand	1	24.000	7.360	1.614	72.630
52	Nitro Plus	Sand	1	18.000	6.670	1.593	71.685
53	Nitro Plus	Sand	2	14.000	4.770	2.016	90.720
*54	Nitro Plus	Sand	2	22.000	6.370	1.364	61.380
55	Nitro Plus	Sand	2	16.000	6.110	1.566	70.470
56	Nitro Plus	Sand	2	26.000	7.100	1.327	59.715
57	Nitro Plus	Sand	4	14.000	3.660	1.643	73.935
58	Nitro Plus	Sand	4	18.000	5.360	1.887	84.915
*59	Nitro Plus	Sand	4	16.000	5.380	3.114	140.130
60	Nitro Plus	Sand	4	18.000	5.020	2.907	130.815
*61	Nitro Plus	Sand	8	24.000	6.810	2.232	100.440
*62	Nitro Plus	Sand	8	16.000	5.020	3.041	136.845
*63	Nitro Plus	Sand	8	22.000	7.110	2.611	117.495
64	Nitro Plus	Sand	8	22.000	5.900	2.055	92.475

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand
Harvest 5, Plant (13 June 2002)

						[B] Tissue	
Sample	Alfalfa Var.	Soil Type	Trt	Wet Wt. (g)	Dry Wt. (g)	ICP	[B]
1	Nitro Plus	Silt Loam	0	14.000	3.420	1.490	67.050
2	Nitro Plus	Silt Loam	0	16.000	4.890	1.536	69.120
3	Nitro Plus	Silt Loam	0	16.000	4.160	1.793	80.685
4	Nitro Plus	Silt Loam	0	12.000	3.870	1.464	65.880
5	Nitro Plus	Silt Loam	0.125	14.000	3.670	1.533	68.985
6	Nitro Plus	Silt Loam	0.125	16.000	4.290	1.374	61.830
7	Nitro Plus	Silt Loam	0.125	14.000	4.350	1.352	60.840
8	Nitro Plus	Silt Loam	0.125	14.000	4.460	1.318	59.310
9	Nitro Plus	Silt Loam	0.25	12.000	4.610	1.294	58.230
10	Nitro Plus	Silt Loam	0.25	14.000	3.890	1.701	76.545
11	Nitro Plus	Silt Loam	0.25	12.000	4.610	1.724	77.580
12	Nitro Plus	Silt Loam	0.25	14.000	4.380	1.544	69.480
13	Nitro Plus	Silt Loam	0.5	14.000	3.390	1.304	58.680
14	Nitro Plus	Silt Loam	0.5	18.000	4.550	1.613	72.585
15	Nitro Plus	Silt Loam	0.5	22.000	5.700	1.592	71.640
16	Nitro Plus	Silt Loam	0.5	16.000	3.720	1.222	54.990
17	Nitro Plus	Silt Loam	1	18.000	4.840	1.469	66.105
18	Nitro Plus	Silt Loam	1	20.000	5.070	1.701	76.545
19	Nitro Plus	Silt Loam	1	14.000	4.090	1.423	64.035
20	Nitro Plus	Silt Loam	1	14.000	4.730	1.230	55.350
21	Nitro Plus	Silt Loam	2	16.000	3.690	1.058	47.610
22	Nitro Plus	Silt Loam	2	14.000	4.610	1.236	55.620
23	Nitro Plus	Silt Loam	2	14.000	4.290	1.466	65.970
24	Nitro Plus	Silt Loam	2	12.000	3.610	1.006	45.270
25	Nitro Plus	Silt Loam	4	18.000	4.690	1.364	61.380
26	Nitro Plus	Silt Loam	4	16.000	4.530	2.013	90.585
27	Nitro Plus	Silt Loam	4	14.000	3.960	1.731	77.895
28	Nitro Plus	Silt Loam	4	18.000	4.570	2.917	131.265
29	Nitro Plus	Silt Loam	8	12.000	3.480	2.739	123.255
30	Nitro Plus	Silt Loam	8	10.000	3.690	1.817	81.765
31	Nitro Plus	Silt Loam	8	12.000	3.720	2.300	103.500
32	Nitro Plus	Silt Loam	8	18.000	4.110	2.062	92.790

D01 -- Greenhouse Alfalfa Experiment with Minidoka Silt Loam and Hayeston Sand
Harvest 5, Plant (13 June 2002)

						[B] Tissue	
Sample	Alfalfa Var.	Soil Type	Trt	Wet Wt. (g)	Dry Wt. (g)	ICP	[B]
33	Nitro Plus	Sand	0	14.000	3.160	1.110	49.950
34	Nitro Plus	Sand	0	8.000	4.420	0.821	36.923
35	Nitro Plus	Sand	0	8.000	4.350	0.627	28.197
36	Nitro Plus	Sand	0	12.000	3.350	0.705	31.703
*37	Nitro Plus	Sand	0.125	16.000	3.350	1.199	53.955
38	Nitro Plus	Sand	0.125	18.000	5.280	1.125	50.625
39	Nitro Plus	Sand	0.125	14.000	4.990	0.919	41.373
40	Nitro Plus	Sand	0.125	16.000	3.570	0.853	38.394
41	Nitro Plus	Sand	0.25	14.000	3.270	0.888	39.978
42	Nitro Plus	Sand	0.25	6.000	1.250	0.688	30.978
43	Nitro Plus	Sand	0.25	20.000	5.290	1.224	55.080
*44	Nitro Plus	Sand	0.25	10.000	2.330	0.945	42.512
45	Nitro Plus	Sand	0.5	16.000	5.280	1.016	45.720
46	Nitro Plus	Sand	0.5	20.000	5.240	0.946	42.557
47	Nitro Plus	Sand	0.5	12.000	5.210	0.985	44.330
48	Nitro Plus	Sand	0.5	20.000	4.640	0.935	42.071
*49	Nitro Plus	Sand	1	16.000	3.880	1.314	59.130
50	Nitro Plus	Sand	1	14.000	3.900	1.475	66.375
*51	Nitro Plus	Sand	1	14.000	4.450	1.042	46.890
52	Nitro Plus	Sand	1	18.000	3.850	1.085	48.825
53	Nitro Plus	Sand	2	24.000	5.410	1.235	55.575
*54	Nitro Plus	Sand	2	12.000	4.650	1.033	46.485
55	Nitro Plus	Sand	2	10.000	4.900	1.487	66.915
56	Nitro Plus	Sand	2	12.000	3.780	1.452	65.340
57	Nitro Plus	Sand	4	6.000	3.180	1.402	63.090
58	Nitro Plus	Sand	4	14.000	4.320	3.181	143.145
*59	Nitro Plus	Sand	4	14.000	5.440	2.717	122.265
60	Nitro Plus	Sand	4	20.000	4.400	1.491	67.095
*61	Nitro Plus	Sand	8	8.000	1.830	2.600	117.000
*62	Nitro Plus	Sand	8	6.000	1.680	3.447	155.115
*63	Nitro Plus	Sand	8	14.000	4.170	4.697	211.365
64	Nitro Plus	Sand	8	12.000	3.580	9.524	428.580

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 1, Soil (6 February 2003)

			HWB		PHWB		DTPA-Sorbitol	
Alfalfa Var.	Trt	Sample	ICP reading	B ppm soil	ICP reading	B ppm soil	ICP reading	B ppm soil
Nitro Plus	0	1	0.0232	0.046	0.0108	0.216	0.2686	0.537
Nitro Plus	0	2	0.0226	0.045	0.0061	0.122	0.1667	0.333
Nitro Plus	0	3	0.0198	0.040	0.0027	0.054	0.2256	0.451
Nitro Plus	0	4	0.1550	0.310	0.0028	0.056	0.1801	0.360
Nitro Plus	0.125	5	0.0505	0.101	0.0079	0.158	0.2440	0.488
Nitro Plus	0.125	6	0.0571	0.114	0.0094	0.188	0.2646	0.529
Nitro Plus	0.125	7	0.0468	0.094	0.0086	0.172	0.2368	0.474
Nitro Plus	0.125	8	0.0561	0.112	0.0090	0.180	0.2328	0.466
Nitro Plus	0.25	9	0.0706	0.141	0.0327	0.654	0.2965	0.593
Nitro Plus	0.25	10	0.0861	0.172	0.0280	0.560	0.3219	0.644
Nitro Plus	0.25	11	0.0816	0.163	0.0214	0.428	0.2500	0.500
Nitro Plus	0.25	12	0.0844	0.169	0.0192	0.384	0.2394	0.479
Nitro Plus	0.5	13	0.1799	0.360	0.1243	2.486	0.3182	0.636
Nitro Plus	0.5	14	0.1814	0.363	0.0350	0.700	0.3420	0.684
Nitro Plus	0.5	15	0.1392	0.278	0.0292	0.584	0.2778	0.556
Nitro Plus	0.5	16	0.1151	0.230	0.0241	0.482	0.2828	0.566
Nitro Plus	0.75	17	0.2813	0.563	0.0444	0.888	0.4322	0.864
Nitro Plus	0.75	18	0.3064	0.613	0.0683	1.366	0.4241	0.848
Nitro Plus	0.75	19	0.2949	0.590	0.0553	1.106	0.4403	0.881
Nitro Plus	0.75	20	0.3147	0.629	0.0555	1.110	0.5447	1.089
Nitro Plus	1	21	0.3600	0.720	0.0766	1.532	0.5549	1.110
Nitro Plus	1	22	0.4266	0.853	0.0766	1.532	0.5497	1.099
Nitro Plus	1	23	0.3536	0.707	0.0701	1.402	0.5077	1.015
Nitro Plus	1	24	0.4273	0.855	0.0738	1.476	0.5735	1.147
Nitro Plus	1.5	25	0.5005	1.001	0.0907	1.814	0.6887	1.377
Nitro Plus	1.5	26	0.5193	1.039	0.0888	1.776	0.6609	1.322
Nitro Plus	1.5	27	0.5908	1.182	0.1036	2.072	0.6321	1.264
Nitro Plus	1.5	28	0.4866	0.973	0.0878	1.756	0.6616	1.323
Nitro Plus	2	29	0.8801	1.760	0.1256	2.512	0.9207	1.841
Nitro Plus	2	30	0.7900	1.580	0.1286	2.572	0.9433	1.887
Nitro Plus	2	31	0.8724	1.745	0.1365	2.730	1.0990	2.198
Nitro Plus	2	32	0.7878	1.576	0.1430	2.860	1.0530	2.106
Nitro Plus	4	33	1.5410	3.082	0.2479	4.958	2.0170	4.034
Nitro Plus	4	34	1.7020	3.404	0.2449	4.898	1.9630	3.926
Nitro Plus	4	35	1.7460	3.492	0.2607	5.214	1.8540	3.708
Nitro Plus	4	36	1.6390	3.278	0.2567	5.134	1.6370	3.274
Nitro Plus	8	37	3.5840	7.168	0.6542	13.084	3.6300	7.260
Nitro Plus	8	38	3.8710	7.742	0.5691	11.382	3.5970	7.194
Nitro Plus	8	39	3.6570	7.314	0.5722	11.444	3.2870	6.574
Nitro Plus	8	40	3.6590	7.318	0.5096	10.192	3.1150	6.230

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 1, Soil (6 February 2003)

			HWB		PHWB		DTPA-Sorbitol	
Alfalfa Var.	Trt	Sample	ICP reading	B ppm soil	ICP reading	B ppm soil	ICP reading	B ppm soil
Tahoe 2001	0	41	0.0389	0.078	0.0040	0.080	0.1853	0.371
Tahoe 2001	0	42	0.1730	0.346	0.0000	0.000	0.1514	0.303
Tahoe 2001	0	43	0.1100	0.220	0.0000	0.000	0.1701	0.340
Tahoe 2001	0	44	0.1160	0.232	0.0000	0.000	0.1594	0.319
Tahoe 2001	0.125	45	0.8700	1.740	0.0047	0.094	0.2463	0.493
Tahoe 2001	0.125	46	0.1072	0.214	0.0034	0.068	0.2574	0.515
Tahoe 2001	0.125	47	0.0451	0.090	0.0000	0.000	0.2043	0.409
Tahoe 2001	0.125	48	0.0478	0.096	0.0021	0.042	0.2053	0.411
Tahoe 2001	0.25	49	0.0676	0.135	0.0366	0.732	0.2512	0.502
Tahoe 2001	0.25	50	0.0785	0.157	0.0327	0.654	0.2277	0.455
Tahoe 2001	0.25	51	0.0873	0.175	0.0236	0.472	0.1972	0.394
Tahoe 2001	0.25	52	0.0971	0.194	0.0275	0.550	0.2204	0.441
Tahoe 2001	0.5	53	0.1754	0.351	0.0393	0.786	0.2709	0.542
Tahoe 2001	0.5	54	0.1872	0.374	0.0419	0.838	0.3237	0.647
Tahoe 2001	0.5	55	0.1766	0.353	0.0342	0.684	0.2985	0.597
Tahoe 2001	0.5	56	0.1577	0.315	0.0324	0.648	0.2712	0.542
Tahoe 2001	0.75	57	0.2525	0.505	0.0514	1.028	0.3592	0.718
Tahoe 2001	0.75	58	0.2517	0.503	0.0720	1.440	0.4296	0.859
Tahoe 2001	0.75	59	0.2250	0.450	0.0586	1.172	0.3941	0.788
Tahoe 2001	0.75	60	0.2034	0.407	0.0577	1.154	0.3671	0.734
Tahoe 2001	1	61	0.3177	0.635	0.0718	1.436	0.4492	0.898
Tahoe 2001	1	62	0.3236	0.647	0.0806	1.612	0.4775	0.955
Tahoe 2001	1	63	0.3345	0.669	0.0778	1.556	0.4202	0.840
Tahoe 2001	1	64	0.3672	0.734	0.0787	1.574	0.4723	0.945
Tahoe 2001	1.5	65	0.4876	0.975	0.0982	1.964	0.6295	1.259
Tahoe 2001	1.5	66	0.4758	0.952	0.0887	1.774	0.6220	1.244
Tahoe 2001	1.5	67	0.3352	0.670	0.0974	1.948	0.5274	1.055
Tahoe 2001	1.5	68	0.4615	0.923	0.1242	2.484	0.7519	1.504
Tahoe 2001	2	69	0.5040	1.008	0.1242	2.484	0.7595	1.519
Tahoe 2001	2	70	0.5554	1.111	0.1464	2.928	0.7874	1.575
Tahoe 2001	2	71	0.5370	1.074	0.1426	2.852	0.9048	1.810
Tahoe 2001	2	72	0.4909	0.982	0.1386	2.772	0.8480	1.696
Tahoe 2001	4	73	1.7240	3.448	0.2785	5.570	1.8180	3.636
Tahoe 2001	4	74	1.5580	3.116	0.2632	5.264	1.7190	3.438
Tahoe 2001	4	75	1.6290	3.258	0.2995	5.990	1.8690	3.738
Tahoe 2001	4	76	1.7080	3.416	0.2912	5.824	1.8990	3.798
Tahoe 2001	8	77	3.5580	7.116	0.5255	10.510	3.8280	7.656
Tahoe 2001	8	78	2.6300	5.260	0.5058	10.116	3.3800	6.760
Tahoe 2001	8	79	2.6240	5.248	0.5566	11.132	3.6630	7.326
Tahoe 2001	8	80	3.3710	6.742	0.5877	11.754	3.8440	7.688

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 1, Soil (6 February 2003)

			pH	O.M.	Mehlich III - P		Mehlich III - K	
Alfalfa Var.	Trt	Sample	2:1 CaCl2		ICP	P ppm soil	ICP	K ppm soil
Nitro Plus	0	1	6.64	0.586	5.395	53.950	9.894	98.940
Nitro Plus	0	2	6.70	0.586	3.369	33.690	9.785	97.850
Nitro Plus	0	3	6.67	0.586	3.591	35.910	9.311	93.110
Nitro Plus	0	4	6.66	0.586	3.536	35.360	9.540	95.400
Nitro Plus	0.125	5	6.63	0.586	3.681	36.810	9.502	95.020
Nitro Plus	0.125	6	6.62	0.586	3.825	38.250	9.850	98.500
Nitro Plus	0.125	7	6.59	0.586	3.341	33.410	8.893	88.930
Nitro Plus	0.125	8	6.62	0.586	3.999	39.990	10.690	106.900
Nitro Plus	0.25	9	6.60	0.586	4.467	44.670	13.730	137.300
Nitro Plus	0.25	10	6.65	0.586	3.444	34.440	8.973	89.730
Nitro Plus	0.25	11	6.70	0.586	3.493	34.930	7.369	73.690
Nitro Plus	0.25	12	6.80	0.586	3.832	38.320	9.055	90.550
Nitro Plus	0.5	13	6.81	0.586	3.860	38.600	8.667	86.670
Nitro Plus	0.5	14	6.72	0.586	3.933	39.330	7.622	76.220
Nitro Plus	0.5	15	6.52	0.586	3.144	31.440	8.177	81.770
Nitro Plus	0.5	16	6.65	0.586	4.124	41.240	8.193	81.930
Nitro Plus	0.75	17	6.63	0.586	3.588	35.880	11.170	111.700
Nitro Plus	0.75	18	6.68	0.586	3.188	31.880	9.973	99.730
Nitro Plus	0.75	19	6.58	0.586	3.575	35.750	11.400	114.000
Nitro Plus	0.75	20	6.62	0.586	3.512	35.120	9.869	98.690
Nitro Plus	1	21	6.71	0.586	3.704	37.040	10.660	106.600
Nitro Plus	1	22	6.59	0.586	3.866	38.660	11.050	110.500
Nitro Plus	1	23	6.75	0.586	4.811	48.110	9.436	94.360
Nitro Plus	1	24	6.58	0.586	3.843	38.430	9.321	93.210
Nitro Plus	1.5	25	6.74	0.586	3.328	33.280	9.560	95.600
Nitro Plus	1.5	26	6.74	0.586	3.602	36.020	10.840	108.400
Nitro Plus	1.5	27	6.66	0.586	3.539	35.390	9.760	97.600
Nitro Plus	1.5	28	6.81	0.586	3.392	33.920	8.698	86.980
Nitro Plus	2	29	6.92	0.586	3.503	35.030	8.534	85.340
Nitro Plus	2	30	6.85	0.586	3.640	36.400	8.047	80.470
Nitro Plus	2	31	6.51	0.586	5.841	58.410	14.350	143.500
Nitro Plus	2	32	6.82	0.586	4.105	41.050	10.340	103.400
Nitro Plus	4	33	6.90	0.586	4.180	41.800	10.710	107.100
Nitro Plus	4	34	6.87	0.586	3.530	35.300	9.039	90.390
Nitro Plus	4	35	6.80	0.586	4.220	42.200	10.650	106.500
Nitro Plus	4	36	6.71	0.586	2.925	29.250	7.048	70.480
Nitro Plus	8	37	6.89	0.586	3.427	34.270	8.746	87.460
Nitro Plus	8	38	6.74	0.586	3.683	36.830	9.399	93.990
Nitro Plus	8	39	6.89	0.586	4.477	44.770	12.170	121.700
Nitro Plus	8	40	6.90	0.586	3.922	39.220	10.010	100.100

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 1, Soil (6 February 2003)

			pH	O.M.	Mehlich III - P		Mehlich III - K	
Alfalfa Var.	Trt	Sample	2:1 CaCl2		ICP	P ppm soil	ICP	K ppm soil
Tahoe 2001	0	41	6.75	0.586	3.639	36.390	11.820	118.200
Tahoe 2001	0	42	6.81	0.586	3.347	33.470	9.496	94.960
Tahoe 2001	0	43	6.78	0.586	3.555	35.550	10.690	106.900
Tahoe 2001	0	44	6.95	0.586	2.275	22.750	7.003	70.030
Tahoe 2001	0.125	45	6.69	0.586	3.264	32.640	11.090	110.900
Tahoe 2001	0.125	46	6.87	0.586	3.431	34.310	9.848	98.480
Tahoe 2001	0.125	47	6.96	0.586	3.061	30.610	9.197	91.970
Tahoe 2001	0.125	48	6.90	0.586	3.748	37.480	10.240	102.400
Tahoe 2001	0.25	49	6.87	0.586	3.703	37.030	10.400	104.000
Tahoe 2001	0.25	50	6.85	0.586	4.054	40.540	10.580	105.800
Tahoe 2001	0.25	51	6.56	0.586	4.115	41.150	10.330	103.300
Tahoe 2001	0.25	52	6.79	0.586	3.452	34.520	8.688	86.880
Tahoe 2001	0.5	53	6.80	0.586	3.274	32.740	7.846	78.460
Tahoe 2001	0.5	54	6.70	0.586	4.275	42.750	10.590	105.900
Tahoe 2001	0.5	55	6.61	0.586	4.916	49.160	11.360	113.600
Tahoe 2001	0.5	56	6.64	0.586	4.668	46.680	9.396	93.960
Tahoe 2001	0.75	57	6.65	0.586	4.891	48.910	9.505	95.050
Tahoe 2001	0.75	58	6.70	0.586	4.829	48.290	7.938	79.380
Tahoe 2001	0.75	59	6.59	0.586	5.659	56.590	16.910	169.100
Tahoe 2001	0.75	60	6.67	0.586	3.234	32.340	8.798	87.980
Tahoe 2001	1	61	6.76	0.586	3.120	31.200	8.739	87.390
Tahoe 2001	1	62	6.79	0.586	3.493	34.930	9.011	90.110
Tahoe 2001	1	63	6.84	0.586	3.577	35.770	8.331	83.310
Tahoe 2001	1	64	6.79	0.586	3.862	38.620	9.353	93.530
Tahoe 2001	1.5	65	6.86	0.586	3.882	38.820	8.407	84.070
Tahoe 2001	1.5	66	6.89	0.586	3.947	39.470	9.637	96.370
Tahoe 2001	1.5	67	6.83	0.586	3.847	38.470	8.197	81.970
Tahoe 2001	1.5	68	6.94	0.586	2.974	29.740	8.527	85.270
Tahoe 2001	2	69	6.88	0.586	3.142	31.420	7.945	79.450
Tahoe 2001	2	70	6.84	0.586	4.146	41.460	10.440	104.400
Tahoe 2001	2	71	6.88	0.586	2.946	29.460	8.274	82.740
Tahoe 2001	2	72	6.85	0.586	3.338	33.380	9.114	91.140
Tahoe 2001	4	73	6.88	0.586	3.201	32.010	9.415	94.150
Tahoe 2001	4	74	6.84	0.586	3.269	32.690	8.621	86.210
Tahoe 2001	4	75	6.84	0.586	3.305	33.050	8.577	85.770
Tahoe 2001	4	76	6.84	0.586	3.403	34.030	8.567	85.670
Tahoe 2001	8	77	6.90	0.586	2.982	29.820	9.182	91.820
Tahoe 2001	8	78	6.86	0.586	3.101	31.010	13.720	137.200
Tahoe 2001	8	79	6.96	0.586	3.079	30.790	9.868	98.680
Tahoe 2001	8	80	6.92	0.586	3.061	30.610	9.150	91.500

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 1, Soil (6 February 2003)

			Mehlich 3 - Copper		Mehlich 3 - Iron		Mehlich 3 - Mn		Mehlich 3 - Zinc	
Alfalfa Var.	Trt	Sample	ICP	Cu ppm soil	ICP	Fe ppm soil	ICP	Mn ppm soil	ICP	Zn ppm soil
Nitro Plus	0	1	0.0618	0.618	14.2000	142.000	1.8230	18.230	0.4652	4.652
Nitro Plus	0	2	0.0485	0.485	12.6800	126.800	1.9640	19.640	0.3579	3.579
Nitro Plus	0	3	0.0515	0.515	15.4100	154.100	2.0900	20.900	0.4233	4.233
Nitro Plus	0	4	0.0510	0.510	12.5600	125.600	2.1120	21.120	0.4099	4.099
Nitro Plus	0.125	5	0.0599	0.599	13.2000	132.000	2.0810	20.810	0.4205	4.205
Nitro Plus	0.125	6	0.0619	0.619	13.9500	139.500	1.8610	18.610	0.4411	4.411
Nitro Plus	0.125	7	0.0571	0.571	13.2000	132.000	1.4880	14.880	0.4532	4.532
Nitro Plus	0.125	8	0.0421	0.421	12.4500	124.500	2.0030	20.030	0.3766	3.766
Nitro Plus	0.25	9	0.0466	0.466	13.7100	137.100	2.0590	20.590	0.3840	3.840
Nitro Plus	0.25	10	0.0567	0.567	13.4600	134.600	1.8900	18.900	0.5528	5.528
Nitro Plus	0.25	11	0.0535	0.535	14.0400	140.400	1.8840	18.840	0.5249	5.249
Nitro Plus	0.25	12	0.0582	0.582	13.8500	138.500	1.5500	15.500	0.4466	4.466
Nitro Plus	0.5	13	0.0594	0.594	14.5600	145.600	2.2670	22.670	0.4317	4.317
Nitro Plus	0.5	14	0.0518	0.518	13.5100	135.100	2.2280	22.280	0.4081	4.081
Nitro Plus	0.5	15	0.0452	0.452	13.9000	139.000	1.4510	14.510	0.3948	3.948
Nitro Plus	0.5	16	0.0516	0.516	14.7300	147.300	2.1690	21.690	0.4647	4.647
Nitro Plus	0.75	17	0.0935	0.935	15.0000	150.000	1.7280	17.280	0.3475	3.475
Nitro Plus	0.75	18	0.1065	1.065	13.7000	137.000	1.6490	16.490	0.3108	3.108
Nitro Plus	0.75	19	0.0918	0.918	15.4400	154.400	1.7390	17.390	0.3258	3.258
Nitro Plus	0.75	20	0.0926	0.926	15.2400	152.400	1.7190	17.190	0.3324	3.324
Nitro Plus	1	21	0.0861	0.861	15.1200	151.200	1.7410	17.410	0.6357	6.357
Nitro Plus	1	22	0.1017	1.017	15.3100	153.100	1.6610	16.610	0.3370	3.370
Nitro Plus	1	23	0.0961	0.961	14.3900	143.900	1.5690	15.690	0.3562	3.562
Nitro Plus	1	24	0.0868	0.868	14.4400	144.400	1.5980	15.980	0.3791	3.791
Nitro Plus	1.5	25	0.0741	0.741	13.9000	139.000	1.5370	15.370	0.3119	3.119
Nitro Plus	1.5	26	0.0813	0.813	14.2700	142.700	1.6520	16.520	0.3408	3.408
Nitro Plus	1.5	27	0.0824	0.824	14.5300	145.300	1.6590	16.590	0.3381	3.381
Nitro Plus	1.5	28	0.0634	0.634	11.3500	113.500	1.4490	14.490	0.3164	3.164
Nitro Plus	2	29	0.0630	0.630	10.8900	108.900	1.4780	14.780	0.2821	2.821
Nitro Plus	2	30	0.0555	0.555	11.3100	113.100	1.3870	13.870	0.2911	2.911
Nitro Plus	2	31	0.0630	0.630	13.7400	137.400	1.5110	15.110	0.3283	3.283
Nitro Plus	2	32	0.0691	0.691	13.2000	132.000	1.5610	15.610	0.3188	3.188
Nitro Plus	4	33	0.0641	0.641	13.3300	133.300	1.5740	15.740	0.3210	3.210
Nitro Plus	4	34	0.0694	0.694	11.3700	113.700	1.4380	14.380	0.2948	2.948
Nitro Plus	4	35	0.0776	0.776	12.3200	123.200	1.5650	15.650	0.3313	3.313
Nitro Plus	4	36	0.0739	0.739	11.4300	114.300	1.4970	14.970	0.3088	3.088
Nitro Plus	8	37	0.0721	0.721	11.9300	119.300	1.5910	15.910	0.2938	2.938
Nitro Plus	8	38	0.0788	0.788	12.2300	122.300	1.6130	16.130	1.0060	10.060
Nitro Plus	8	39	0.0741	0.741	13.0100	130.100	1.7320	17.320	0.3202	3.202
Nitro Plus	8	40	0.0851	0.851	11.0900	110.900	1.4410	14.410	0.4485	4.485

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 1, Soil (6 February 2003)

			Mehlich 3 - Copper		Mehlich 3 - Iron		Mehlich 3 - Mn		Mehlich 3 - Zinc	
Alfalfa Var.	Trt	Sample	ICP	Cu ppm soil	ICP	Fe ppm soil	ICP	Mn ppm soil	ICP	Zn ppm soil
Tahoe 2001	0	41	0.0637	0.637	11.1400	111.400	1.3990	13.990	0.2827	2.827
Tahoe 2001	0	42	0.0637	0.637	10.7800	107.800	1.3970	13.970	0.2778	2.778
Tahoe 2001	0	43	0.0608	0.608	11.1300	111.300	1.4440	14.440	0.3368	3.368
Tahoe 2001	0	44	0.0575	0.575	10.1700	101.700	1.3050	13.050	0.2685	2.685
Tahoe 2001	0.125	45	0.0534	0.534	10.8100	108.100	1.4820	14.820	0.2905	2.905
Tahoe 2001	0.125	46	0.0637	0.637	11.9500	119.500	1.4570	14.570	0.3034	3.034
Tahoe 2001	0.125	47	0.0588	0.588	10.5400	105.400	1.3520	13.520	0.3286	3.286
Tahoe 2001	0.125	48	0.0618	0.618	11.8700	118.700	1.5020	15.020	0.3096	3.096
Tahoe 2001	0.25	49	0.0636	0.636	11.8600	118.600	1.5340	15.340	0.3579	3.579
Tahoe 2001	0.25	50	0.0580	0.580	12.9600	129.600	1.6710	16.710	0.3594	3.594
Tahoe 2001	0.25	51	0.0742	0.742	10.2100	102.100	1.4580	14.580	0.3523	3.523
Tahoe 2001	0.25	52	0.0785	0.785	10.5800	105.800	1.4580	14.580	0.4191	4.191
Tahoe 2001	0.5	53	0.0593	0.593	10.1100	101.100	1.3150	13.150	0.3364	3.364
Tahoe 2001	0.5	54	0.0823	0.823	10.9600	109.600	1.5150	15.150	0.7113	7.113
Tahoe 2001	0.5	55	0.0801	0.801	11.2500	112.500	1.5270	15.270	0.3998	3.998
Tahoe 2001	0.5	56	0.0707	0.707	11.6700	116.700	1.5500	15.500	0.4315	4.315
Tahoe 2001	0.75	57	0.0811	0.811	13.0100	130.100	1.5800	15.800	0.4308	4.308
Tahoe 2001	0.75	58	0.0731	0.731	11.0500	110.500	1.4040	14.040	0.4288	4.288
Tahoe 2001	0.75	59	0.0609	0.609	12.4100	124.100	1.5850	15.850	0.3410	3.410
Tahoe 2001	0.75	60	0.0611	0.611	12.1600	121.600	1.4800	14.800	0.3276	3.276
Tahoe 2001	1	61	0.0706	0.706	11.5300	115.300	1.5220	15.220	1.5020	15.020
Tahoe 2001	1	62	0.0578	0.578	11.0100	110.100	1.4460	14.460	0.3531	3.531
Tahoe 2001	1	63	0.0662	0.662	12.1000	121.000	1.5410	15.410	0.3717	3.717
Tahoe 2001	1	64	0.0616	0.616	11.2900	112.900	1.4400	14.400	0.3593	3.593
Tahoe 2001	1.5	65	0.0632	0.632	11.3200	113.200	1.3810	13.810	0.3620	3.620
Tahoe 2001	1.5	66	0.0756	0.756	11.6500	116.500	1.4650	14.650	0.4103	4.103
Tahoe 2001	1.5	67	0.0699	0.699	12.1800	121.800	1.5580	15.580	0.3933	3.933
Tahoe 2001	1.5	68	0.0769	0.769	11.7500	117.500	1.6100	16.100	0.3341	3.341
Tahoe 2001	2	69	0.0732	0.732	11.8000	118.000	1.4570	14.570	0.3408	3.408
Tahoe 2001	2	70	0.0770	0.770	12.0500	120.500	1.4540	14.540	0.3228	3.228
Tahoe 2001	2	71	0.0739	0.739	12.1900	121.900	1.5440	15.440	0.3212	3.212
Tahoe 2001	2	72	0.0807	0.807	12.0300	120.300	1.5070	15.070	0.3498	3.498
Tahoe 2001	4	73	0.0788	0.788	12.6900	126.900	1.6540	16.540	0.3762	3.762
Tahoe 2001	4	74	0.0732	0.732	12.1100	121.100	1.5820	15.820	0.3436	3.436
Tahoe 2001	4	75	0.0698	0.698	13.0200	130.200	1.6620	16.620	0.3551	3.551
Tahoe 2001	4	76	0.0800	0.800	12.1700	121.700	1.5730	15.730	0.3468	3.468
Tahoe 2001	8	77	0.0683	0.683	13.8900	138.900	1.7950	17.950	0.3909	3.909
Tahoe 2001	8	78	0.0718	0.718	13.1400	131.400	1.7740	17.740	0.3389	3.389
Tahoe 2001	8	79	0.0826	0.826	13.9100	139.100	1.7670	17.670	0.4863	4.863
Tahoe 2001	8	80	0.0794	0.794	13.7600	137.600	1.8450	18.450	0.3571	3.571

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 2, Soil (21, 22 January 2004)

			HWB		PHWB		DTPA-sorbitol	
Alfalfa Var.	Trt	Sample	ICP reading	B ppm soil	ICP reading	B ppm soil	ICP reading	B ppm soil
Nitro Plus	0	1	0.0277	0.055	0.0030	0.060	0.0934	0.187
Nitro Plus	0	2	0.0355	0.071	0.0010	0.020	0.0885	0.177
Nitro Plus	0	3	0.0369	0.074	0.0009	0.018	0.1066	0.213
Nitro Plus	0	4	0.0276	0.055	0.0118	0.236	0.0719	0.144
Nitro Plus	0.125	5	0.0323	0.065	0.0103	0.206	0.0793	0.159
Nitro Plus	0.125	6	0.0494	0.099	0.0091	0.182	0.0803	0.161
Nitro Plus	0.125	7	0.0428	0.086	0.0086	0.172	0.0949	0.190
Nitro Plus	0.125	8	0.0432	0.086	0.0093	0.186	0.1076	0.215
Nitro Plus	0.25	9	0.0501	0.100	0.0088	0.176	0.0837	0.167
Nitro Plus	0.25	10	0.0512	0.102	0.0079	0.158	0.0970	0.194
Nitro Plus	0.25	11	0.0522	0.104	0.0080	0.160	0.0977	0.195
Nitro Plus	0.25	12	0.0586	0.117	0.0088	0.176	0.0783	0.157
Nitro Plus	0.5	13	0.0717	0.143	0.0111	0.222	0.1003	0.201
Nitro Plus	0.5	14	0.0964	0.193	0.0137	0.274	0.1043	0.209
Nitro Plus	0.5	15	0.0662	0.132	0.0115	0.230	0.1047	0.209
Nitro Plus	0.5	16	0.0676	0.135	0.0121	0.242	0.1046	0.209
Nitro Plus	0.75	17	0.1299	0.260	0.0186	0.372	0.1476	0.295
Nitro Plus	0.75	18	0.1439	0.288	0.0216	0.432	0.1596	0.319
Nitro Plus	0.75	19	0.1172	0.234	0.0180	0.360	0.1609	0.322
Nitro Plus	0.75	20	0.1531	0.306	0.0192	0.384	0.1828	0.366
Nitro Plus	1	21	0.1319	0.264	0.0211	0.422	0.1595	0.319
Nitro Plus	1	22	0.1428	0.286	0.0260	0.520	0.4317	0.863
Nitro Plus	1	23	0.1515	0.303	0.0224	0.448	0.1576	0.315
Nitro Plus	1	24	0.1373	0.275	0.0216	0.432	0.1733	0.347
Nitro Plus	1.5	25	0.2088	0.418	0.0305	0.610	0.2314	0.463
Nitro Plus	1.5	26	0.2060	0.412	0.0310	0.620	0.2277	0.455
Nitro Plus	1.5	27	0.2406	0.481	0.0388	0.776	0.2448	0.490
Nitro Plus	1.5	28	0.2403	0.481	0.0397	0.794	0.2601	0.520
Nitro Plus	2	29	0.3322	0.664	0.0484	0.968	0.3184	0.637
Nitro Plus	2	30	0.3100	0.620	0.0612	1.224	0.3210	0.642
Nitro Plus	2	31	0.3108	0.622	0.0817	1.634	0.3422	0.684
Nitro Plus	2	32	0.2718	0.544	0.0513	1.026	0.3637	0.727
Nitro Plus	4	33	0.5205	1.041	0.0923	1.846	0.6473	1.295
Nitro Plus	4	34	0.6144	1.229	0.1026	2.052	0.7630	1.526
Nitro Plus	4	35	0.6251	1.250	0.0673	1.346	0.6412	1.282
Nitro Plus	4	36	0.7571	1.514	0.0935	1.870	0.6669	1.334
Nitro Plus	8	37	1.0950	2.190	0.1417	2.834	0.9984	1.997
Nitro Plus	8	38	1.9520	3.904	0.2154	4.308	1.9890	3.978
Nitro Plus	8	39	1.6850	3.370	0.1837	3.674	1.5050	3.010
Nitro Plus	8	40	1.5430	3.086	0.1748	3.496	1.2720	2.544

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 2, Soil (21, 22 January 2004)

			HWB		PHWB		DTPA-sorbitol	
Alfalfa Var.	Trt	Sample	ICP reading	B ppm soil	ICP reading	B ppm soil	ICP reading	B ppm soil
Tahoe 2001	0	41	0.0628	0.126	0.0039	0.078	0.0631	0.126
Tahoe 2001	0	42	0.0337	0.067	0.0007	0.014	0.0693	0.139
Tahoe 2001	0	43	0.0348	0.070	0.0083	0.166	0.0593	0.119
Tahoe 2001	0	44	0.0284	0.057	0.0109	0.218	0.0758	0.152
Tahoe 2001	0.125	45	0.0554	0.111	0.0013	0.026	0.0896	0.179
Tahoe 2001	0.125	46	0.0404	0.081	0.0071	0.142	0.0971	0.194
Tahoe 2001	0.125	47	0.0326	0.065	0.0070	0.140	0.0749	0.150
Tahoe 2001	0.125	48	0.0283	0.057	0.0056	0.112	0.0731	0.146
Tahoe 2001	0.25	49	0.0449	0.090	0.0059	0.118	0.0758	0.152
Tahoe 2001	0.25	50	0.0461	0.092	0.0076	0.152	0.0652	0.130
Tahoe 2001	0.25	51	0.0472	0.094	0.0072	0.144	0.0771	0.154
Tahoe 2001	0.25	52	0.0453	0.091	0.0068	0.136	0.0586	0.117
Tahoe 2001	0.5	53	0.0480	0.096	0.0112	0.224	0.0767	0.153
Tahoe 2001	0.5	54	0.0639	0.128	0.0115	0.230	0.0865	0.173
Tahoe 2001	0.5	55	0.0865	0.173	0.0152	0.304	0.0927	0.185
Tahoe 2001	0.5	56	0.0556	0.111	0.0107	0.214	0.0645	0.129
Tahoe 2001	0.75	57	0.0847	0.169	0.0155	0.310	0.1060	0.212
Tahoe 2001	0.75	58	0.0909	0.182	0.0146	0.292	0.1087	0.217
Tahoe 2001	0.75	59	0.0914	0.183	0.0152	0.304	0.1018	0.204
Tahoe 2001	0.75	60	0.0784	0.157	0.0162	0.324	0.1046	0.209
Tahoe 2001	1	61	0.1136	0.227	0.0219	0.438	0.1505	0.301
Tahoe 2001	1	62	0.1070	0.214	0.0236	0.472	0.1611	0.322
Tahoe 2001	1	63	0.0975	0.195	0.0197	0.394	0.1745	0.349
Tahoe 2001	1	64	0.9840	1.968	0.0234	0.468	0.1631	0.326
Tahoe 2001	1.5	65	0.1709	0.342	0.0278	0.556	0.2263	0.453
Tahoe 2001	1.5	66	0.2255	0.451	0.0434	0.868	0.2831	0.566
Tahoe 2001	1.5	67	0.1936	0.387	0.0306	0.612	0.1936	0.387
Tahoe 2001	1.5	68	0.1946	0.389	0.0386	0.772	0.2642	0.528
Tahoe 2001	2	69	0.2569	0.514	0.0487	0.974	0.3573	0.715
Tahoe 2001	2	70	0.2143	0.429	0.0445	0.890	0.2892	0.578
Tahoe 2001	2	71	0.3081	0.616	0.0546	1.092	0.3428	0.686
Tahoe 2001	2	72	0.2373	0.475	0.0392	0.784	0.2583	0.517
Tahoe 2001	4	73	0.8039	1.608	0.1064	2.128	0.9330	1.866
Tahoe 2001	4	74	0.6902	1.380	0.0952	1.904	0.6063	1.213
Tahoe 2001	4	75	0.6949	1.390	0.1065	2.130	0.6947	1.389
Tahoe 2001	4	76	0.6535	1.307	0.1088	2.176	0.7200	1.440
Tahoe 2001	8	77	1.4970	2.994	0.2149	4.298	1.7370	3.474
Tahoe 2001	8	78	0.9473	1.895	0.1859	3.718	1.3360	2.672
Tahoe 2001	8	79	1.5870	3.174	0.2194	4.388	1.7520	3.504
Tahoe 2001	8	80	1.4030	2.806	0.2314	4.628	1.7890	3.578

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 2, Soil (21,22 January 2004)

			pH	O.M.	Mehlich III - P		Mehlich III - K	
Alfalfa Var.	Trt	Sample	2:1 CaCl2		ICP	P ppm soil	ICP	K ppm soil
Nitro Plus	0	1	7.66	0.715	2.069	20.690	1.105	11.050
Nitro Plus	0	2	7.73	0.645	2.253	22.530	1.124	11.240
Nitro Plus	0	3	7.53	0.754	2.396	23.960	1.869	18.690
Nitro Plus	0	4	7.68	0.632	2.235	22.350	1.355	13.550
Nitro Plus	0.125	5	7.68	0.696	2.316	23.160	0.943	9.432
Nitro Plus	0.125	6	7.71	0.696	2.243	22.430	1.685	16.850
Nitro Plus	0.125	7	7.64	0.613	2.454	24.540	1.127	11.270
Nitro Plus	0.125	8	7.50	0.703	2.165	21.650	1.095	10.950
Nitro Plus	0.25	9	7.72	0.664	1.950	19.500	1.335	13.350
Nitro Plus	0.25	10	7.59	0.677	2.092	20.920	1.033	10.330
Nitro Plus	0.25	11	7.66	0.722	2.398	23.980	1.175	11.750
Nitro Plus	0.25	12	7.72	0.600	2.166	21.660	2.289	22.890
Nitro Plus	0.5	13	7.60	0.645	2.080	20.800	1.071	10.710
Nitro Plus	0.5	14	7.68	0.549	2.893	28.930	1.509	15.090
Nitro Plus	0.5	15	7.60	0.639	2.468	24.680	1.690	16.900
Nitro Plus	0.5	16	7.67	0.588	2.472	24.720	1.391	13.910
Nitro Plus	0.75	17	7.68	0.620	2.760	27.600	1.241	12.410
Nitro Plus	0.75	18	7.58	0.722	2.193	21.930	1.483	14.830
Nitro Plus	0.75	19	7.71	0.626	2.255	22.550	0.959	9.593
Nitro Plus	0.75	20	7.77	0.600	2.224	22.240	1.033	10.330
Nitro Plus	1	21	7.70	0.536	1.906	19.060	1.363	13.630
Nitro Plus	1	22	7.62	0.613	2.296	22.960	1.074	10.740
Nitro Plus	1	23	7.68	0.734	2.486	24.860	1.414	14.140
Nitro Plus	1	24	7.64	0.600	2.264	22.640	1.546	15.460
Nitro Plus	1.5	25	7.76	0.575	2.325	23.250	1.027	10.270
Nitro Plus	1.5	26	7.61	0.581	2.441	24.410	1.264	12.640
Nitro Plus	1.5	27	7.66	0.639	2.147	21.470	1.354	13.540
Nitro Plus	1.5	28	7.74	0.817	2.187	21.870	1.386	13.860
Nitro Plus	2	29	7.71	0.562	2.151	21.510	1.009	10.090
Nitro Plus	2	30	7.76	0.894	2.154	21.540	1.478	14.780
Nitro Plus	2	31	7.75	0.767	2.516	25.160	1.413	14.130
Nitro Plus	2	32	7.75	0.856	2.138	21.380	1.495	14.950
Nitro Plus	4	33	7.68	0.609	1.924	19.240	1.761	17.610
Nitro Plus	4	34	7.72	0.634	2.040	20.400	1.392	13.920
Nitro Plus	4	35	7.70	0.647	2.346	23.460	1.601	16.010
Nitro Plus	4	36	7.85	0.761	2.498	24.980	2.422	24.220
Nitro Plus	8	37	7.47	0.589	4.060	40.600	7.842	78.420
Nitro Plus	8	38	7.78	0.621	3.219	32.190	1.643	16.430
Nitro Plus	8	39	7.68	0.494	4.092	40.920	9.492	94.920
Nitro Plus	8	40	7.79	0.577	2.301	23.010	1.913	19.130

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 2, Soil (21,22 January 2004)

			pH	O.M.	Mehlich III - P		Mehlich III - K	
Alfalfa Var.	Trt	Sample	2:1 CaCl2		ICP	P ppm soil	ICP	K ppm soil
Tahoe 2001	0	41	7.79	0.754	1.854	18.540	2.130	21.300
Tahoe 2001	0	42	7.65	0.634	2.010	20.100	2.810	28.100
Tahoe 2001	0	43	7.76	0.621	1.830	18.300	1.133	11.330
Tahoe 2001	0	44	7.72	0.621	1.892	18.920	0.975	9.750
Tahoe 2001	0.125	45	7.75	0.647	2.030	20.300	1.973	19.730
Tahoe 2001	0.125	46	7.73	0.723	2.307	23.070	0.762	7.615
Tahoe 2001	0.125	47	7.77	0.596	2.134	21.340	1.205	12.050
Tahoe 2001	0.125	48	7.73	0.691	2.252	22.520	1.454	14.540
Tahoe 2001	0.25	49	7.63	0.685	1.709	17.090	1.607	16.070
Tahoe 2001	0.25	50	7.78	0.697	1.474	14.740	1.265	12.650
Tahoe 2001	0.25	51	7.75	0.729	1.884	18.840	1.109	11.090
Tahoe 2001	0.25	52	7.75	0.716	1.767	17.670	0.851	8.508
Tahoe 2001	0.5	53	7.67	0.710	1.786	17.860	1.360	13.600
Tahoe 2001	0.5	54	7.67	0.729	1.222	12.220	0.990	9.903
Tahoe 2001	0.5	55	7.76	0.666	1.618	16.180	1.087	10.870
Tahoe 2001	0.5	56	7.77	0.583	1.625	16.250	0.834	8.342
Tahoe 2001	0.75	57	7.69	0.640	1.566	15.660	1.322	13.220
Tahoe 2001	0.75	58	7.79	0.609	1.637	16.370	1.343	13.430
Tahoe 2001	0.75	59	7.73	0.634	1.796	17.960	1.404	14.040
Tahoe 2001	0.75	60	7.73	0.849	1.760	17.600	1.939	19.390
Tahoe 2001	1	61	7.73	0.818	1.741	17.410	1.571	15.710
Tahoe 2001	1	62	7.68	0.678	2.080	20.800	1.352	13.520
Tahoe 2001	1	63	7.74	0.628	2.107	21.070	1.765	17.650
Tahoe 2001	1	64	7.84	0.659	2.035	20.350	1.242	12.420
Tahoe 2001	1.5	65	7.08	0.653	2.350	23.500	2.265	22.650
Tahoe 2001	1.5	66	7.76	0.609	2.440	24.400	1.340	13.400
Tahoe 2001	1.5	67	7.70	0.628	2.346	23.460	1.151	11.510
Tahoe 2001	1.5	68	7.71	0.685	2.604	26.040	1.648	16.480
Tahoe 2001	2	69	7.69	0.551	2.816	28.160	1.840	18.400
Tahoe 2001	2	70	7.74	0.615	3.260	32.600	1.172	11.720
Tahoe 2001	2	71	7.73	0.717	3.608	36.080	1.286	12.860
Tahoe 2001	2	72	7.68	0.629	3.467	34.670	0.871	8.710
Tahoe 2001	4	73	7.85	0.616	2.262	22.620	1.222	12.220
Tahoe 2001	4	74	7.77	0.705	1.849	18.490	1.575	15.750
Tahoe 2001	4	75	7.70	0.679	2.161	21.610	1.124	11.240
Tahoe 2001	4	76	7.84	0.654	2.217	22.170	1.553	15.530
Tahoe 2001	8	77	7.77	0.730	2.500	25.000	1.604	16.040
Tahoe 2001	8	78	7.81	0.590	2.627	26.270	0.805	8.054
Tahoe 2001	8	79	7.81	0.584	2.761	27.610	1.451	14.510
Tahoe 2001	8	80	7.88	0.737	2.539	25.390	1.095	10.950

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 2, Soil (21,22 January 2004)

			Mehlich 3 - Copper		Mehlich 3 - Iron		Mehlich 3 - Mn		Mehlich 3 - Zinc	
Alfalfa Var.	Trt	Sample	ICP	Cu ppm soil	ICP	Fe ppm soil	ICP	Mn ppm soil	ICP	Zn ppm soil
Nitro Plus	0	1	0.0856	0.856	12.1000	121.000	2.8020	28.020	0.3788	3.788
Nitro Plus	0	2	0.1050	1.050	13.5600	135.600	2.8180	28.180	0.4001	4.001
Nitro Plus	0	3	0.0984	0.984	13.8600	138.600	2.9150	29.150	0.4448	4.448
Nitro Plus	0	4	0.0896	0.896	12.7000	127.000	2.8220	28.220	0.3882	3.882
Nitro Plus	0.125	5	0.0940	0.940	14.5100	145.100	2.8960	28.960	0.3946	3.946
Nitro Plus	0.125	6	0.1049	1.049	12.3500	123.500	2.3470	23.470	0.4867	4.867
Nitro Plus	0.125	7	0.1000	1.000	14.7600	147.600	2.8280	28.280	0.4073	4.073
Nitro Plus	0.125	8	0.0896	0.896	16.1000	161.000	2.8940	28.940	0.3769	3.769
Nitro Plus	0.25	9	0.0809	0.809	11.4800	114.800	2.0060	20.060	0.3638	3.638
Nitro Plus	0.25	10	0.0818	0.818	14.2500	142.500	2.9550	29.550	0.3611	3.611
Nitro Plus	0.25	11	0.0941	0.941	14.3900	143.900	3.0480	30.480	0.3828	3.828
Nitro Plus	0.25	12	0.0857	0.857	10.8200	108.200	2.2180	22.180	0.3832	3.832
Nitro Plus	0.5	13	0.0717	0.717	11.3400	113.400	2.0410	20.410	0.3621	3.621
Nitro Plus	0.5	14	0.0926	0.926	12.7300	127.300	2.1850	21.850	0.3855	3.855
Nitro Plus	0.5	15	0.0857	0.857	12.1400	121.400	2.1880	21.880	0.3678	3.678
Nitro Plus	0.5	16	0.0802	0.802	11.5300	115.300	2.4340	24.340	0.3789	3.789
Nitro Plus	0.75	17	0.0841	0.841	13.0400	130.400	1.9070	19.070	0.4086	4.086
Nitro Plus	0.75	18	0.1089	1.089	14.3200	143.200	3.0370	30.370	0.3899	3.899
Nitro Plus	0.75	19	0.0974	0.974	14.2600	142.600	2.0630	20.630	0.4002	4.002
Nitro Plus	0.75	20	0.0996	0.996	11.8800	118.800	1.9950	19.950	0.3623	3.623
Nitro Plus	1	21	0.0832	0.832	11.8600	118.600	2.3140	23.140	0.3824	3.824
Nitro Plus	1	22	0.1005	1.005	13.8400	138.400	3.0860	30.860	0.3687	3.687
Nitro Plus	1	23	0.1009	1.009	12.9000	129.000	2.1630	21.630	0.9867	9.867
Nitro Plus	1	24	0.0834	0.834	13.8700	138.700	2.8980	28.980	0.3697	3.697
Nitro Plus	1.5	25	0.0901	0.901	12.5900	125.900	2.7650	27.650	0.3891	3.891
Nitro Plus	1.5	26	0.0916	0.916	13.1200	131.200	2.7180	27.180	0.4040	4.040
Nitro Plus	1.5	27	0.0891	0.891	13.2800	132.800	2.4660	24.660	0.3636	3.636
Nitro Plus	1.5	28	0.0983	0.983	12.7400	127.400	2.6570	26.570	0.4200	4.200
Nitro Plus	2	29	0.0991	0.991	13.2000	132.000	1.9530	19.530	0.3865	3.865
Nitro Plus	2	30	0.0951	0.951	13.6000	136.000	2.8750	28.750	0.4111	4.111
Nitro Plus	2	31	0.1059	1.059	14.5000	145.000	2.4150	24.150	0.4462	4.462
Nitro Plus	2	32	0.1128	1.128	11.7400	117.400	2.6260	26.260	0.3252	3.252
Nitro Plus	4	33	0.1085	1.085	11.6300	116.300	2.7150	27.150	0.3300	3.300
Nitro Plus	4	34	0.0981	0.981	10.3300	103.300	2.0640	20.640	0.3394	3.394
Nitro Plus	4	35	0.1095	1.095	13.2600	132.600	2.4410	24.410	0.3593	3.593
Nitro Plus	4	36	0.1068	1.068	10.3800	103.800	1.8120	18.120	0.4066	4.066
Nitro Plus	8	37	0.0943	0.943	10.2000	102.000	1.9980	19.980	0.6622	6.622
Nitro Plus	8	38	0.1012	1.012	11.5400	115.400	1.7380	17.380	0.4167	4.167
Nitro Plus	8	39	0.1015	1.015	11.6600	116.600	1.9550	19.550	0.4211	4.211
Nitro Plus	8	40	0.0862	0.862	10.8400	108.400	1.9600	19.600	0.3219	3.219

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 2, Soil (21,22 January 2004)

			Mehlich 3 - Copper		Mehlich 3 - Iron		Mehlich 3 - Mn		Mehlich 3 - Zinc	
Alfalfa Var.	Trt	Sample	ICP	Cu ppm soil	ICP	Fe ppm soil	ICP	Mn ppm soil	ICP	Zn ppm soil
Tahoe 2001	0	41	0.0968	0.968	10.7400	107.400	1.9210	19.210	0.3626	3.626
Tahoe 2001	0	42	0.1088	1.088	12.3100	123.100	2.7680	27.680	0.3678	3.678
Tahoe 2001	0	43	0.1031	1.031	10.6400	106.400	1.6510	16.510	0.3164	3.164
Tahoe 2001	0	44	0.1037	1.037	12.1000	121.000	2.5360	25.360	0.3357	3.357
Tahoe 2001	0.125	45	0.0987	0.987	11.2700	112.700	1.5110	15.110	0.3531	3.531
Tahoe 2001	0.125	46	0.1085	1.085	13.9700	139.700	2.7290	27.290	0.3633	3.633
Tahoe 2001	0.125	47	0.1124	1.124	12.0400	120.400	2.4440	24.440	0.3527	3.527
Tahoe 2001	0.125	48	0.1142	1.142	13.7400	137.400	2.4670	24.670	0.4273	4.273
Tahoe 2001	0.25	49	0.1209	1.209	13.4200	134.200	2.9970	29.970	0.4344	4.344
Tahoe 2001	0.25	50	0.1025	1.025	11.3100	113.100	2.0670	20.670	0.3344	3.344
Tahoe 2001	0.25	51	0.0978	0.978	11.7400	117.400	2.6490	26.490	0.3310	3.310
Tahoe 2001	0.25	52	0.1153	1.153	11.3500	113.500	2.2470	22.470	0.3274	3.274
Tahoe 2001	0.5	53	0.0971	0.971	12.2400	122.400	2.8650	28.650	0.3586	3.586
Tahoe 2001	0.5	54	0.0951	0.951	12.9600	129.600	2.4300	24.300	0.2817	2.817
Tahoe 2001	0.5	55	0.0959	0.959	11.7600	117.600	2.8600	28.600	0.3110	3.110
Tahoe 2001	0.5	56	0.0999	0.999	11.3300	113.300	2.2000	22.000	0.3093	3.093
Tahoe 2001	0.75	57	0.1006	1.006	12.6100	126.100	3.0500	30.500	0.4176	4.176
Tahoe 2001	0.75	58	0.1029	1.029	11.0300	110.300	2.0210	20.210	0.3868	3.868
Tahoe 2001	0.75	59	0.1029	1.029	12.2600	122.600	2.4370	24.370	0.3264	3.264
Tahoe 2001	0.75	60	0.1065	1.065	12.5700	125.700	2.5310	25.310	0.3279	3.279
Tahoe 2001	1	61	0.0969	0.969	11.1200	111.200	1.7180	17.180	0.3488	3.488
Tahoe 2001	1	62	0.1031	1.031	11.4100	114.100	2.4040	24.040	0.3308	3.308
Tahoe 2001	1	63	0.1084	1.084	11.6900	116.900	2.4670	24.670	0.3796	3.796
Tahoe 2001	1	64	0.1046	1.046	10.7800	107.800	1.6020	16.020	0.3572	3.572
Tahoe 2001	1.5	65	0.0948	0.948	18.2100	182.100	2.8810	28.810	0.3711	3.711
Tahoe 2001	1.5	66	0.0897	0.897	9.8110	98.110	1.8120	18.120	0.3718	3.718
Tahoe 2001	1.5	67	0.0756	0.756	10.8200	108.200	1.9090	19.090	0.3401	3.401
Tahoe 2001	1.5	68	0.0902	0.902	12.3100	123.100	2.6770	26.770	0.4325	4.325
Tahoe 2001	2	69	0.0829	0.829	11.8400	118.400	1.9420	19.420	0.4360	4.360
Tahoe 2001	2	70	0.0941	0.941	11.4600	114.600	1.9100	19.100	0.4481	4.481
Tahoe 2001	2	71	0.0993	0.993	13.0600	130.600	2.5870	25.870	0.4578	4.578
Tahoe 2001	2	72	0.0832	0.832	12.0900	120.900	2.5660	25.660	0.4429	4.429
Tahoe 2001	4	73	0.0846	0.846	10.7900	107.900	1.9660	19.660	0.4322	4.322
Tahoe 2001	4	74	0.0998	0.998	12.6700	126.700	2.6950	26.950	0.3740	3.740
Tahoe 2001	4	75	0.0916	0.916	12.6300	126.300	2.4810	24.810	0.3745	3.745
Tahoe 2001	4	76	0.0851	0.851	11.7800	117.800	2.0180	20.180	0.3600	3.600
Tahoe 2001	8	77	0.0827	0.827	11.9200	119.200	1.8570	18.570	0.3933	3.933
Tahoe 2001	8	78	0.0793	0.793	11.9500	119.500	2.4690	24.690	0.3878	3.878
Tahoe 2001	8	79	0.0675	0.675	12.3900	123.900	1.8610	18.610	0.3810	3.810
Tahoe 2001	8	80	0.1030	1.030	12.3100	123.100	1.3410	13.410	0.5245	5.245

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 1, Plant (31 May 2003)

					[B] Tissue	
Sample	Alfalfa Var.	Trt	Wet Wt. (g)	Dry Wt. (g)	ICP	[B]
1	Nitro Plus	0	8.467	1.868	2.210	99.450
2	Nitro Plus	0	8.289	0.832	2.373	106.785
3	Nitro Plus	0	7.487	1.644	2.774	124.830
4	Nitro Plus	0	7.951	1.758	2.004	90.180
5	Nitro Plus	0.125	10.282	2.288	2.724	122.580
6	Nitro Plus	0.125	7.129	1.518	3.847	173.115
7	Nitro Plus	0.125	7.445	1.641	2.636	118.620
8	Nitro Plus	0.125	9.512	2.078	2.339	105.255
9	Nitro Plus	0.25	10.504	2.259	1.770	79.650
10	Nitro Plus	0.25	7.815	1.616	2.229	100.305
11	Nitro Plus	0.25	8.122	1.834	1.781	80.145
12	Nitro Plus	0.25	7.669	1.667	2.845	128.025
13	Nitro Plus	0.5	8.308	1.856	2.121	95.445
14	Nitro Plus	0.5	2.947	0.482	3.077	138.465
15	Nitro Plus	0.5	8.082	1.722	3.523	158.535
16	Nitro Plus	0.5	7.900	1.586	3.891	175.095
17	Nitro Plus	0.75	6.687	1.431	4.211	189.495
18	Nitro Plus	0.75	8.090	1.617	4.714	212.130
19	Nitro Plus	0.75	5.790	1.335	4.809	216.405
20	Nitro Plus	0.75	8.562	1.962	4.819	216.855
21	Nitro Plus	1	7.864	1.762	4.452	200.340
22	Nitro Plus	1	8.762	1.911	4.107	184.815
23	Nitro Plus	1	8.590	1.844	3.840	172.800
24	Nitro Plus	1	8.839	2.014	3.900	175.500
25	Nitro Plus	1.5	8.257	1.833	4.298	193.410
26	Nitro Plus	1.5	8.821	1.778	4.620	207.900
27	Nitro Plus	1.5	7.103	1.645	4.535	204.075
28	Nitro Plus	1.5	8.086	1.737	3.840	172.800
29	Nitro Plus	2	8.189	1.846	4.666	209.970
30	Nitro Plus	2	9.915	2.029	4.961	223.245
31	Nitro Plus	2	5.987	1.263	4.603	207.135
32	Nitro Plus	2	8.415	1.825	4.819	216.855
33	Nitro Plus	4	7.114	1.534	6.624	298.080
34	Nitro Plus	4	8.430	1.808	5.423	244.035
35	Nitro Plus	4	7.988	1.771	6.679	300.555
36	Nitro Plus	4	6.965	1.535	6.520	293.400
37	Nitro Plus	8	0.000	0.000	.	.
38	Nitro Plus	8	4.802	0.841	2.948	265.320
39	Nitro Plus	8	0.000	0.000	.	.
40	Nitro Plus	8	7.622	1.363	4.179	188.055

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 1, Plant (31 May 2003)

Sample	Alfalfa Var.	Trt	Wet Wt. (g)	Dry Wt. (g)	[B] Tissue ICP	[B]
41	Tahoe 2001	0	9.107	1.988	1.860	83.700
42	Tahoe 2001	0	6.812	1.515	2.097	94.365
43	Tahoe 2001	0	7.017	1.558	3.240	145.800
44	Tahoe 2001	0	9.764	2.175	2.768	124.560
45	Tahoe 2001	0.125	5.533	0.217	3.756	169.020
46	Tahoe 2001	0.125	8.035	1.769	4.747	213.615
47	Tahoe 2001	0.125	8.185	1.814	2.114	95.130
48	Tahoe 2001	0.125	7.442	1.669	2.472	111.240
49	Tahoe 2001	0.25	8.413	1.970	2.186	98.370
50	Tahoe 2001	0.25	7.319	1.560	2.767	124.515
51	Tahoe 2001	0.25	7.843	1.713	2.842	127.890
52	Tahoe 2001	0.25	9.400	2.030	2.805	126.225
53	Tahoe 2001	0.5	10.485	2.128	3.087	138.915
54	Tahoe 2001	0.5	8.010	1.632	3.725	167.625
55	Tahoe 2001	0.5	5.048	1.023	3.946	177.570
56	Tahoe 2001	0.5	7.233	1.514	3.205	144.225
57	Tahoe 2001	0.75	1.690	0.383	3.127	140.715
58	Tahoe 2001	0.75	8.675	1.895	4.267	192.015
59	Tahoe 2001	0.75	7.586	1.657	3.373	151.785
60	Tahoe 2001	0.75	7.467	1.656	3.675	165.375
61	Tahoe 2001	1	4.468	1.070	4.225	190.125
62	Tahoe 2001	1	8.373	1.823	4.278	192.510
63	Tahoe 2001	1	8.872	1.928	3.906	175.770
64	Tahoe 2001	1	8.049	1.814	3.842	172.890
65	Tahoe 2001	1.5	9.226	2.025	4.383	197.24
66	Tahoe 2001	1.5	7.348	1.56	4.585	206.33
67	Tahoe 2001	1.5	7.493	1.686	4.679	210.56
68	Tahoe 2001	1.5	7.908	1.574	5.357	241.07
69	Tahoe 2001	2	6.043	1.391	5.675	255.38
70	Tahoe 2001	2	7.133	1.57	5.146	231.57
71	Tahoe 2001	2	7.406	1.559	4.357	196.07
72	Tahoe 2001	2	7.413	1.829	5.821	261.95
73	Tahoe 2001	4	9.063	1.956	6.412	288.54
74	Tahoe 2001	4	7.898	1.793	8.73	392.85
75	Tahoe 2001	4	8.503	2.001	7.455	335.48
76	Tahoe 2001	4	9.466	2.016	6.331	284.9
77	Tahoe 2001	8	6.31	1.324	5.841	262.85
78	Tahoe 2001	8	5.869	1.255	8.279	372.56
79	Tahoe 2001	8	0.121	0	.	.
80	Tahoe 2001	8	7.931	1.698	6.183	278.24

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 2, Plant (24 June 2003)

					[B] Tissue	
Sample	Alfalfa Var.	Trt	Wet Wt. (g)	Dry Wt. (g)	ICP	[B]
1	Nitro Plus	0	7.466	2.092	1.046	47.070
2	Nitro Plus	0	12.086	2.867	0.999	44.960
3	Nitro Plus	0	9.295	2.457	1.347	60.615
4	Nitro Plus	0	11.453	3.024	1.075	48.375
5	Nitro Plus	0.125	10.976	2.886	1.479	66.555
6	Nitro Plus	0.125	11.889	2.944	1.544	69.480
7	Nitro Plus	0.125	10.846	2.600	1.098	49.410
8	Nitro Plus	0.125	12.979	3.343	1.314	59.130
9	Nitro Plus	0.25	9.119	2.351	1.335	60.075
10	Nitro Plus	0.25	11.192	2.602	1.741	78.345
11	Nitro Plus	0.25	9.754	2.644	1.546	69.570
12	Nitro Plus	0.25	12.148	3.301	1.432	64.440
13	Nitro Plus	0.5	12.769	3.113	1.695	76.275
14	Nitro Plus	0.5	2.820	0.533	1.965	88.425
15	Nitro Plus	0.5	9.653	2.520	1.977	88.965
16	Nitro Plus	0.5	10.825	2.716	1.505	67.725
17	Nitro Plus	0.75	9.751	2.580	2.154	96.930
18	Nitro Plus	0.75	12.036	2.964	2.339	105.255
19	Nitro Plus	0.75	7.327	2.086	2.229	100.305
20	Nitro Plus	0.75	11.039	2.996	1.733	77.985
21	Nitro Plus	1	10.372	2.892	2.414	108.630
22	Nitro Plus	1	13.144	3.147	2.243	100.935
23	Nitro Plus	1	12.259	3.210	1.838	82.710
24	Nitro Plus	1	10.053	2.884	2.269	102.105
25	Nitro Plus	1.5	8.788	2.276	2.995	134.775
26	Nitro Plus	1.5	11.102	2.932	2.353	105.885
27	Nitro Plus	1.5	10.750	2.862	2.111	94.995
28	Nitro Plus	1.5	8.623	2.363	2.395	107.775
29	Nitro Plus	2	9.399	2.355	3.155	141.975
30	Nitro Plus	2	8.655	2.112	3.317	149.265
31	Nitro Plus	2	10.177	2.487	2.761	124.245
32	Nitro Plus	2	8.614	2.315	2.655	119.475
33	Nitro Plus	4	8.918	2.486	3.397	152.865
34	Nitro Plus	4	10.552	2.488	2.938	132.210
35	Nitro Plus	4	7.877	2.301	3.358	151.110
36	Nitro Plus	4	9.388	2.596	2.938	132.210
37	Nitro Plus	8	0.000	0.000	.	.
38	Nitro Plus	8	4.509	1.049	4.892	220.140
39	Nitro Plus	8	0.000	0.000	.	.
40	Nitro Plus	8	5.914	1.366	3.204	144.180

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 2, Plant (24 June 2003)

					[B] Tissue	
Sample	Alfalfa Var.	Trt	Wet Wt. (g)	Dry Wt. (g)	ICP	[B]
41	Tahoe 2001	0	12.044	2.919	1.005	45.225
42	Tahoe 2001	0	12.208	3.034	0.933	41.985
43	Tahoe 2001	0	11.029	2.786	1.487	66.915
44	Tahoe 2001	0	12.471	3.113	1.053	47.385
45	Tahoe 2001	0.125	13.251	3.414	2.047	92.115
46	Tahoe 2001	0.125	11.584	2.861	2.476	111.420
47	Tahoe 2001	0.125	10.508	2.867	1.675	75.375
48	Tahoe 2001	0.125	11.385	3.229	1.456	65.520
49	Tahoe 2001	0.25	11.356	3.000	1.717	77.265
50	Tahoe 2001	0.25	10.330	2.668	1.863	83.835
51	Tahoe 2001	0.25	12.529	3.451	1.605	72.225
52	Tahoe 2001	0.25	14.760	3.795	1.508	67.860
53	Tahoe 2001	0.5	12.746	3.094	1.999	89.955
54	Tahoe 2001	0.5	12.366	2.878	1.981	89.145
55	Tahoe 2001	0.5	9.745	2.306	2.043	91.935
56	Tahoe 2001	0.5	10.782	2.834	2.014	90.630
57	Tahoe 2001	0.75	10.255	2.438	2.209	99.405
58	Tahoe 2001	0.75	15.369	3.331	2.141	96.345
59	Tahoe 2001	0.75	10.792	2.903	2.024	91.080
60	Tahoe 2001	0.75	12.100	2.826	2.190	98.550
61	Tahoe 2001	1	11.449	2.907	1.490	67.050
62	Tahoe 2001	1	10.803	2.505	2.271	102.195
63	Tahoe 2001	1	11.104	2.969	1.861	83.745
64	Tahoe 2001	1	11.974	3.340	1.899	85.455
65	Tahoe 2001	1.5	12.1	3.148	2.112	95.04
66	Tahoe 2001	1.5	12.669	2.838	2.004	90.18
67	Tahoe 2001	1.5	9.339	2.55	2.221	99.945
68	Tahoe 2001	1.5	12.901	3.25	2.175	97.875
69	Tahoe 2001	2	2.543	1.075	2.719	122.36
70	Tahoe 2001	2	10.096	2.651	2.207	99.315
71	Tahoe 2001	2	12.337	3.024	1.836	82.62
72	Tahoe 2001	2	10.604	2.749	2.633	118.49
73	Tahoe 2001	4	12.493	3.018	2.585	116.33
74	Tahoe 2001	4	12.013	3.011	3.401	153.05
75	Tahoe 2001	4	10.15	2.629	2.255	101.48
76	Tahoe 2001	4	10.746	2.864	2.645	119.03
77	Tahoe 2001	8	6.917	1.645	3.708	166.86
78	Tahoe 2001	8	7.381	1.727	4.022	180.99
79	Tahoe 2001	8	0.584	0.105	.	.
80	Tahoe 2001	8	9.249	2.244	3.622	162.99

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 3, Plant (22 July 2003)

Sample	Alfalfa Var.	Trt	Wet Wt. (g)	Dry Wt. (g)	[B] Tissue ICP	[B] Tissue [B]
1	Nitro Plus	0	13.719	3.329	0.533	23.972
2	Nitro Plus	0	10.347	2.505	0.506	22.766
3	Nitro Plus	0	7.487	2.060	0.440	19.800
4	Nitro Plus	0	10.377	2.485	0.441	19.823
5	Nitro Plus	0.125	13.034	3.404	0.698	31.397
6	Nitro Plus	0.125	8.952	2.424	0.810	36.455
7	Nitro Plus	0.125	9.987	2.558	.	.
8	Nitro Plus	0.125	9.639	2.620	.	.
9	Nitro Plus	0.25	12.494	3.230	0.599	26.937
10	Nitro Plus	0.25	10.323	2.810	0.827	37.206
11	Nitro Plus	0.25	9.527	2.803	0.732	32.918
12	Nitro Plus	0.25	10.534	2.691	.	.
13	Nitro Plus	0.5	12.385	3.084	.	.
14	Nitro Plus	0.5	5.562	1.281	1.184	53.280
15	Nitro Plus	0.5	8.165	2.180	1.217	54.765
16	Nitro Plus	0.5	7.601	1.886	1.536	69.120
17	Nitro Plus	0.75	12.796	3.039	1.994	89.730
18	Nitro Plus	0.75	9.257	2.744	1.803	81.135
19	Nitro Plus	0.75	8.477	2.262	1.929	86.805
20	Nitro Plus	0.75	8.060	2.364	1.833	82.485
21	Nitro Plus	1	13.816	3.463	1.417	63.765
22	Nitro Plus	1	11.489	2.927	1.253	56.385
23	Nitro Plus	1	8.509	2.091	2.194	98.730
24	Nitro Plus	1	10.240	2.603	1.626	73.170
25	Nitro Plus	1.5	13.623	3.498	2.038	91.710
26	Nitro Plus	1.5	11.696	3.048	2.321	104.445
27	Nitro Plus	1.5	0.534	0.497	0.720	32.382
28	Nitro Plus	1.5	8.903	2.448	1.718	77.310
29	Nitro Plus	2	9.978	2.381	2.036	91.620
30	Nitro Plus	2	12.247	2.981	2.156	97.020
31	Nitro Plus	2	6.585	1.792	2.240	100.800
32	Nitro Plus	2	8.948	2.267	1.967	88.515
33	Nitro Plus	4	8.178	2.481	3.435	154.575
34	Nitro Plus	4	9.487	2.458	3.062	137.790
35	Nitro Plus	4	9.346	2.498	3.595	161.775
36	Nitro Plus	4	7.918	2.295	3.464	155.880
37	Nitro Plus	8	0.000	0.000	.	.
38	Nitro Plus	8	3.674	0.970	3.869	348.210
39	Nitro Plus	8	0.000	0.000	.	.
40	Nitro Plus	8	2.770	0.715	2.814	253.260

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 3, Plant (22 July 2003)

					[B] Tissue	
Sample	Alfalfa Var.	Trt	Wet Wt. (g)	Dry Wt. (g)	ICP	[B]
41	Tahoe 2001	0	12.224	3.057	0.554	24.939
42	Tahoe 2001	0	10.638	2.720	0.573	25.763
43	Tahoe 2001	0	10.518	2.843	0.637	28.674
44	Tahoe 2001	0	8.649	2.317	0.414	18.617
45	Tahoe 2001	0.125	13.194	3.127	0.791	35.573
46	Tahoe 2001	0.125	11.153	2.746	0.796	35.816
47	Tahoe 2001	0.125	7.472	2.066	0.708	31.851
48	Tahoe 2001	0.125	9.769	2.743	0.526	23.666
49	Tahoe 2001	0.25	9.390	2.352	0.582	26.172
50	Tahoe 2001	0.25	8.356	2.281	0.716	32.238
51	Tahoe 2001	0.25	8.796	2.379	0.728	32.756
52	Tahoe 2001	0.25	9.728	2.835	0.618	27.806
53	Tahoe 2001	0.5	13.592	3.418	1.189	53.505
54	Tahoe 2001	0.5	8.123	2.128	1.203	54.135
55	Tahoe 2001	0.5	6.711	1.862	1.379	62.055
56	Tahoe 2001	0.5	8.982	2.261	1.302	58.590
57	Tahoe 2001	0.75	11.746	2.827	1.352	60.840
58	Tahoe 2001	0.75	9.399	2.513	1.340	60.300
59	Tahoe 2001	0.75	7.250	2.024	1.362	61.290
60	Tahoe 2001	0.75	11.805	3.162	1.144	51.480
61	Tahoe 2001	1	11.471	2.889	1.045	47.025
62	Tahoe 2001	1	10.749	2.924	1.645	74.025
63	Tahoe 2001	1	9.975	2.669	1.672	75.240
64	Tahoe 2001	1	10.511	2.875	1.717	77.265
65	Tahoe 2001	1.5	12.552	2.838	1.729	77.805
66	Tahoe 2001	1.5	9.141	2.503	1.513	68.085
67	Tahoe 2001	1.5	7.558	2.097	1.733	77.985
68	Tahoe 2001	1.5	8.82	2.086	1.551	69.795
69	Tahoe 2001	2	11.669	3.5	1.429	64.305
70	Tahoe 2001	2	9.222	2.564	1.808	81.36
71	Tahoe 2001	2	8.198	2.188	1.776	79.92
72	Tahoe 2001	2	11.427	3.048	1.637	73.665
73	Tahoe 2001	4	10.004	2.641	3.779	170.06
74	Tahoe 2001	4	8.06	2.139	4.157	187.07
75	Tahoe 2001	4	6.875	2.219	3.078	138.51
76	Tahoe 2001	4	10.5	2.923	2.944	132.48
77	Tahoe 2001	8	7.376	1.854	4.897	220.37
78	Tahoe 2001	8	10.74	2.79	3.97	178.65
79	Tahoe 2001	8	1.654	0.382	.	.
80	Tahoe 2001	8	10.194	2.792	4.147	186.62

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 4, Plant (11 August 2003)

Sample	Alfalfa Var.	Trt	Wet Wt. (g)	Dry Wt. (g)	[B] Tissue ICP	[B] Tissue [B]
1	Nitro Plus	0	9.293	2.695	0.739	33.260
2	Nitro Plus	0	9.037	2.179	0.997	44.852
3	Nitro Plus	0	5.632	1.639	1.098	49.410
4	Nitro Plus	0	8.328	1.989	0.884	39.789
5	Nitro Plus	0.125	7.897	2.448	0.036	1.607
6	Nitro Plus	0.125	9.378	2.176	1.504	67.680
7	Nitro Plus	0.125	7.939	1.893	1.020	45.900
8	Nitro Plus	0.125	8.610	2.419	0.945	42.521
9	Nitro Plus	0.25	12.376	2.676	1.217	54.765
10	Nitro Plus	0.25	9.284	2.058	1.480	66.600
11	Nitro Plus	0.25	8.230	2.245	1.321	59.445
12	Nitro Plus	0.25	10.911	2.523	1.132	50.940
13	Nitro Plus	0.5	10.554	2.621	1.483	66.735
14	Nitro Plus	0.5	5.003	1.084	0.677	60.948
15	Nitro Plus	0.5	7.301	2.153	1.443	64.935
16	Nitro Plus	0.5	5.277	1.554	1.607	72.315
17	Nitro Plus	0.75	11.977	2.634	1.890	85.050
18	Nitro Plus	0.75	10.675	2.380	1.896	85.320
19	Nitro Plus	0.75	8.033	2.218	1.554	69.930
20	Nitro Plus	0.75	7.433	2.151	1.435	64.575
21	Nitro Plus	1	10.775	2.325	2.016	90.720
22	Nitro Plus	1	9.419	2.424	1.507	67.815
23	Nitro Plus	1	5.580	1.801	1.536	69.120
24	Nitro Plus	1	7.502	2.000	1.361	61.245
25	Nitro Plus	1.5	9.409	2.598	1.616	72.720
26	Nitro Plus	1.5	9.231	2.206	1.733	77.985
27	Nitro Plus	1.5	4.311	1.093	1.246	112.140
28	Nitro Plus	1.5	7.669	2.455	1.467	66.015
29	Nitro Plus	2	9.597	2.467	1.713	77.085
30	Nitro Plus	2	9.067	2.460	2.202	99.090
31	Nitro Plus	2	3.906	1.198	2.550	114.750
32	Nitro Plus	2	9.478	2.167	1.870	84.150
33	Nitro Plus	4	8.227	2.151	2.262	101.790
34	Nitro Plus	4	8.217	1.983	2.307	103.815
35	Nitro Plus	4	5.451	1.734	3.148	141.660
36	Nitro Plus	4	7.238	2.231	2.942	132.390
37	Nitro Plus	8	0.000	0.000	.	.
38	Nitro Plus	8	7.061	1.877	3.137	141.165
39	Nitro Plus	8	0.000	0.000	.	.
40	Nitro Plus	8	4.816	1.291	2.542	114.390

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 4, Plant (11 August 2003)

Sample	Alfalfa Var.	Trt	Wet Wt. (g)	Dry Wt. (g)	[B] Tissue ICP	[B] Tissue [B]
41	Tahoe 2001	0	8.998	2.379	0.580	26.096
42	Tahoe 2001	0	10.681	2.589	0.636	28.634
43	Tahoe 2001	0	8.533	2.481	0.589	26.510
44	Tahoe 2001	0	7.739	1.921	0.483	21.726
45	Tahoe 2001	0.125	11.240	2.554	0.622	27.990
46	Tahoe 2001	0.125	11.319	2.615	0.509	22.896
47	Tahoe 2001	0.125	9.290	2.108	0.440	19.778
48	Tahoe 2001	0.125	9.064	2.343	0.482	21.686
49	Tahoe 2001	0.25	9.011	2.180	0.954	42.939
50	Tahoe 2001	0.25	5.068	1.783	0.896	40.320
51	Tahoe 2001	0.25	8.268	2.113	1.283	57.735
52	Tahoe 2001	0.25	8.607	2.048	0.824	37.094
53	Tahoe 2001	0.5	10.117	2.363	1.280	57.600
54	Tahoe 2001	0.5	9.466	2.147	1.107	49.815
55	Tahoe 2001	0.5	6.500	2.110	1.341	60.345
56	Tahoe 2001	0.5	8.038	2.030	1.829	82.305
57	Tahoe 2001	0.75	10.839	2.490	1.606	72.270
58	Tahoe 2001	0.75	10.226	2.381	1.240	55.800
59	Tahoe 2001	0.75	7.041	1.941	1.189	53.505
60	Tahoe 2001	0.75	9.796	2.341	1.737	78.165
61	Tahoe 2001	1	9.585	2.145	1.500	67.500
62	Tahoe 2001	1	7.149	2.273	1.517	68.265
63	Tahoe 2001	1	7.228	2.408	1.593	71.685
64	Tahoe 2001	1	9.570	2.198	1.511	67.995
65	Tahoe 2001	1.5	11.733	2.524	1.64	73.8
66	Tahoe 2001	1.5	8.346	2.265	1.772	79.74
67	Tahoe 2001	1.5	10.477	2.357	1.646	74.07
68	Tahoe 2001	1.5	9.088	2.158	1.648	74.16
69	Tahoe 2001	2	11.075	2.668	0.955	42.989
70	Tahoe 2001	2	8.245	1.968	2.109	94.905
71	Tahoe 2001	2	6.731	1.778	1.942	87.39
72	Tahoe 2001	2	9.743	2.177	2.202	99.09
73	Tahoe 2001	4	11.459	2.63	2.673	120.29
74	Tahoe 2001	4	10.743	2.351	2.717	122.27
75	Tahoe 2001	4	6.123	1.949	2.528	113.76
76	Tahoe 2001	4	7.681	2.115	2.634	118.53
77	Tahoe 2001	8	9.647	2.23	3.73	167.85
78	Tahoe 2001	8	10.371	2.094	3.118	140.31
79	Tahoe 2001	8	5.266	1.053	1.508	135.72
80	Tahoe 2001	8	7.695	2.317	5.639	253.76

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 5, Plant (11 September 2003)

Sample	Alfalfa Var.	Trt	Wet Wt. (g)	Dry Wt. (g)	[B] Tissue	
					ICP	[B]
1	Nitro Plus	0	10.178	2.963	0.764	34.371
2	Nitro Plus	0	10.733	3.133	0.533	23.963
3	Nitro Plus	0	11.872	3.387	0.558	25.101
4	Nitro Plus	0	12.284	3.018	0.655	29.489
5	Nitro Plus	0.125	12.084	3.498	0.581	26.127
6	Nitro Plus	0.125	10.794	3.437	0.561	25.241
7	Nitro Plus	0.125	10.937	3.146	0.413	18.567
8	Nitro Plus	0.125	14.574	3.926	0.495	22.253
9	Nitro Plus	0.25	13.947	3.674	0.389	17.487
10	Nitro Plus	0.25	13.809	3.897	0.438	19.715
11	Nitro Plus	0.25	12.060	3.366	0.425	19.107
12	Nitro Plus	0.25	14.775	4.147	0.523	23.535
13	Nitro Plus	0.5	11.182	3.492	0.531	23.904
14	Nitro Plus	0.5	7.835	2.217	0.739	33.264
15	Nitro Plus	0.5	13.622	3.880	0.636	28.602
16	Nitro Plus	0.5	10.452	3.183	0.475	21.357
17	Nitro Plus	0.75	11.683	3.629	0.379	17.051
18	Nitro Plus	0.75	9.919	2.726	0.369	16.601
19	Nitro Plus	0.75	12.796	3.293	0.581	26.132
20	Nitro Plus	0.75	14.777	3.882	0.377	16.961
21	Nitro Plus	1	14.946	4.165	0.697	31.374
22	Nitro Plus	1	11.127	3.105	1.157	52.065
23	Nitro Plus	1	13.134	3.652	0.844	37.967
24	Nitro Plus	1	13.286	3.603	1.261	56.745
25	Nitro Plus	1.5	11.440	3.569	1.728	77.760
26	Nitro Plus	1.5	12.069	3.434	1.766	79.470
27	Nitro Plus	1.5	11.427	3.373	2.041	91.845
28	Nitro Plus	1.5	12.926	3.502	1.829	82.305
29	Nitro Plus	2	11.904	3.479	2.299	103.455
30	Nitro Plus	2	11.832	3.383	2.006	90.270
31	Nitro Plus	2	12.473	3.502	1.702	76.590
32	Nitro Plus	2	13.257	3.465	1.545	69.525
33	Nitro Plus	4	10.715	3.777	2.128	95.760
34	Nitro Plus	4	8.793	2.798	2.520	113.400
35	Nitro Plus	4	11.397	3.596	2.449	110.205
36	Nitro Plus	4	12.417	3.094	2.837	127.665
37	Nitro Plus	8	0.000	0.000	.	.
38	Nitro Plus	8	9.659	3.138	2.145	96.525
39	Nitro Plus	8	0.000	0.000	.	.
40	Nitro Plus	8	11.825	3.094	2.361	106.245

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 5, Plant (11 September 2003)

					[B] Tissue	
Sample	Alfalfa Var.	Trt	Wet Wt. (g)	Dry Wt. (g)	ICP	[B]
41	Tahoe 2001	0	14.116	3.926	0.711	31.995
42	Tahoe 2001	0	10.096	3.221	0.533	23.981
43	Tahoe 2001	0	11.071	2.845	0.676	30.416
44	Tahoe 2001	0	16.424	3.976	0.650	29.228
45	Tahoe 2001	0.125	12.353	3.195	0.687	30.911
46	Tahoe 2001	0.125	9.057	2.574	0.691	31.091
47	Tahoe 2001	0.125	12.565	3.780	0.515	23.180
48	Tahoe 2001	0.125	13.047	3.461	0.574	25.826
49	Tahoe 2001	0.25	9.788	2.885	0.576	25.920
50	Tahoe 2001	0.25	14.164	3.693	0.645	29.007
51	Tahoe 2001	0.25	11.294	3.193	0.523	23.535
52	Tahoe 2001	0.25	15.278	3.738	0.479	21.555
53	Tahoe 2001	0.5	12.090	3.440	0.407	18.329
54	Tahoe 2001	0.5	12.018	3.167	1.288	57.960
55	Tahoe 2001	0.5	12.076	3.355	0.793	35.681
56	Tahoe 2001	0.5	12.664	3.047	1.045	47.025
57	Tahoe 2001	0.75	12.209	3.491	0.542	24.404
58	Tahoe 2001	0.75	12.053	3.404	0.711	31.986
59	Tahoe 2001	0.75	11.971	3.801	1.349	60.705
60	Tahoe 2001	0.75	11.779	3.321	1.094	49.230
61	Tahoe 2001	1	16.471	4.294	1.719	77.355
62	Tahoe 2001	1	11.725	3.902	1.869	84.105
63	Tahoe 2001	1	12.352	3.531	1.566	70.470
64	Tahoe 2001	1	13.350	3.507	1.792	80.640
65	Tahoe 2001	1.5	4.088	1.166	4.238	190.71
66	Tahoe 2001	1.5	10.685	3.549	1.574	70.83
67	Tahoe 2001	1.5	13.728	3.528	1.675	75.375
68	Tahoe 2001	1.5	14.336	3.347	2.595	116.78
69	Tahoe 2001	2	11.609	3.924	2.062	92.79
70	Tahoe 2001	2	8.192	2.877	1.937	87.165
71	Tahoe 2001	2	11.938	3.152	1.75	78.75
72	Tahoe 2001	2	15.096	3.632	2.234	100.53
73	Tahoe 2001	4	12.527	3.345	2.315	104.18
74	Tahoe 2001	4	14.446	4.126	2.956	133.02
75	Tahoe 2001	4	11.825	3.015	1.945	87.525
76	Tahoe 2001	4	12.876	3.187	2.018	90.81
77	Tahoe 2001	8	14.816	4.014	3.989	179.51
78	Tahoe 2001	8	11.709	3.552	4.749	213.71
79	Tahoe 2001	8	10.84	2.846	4.546	204.57
80	Tahoe 2001	8	14.891	3.87	3.487	156.92

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 6, Plant (22 October 2003)

Sample	Alfalfa Var.	Trt	# Plants	Wet Wt. (g)	Dry Wt. (g)	[B] Tissue ICP	[B] Tissue [B]
1	Nitro Plus	0	5	8.589	2.364	0.383	17.217
2	Nitro Plus	0	5	8.019	2.157	0.333	15.003
3	Nitro Plus	0	5	8.382	2.349	0.301	13.545
4	Nitro Plus	0	5	11.448	2.960	0.334	15.012
5	Nitro Plus	0.125	5	6.723	2.091	0.348	15.678
6	Nitro Plus	0.125	5	7.558	1.976	0.456	20.538
7	Nitro Plus	0.125	5	9.457	2.592	0.652	29.349
8	Nitro Plus	0.125	5	6.806	1.810	0.539	24.242
9	Nitro Plus	0.25	5	8.810	2.327	0.863	38.822
10	Nitro Plus	0.25	5	8.586	2.479	1.097	49.365
11	Nitro Plus	0.25	5	7.440	2.007	0.753	33.876
12	Nitro Plus	0.25	5	11.369	3.093	0.942	42.399
13	Nitro Plus	0.5	5	8.893	2.628	1.206	54.270
14	Nitro Plus	0.5	3	7.438	1.841	1.580	71.100
15	Nitro Plus	0.5	5	8.032	2.153	1.010	45.450
16	Nitro Plus	0.5	5	9.215	2.130	0.989	44.519
17	Nitro Plus	0.75	5	8.098	2.260	1.267	57.015
18	Nitro Plus	0.75	5	6.703	1.800	0.991	44.595
19	Nitro Plus	0.75	5	8.065	2.169	1.176	52.920
20	Nitro Plus	0.75	5	7.139	2.050	1.251	56.295
21	Nitro Plus	1	5	10.004	2.669	1.948	87.660
22	Nitro Plus	1	5	7.281	1.953	2.026	91.170
23	Nitro Plus	1	5	7.932	2.180	1.310	58.950
24	Nitro Plus	1	5	10.749	2.829	1.774	79.830
25	Nitro Plus	1.5	5	9.634	2.642	1.911	85.995
26	Nitro Plus	1.5	5	9.732	2.574	1.747	78.615
27	Nitro Plus	1.5	5	6.863	1.822	2.480	111.600
28	Nitro Plus	1.5	5	9.690	2.527	2.327	104.715
29	Nitro Plus	2	5	7.510	2.074	2.052	92.340
30	Nitro Plus	2	5	6.832	1.981	1.405	63.225
31	Nitro Plus	2	5	9.217	2.501	1.918	86.310
32	Nitro Plus	2	5	10.200	2.326	2.201	99.045
33	Nitro Plus	4	5	9.514	2.502	2.438	109.710
34	Nitro Plus	4	5	5.871	1.753	2.967	133.515
35	Nitro Plus	4	5	7.869	2.130	3.128	140.760
36	Nitro Plus	4	5	8.009	2.040	2.283	102.735
37	Nitro Plus	8	0	0.000	0.000	.	.
38	Nitro Plus	8	2	5.666	1.866	2.883	129.735
39	Nitro Plus	8	0	0.000	0.000	.	.
40	Nitro Plus	8	2	7.757	2.051	4.098	184.410

B03 -- Greenhouse Alfalfa Experiment with Darco Loamy Fine Sand
Harvest 6, Plant (22 October 2003)

						[B] Tissue	
Sample	Alfalfa Var.	Trt	# Plants	Wet Wt. (g)	Dry Wt. (g)	ICP	[B]
41	Tahoe 2001	0	5	9.840	2.856	0.380	17.118
42	Tahoe 2001	0	5	7.811	2.290	0.384	17.285
43	Tahoe 2001	0	5	8.559	2.236	0.437	19.674
44	Tahoe 2001	0	5	12.749	3.048	0.581	26.132
45	Tahoe 2001	0.125	5	7.605	1.967	0.683	30.731
46	Tahoe 2001	0.125	5	7.003	1.910	0.701	31.545
47	Tahoe 2001	0.125	5	8.776	2.316	0.684	30.785
48	Tahoe 2001	0.125	5	8.645	2.512	0.741	33.332
49	Tahoe 2001	0.25	5	8.195	2.046	0.790	35.541
50	Tahoe 2001	0.25	5	8.339	2.363	0.758	34.115
51	Tahoe 2001	0.25	5	8.444	2.197	0.946	42.557
52	Tahoe 2001	0.25	5	10.947	2.697	0.734	33.021
53	Tahoe 2001	0.5	5	6.936	2.110	0.865	38.930
54	Tahoe 2001	0.5	5	7.549	2.251	0.871	39.186
55	Tahoe 2001	0.5	3	7.008	1.993	1.194	53.730
56	Tahoe 2001	0.5	4	7.062	1.878	1.364	61.380
57	Tahoe 2001	0.75	5	8.958	2.165	1.607	72.315
58	Tahoe 2001	0.75	5	7.787	1.796	1.246	56.070
59	Tahoe 2001	0.75	5	7.949	2.085	1.214	54.630
60	Tahoe 2001	0.75	5	11.202	2.673	1.780	80.100
61	Tahoe 2001	1	5	9.626	2.475	1.172	52.740
62	Tahoe 2001	1	5	8.020	2.324	1.051	47.295
63	Tahoe 2001	1	5	7.380	1.845	.	.
64	Tahoe 2001	1	5	9.679	2.741	1.361	61.245
65	Tahoe 2001	1.5	5	10.634	2.317	2.277	102.47
66	Tahoe 2001	1.5	5	8.759	2.296	0.953	42.867
67	Tahoe 2001	1.5	5	7.76	1.988	1.317	59.265
68	Tahoe 2001	1.5	5	11.42	2.466	1.694	76.23
69	Tahoe 2001	2	5	11.902	3.115	1.467	66.015
70	Tahoe 2001	2	5	6.21	1.929	1.076	48.42
71	Tahoe 2001	2	5	7.42	1.971	0.98	44.109
72	Tahoe 2001	2	5	8.43	2.434	1.384	62.28
73	Tahoe 2001	4	3	8.353	2.212	1.754	78.93
74	Tahoe 2001	4	5	7.097	2.033	1.898	85.41
75	Tahoe 2001	4	5	7.57	2.071	1.825	82.125
76	Tahoe 2001	4	5	10.708	2.539	1.856	83.52
77	Tahoe 2001	8	5	6.045	1.574	2.356	106.02
78	Tahoe 2001	8	5	6.878	2.028	3.093	139.19
79	Tahoe 2001	8	1	6.396	1.47	2.722	122.49
80	Tahoe 2001	8	5	11.256	2.671	3.645	164.03

FIELD ALFALFA EXPERIMENT DATA

D03 -- Alfalfa Field Experiment with Darco Loamy Fine Sand
Soil Samples taken June 1994

						HWB	PHWB		DTPA-Sorbitol	
Trt	Rep	Lime rate	ECCE	B	pH	B ppm soil	ICP	B ppm soil	ICP	B ppm soil
1	1	0	0	0	5.07	0.31	0.0824	0.28	0.0824	0.16
2	1	0	0	2	5.17	0.38	0.1077	0.33	0.1077	0.22
3	1	0	0	4	5.08	0.33	0.1064	0.32	0.1064	0.21
4	1	1	62	0	6.49	0.28	0.0507	0.29	0.0507	0.10
5	1	1	62	2	6.71	0.27	0.0522	0.32	0.0522	0.10
6	1	1	62	4	6.55	0.42	0.0910	0.42	0.0910	0.18
7	1	1	100	0	6.8	0.30	0.0464	0.25	0.0464	0.09
8	1	1	100	2	6.82	0.29	0.0529	0.41	0.0529	0.11
9	1	1	100	4	6.86	0.41	0.0899	0.49	0.0899	0.18
10	1	2	62	0	6.73	0.24	0.0403	0.29	0.0403	0.08
11	1	2	62	2	6.84	0.40	0.0647	0.35	0.0647	0.13
12	1	2	62	4	7.02	0.47	0.1143	0.51	0.1143	0.23
13	1	2	100	0	7.21	0.25	0.0522	0.30	0.0522	0.10
14	1	2	100	2	7.36	0.46	0.0626	0.42	0.0626	0.13
15	1	2	100	4	7.14	0.36	0.0787	0.45	0.0787	0.16
1	2	0	0	0	5.24	0.24	0.0726	0.28	0.0726	0.15
2	2	0	0	2	5.1	0.38	0.0970	0.35	0.0970	0.19
3	2	0	0	4	5.01	0.39	0.1111	0.46	0.1111	0.22
4	2	1	62	0	6.63	0.28	0.0479	0.33	0.0479	0.10
5	2	1	62	2	6.52	0.30	0.0530	0.37	0.0530	0.11
6	2	1	62	4	6.44	0.40	0.0844	0.40	0.0844	0.17
7	2	1	100	0	6.6	0.29	0.0570	0.35	0.0570	0.11
8	2	1	100	2	6.5	0.35	0.0661	0.41	0.0661	0.13
9	2	1	100	4	6.84	0.37	0.0835	0.40	0.0835	0.17
10	2	2	62	0	6.68	0.25	0.0419	0.30	0.0419	0.08
11	2	2	62	2	6.78	0.30	0.0525	0.43	0.0525	0.11
12	2	2	62	4	6.59	0.44	0.0984	0.43	0.0984	0.20
13	2	2	100	0	7.41	0.29	0.0419	0.33	0.0419	0.08
14	2	2	100	2	7.13	0.37	.	.	.	.
15	2	2	100	4	7.18	0.36	.	.	.	.

D03 -- Alfalfa Field Experiment with Darco Loamy Fine Sand
Soil Samples taken June 1994

						HWB	PHWB		DTPA-Sorbitol	
Trt	Rep	Lime rate	ECCE	B	pH	B ppm soil	ICP	B ppm soil	ICP	B ppm soil
1	3	0	0	0	5.17	0.26	0.0700	0.27	0.0700	0.14
2	3	0	0	2	5	0.41	.	.	.	.
3	3	0	0	4	5.12	0.38	0.0946	0.33	0.0946	0.19
4	3	1	62	0	6.2	0.29	0.0446	0.28	0.0446	0.09
5	3	1	62	2	6.21	0.31	0.0643	0.27	0.0643	0.13
6	3	1	62	4	6.07	0.41	0.0771	0.33	0.0771	0.15
7	3	1	100	0	6.7	0.28	0.0369	0.27	0.0369	0.07
8	3	1	100	2	6.59	0.26	0.0553	0.31	0.0553	0.11
9	2	1	100	4	6.26	0.56	0.1111	0.51	0.1111	0.22
10	3	2	62	0	6.37	0.22	0.0428	0.21	0.0428	0.09
11	3	2	62	2	6.56	0.40	0.0720	0.40	0.0720	0.14
12	3	2	62	4	6.94	0.30	0.0573	0.58	0.0573	0.11
13	3	2	100	0	7.23	0.26	0.0373	0.48	0.0373	0.07
14	3	2	100	2	7.22	0.35	0.0557	0.39	0.0557	0.11
15	3	2	100	4	7.06	0.46	0.0759	0.41	0.0759	0.15
1	4	0	0	0	5.1	0.22	0.0770	0.26	0.0770	0.15
2	4	0	0	2	5.11	0.41	0.1094	0.33	0.1094	0.22
3	4	0	0	4	5.18	0.39	0.1172	0.41	0.1172	0.23
4	4	1	62	0	6.33	0.25	0.0522	0.24	0.0522	0.10
5	4	1	62	2	6.01	0.33	0.0734	0.27	0.0734	0.15
6	4	1	62	4	6.31	0.43	0.1154	0.37	0.1154	0.23
7	4	1	100	0	6.95	0.32	0.0711	0.21	0.0711	0.14
8	4	1	100	2	6.78	0.37	0.1081	0.41	0.1081	0.22
9	4	1	100	4	6.4	0.45	0.4642	0.49	0.4642	0.93
10	4	2	62	0	7.01	0.32	0.0933	0.27	0.0933	0.19
11	4	2	62	2	6.77	0.32	0.0633	0.29	0.0633	0.13
12	4	2	62	4	6.27	0.39	0.0869	0.40	0.0869	0.17
13	4	2	100	0	7.29	0.29	0.0446	0.29	0.0446	0.09
14	4	2	100	2	7.12	0.32	0.0650	0.34	0.0650	0.13
15	4	2	100	4	7.11	0.47	0.0786	0.51	0.0786	0.16

D03 -- Alfalfa Field Experiment with Darco Loamy Fine Sand
Soil Samples taken June 1994

					Yield in lb/A					
Trt	Rep	Lime rate	ECCE	B	H1	H2	H3	H4	H5	H6
1	1	0	0	0	12	19	0	0	0	0
2	1	0	0	2	96	40	0	0	0	0
3	1	0	0	4	10	12	1	0	0	0
4	1	1	62	0	370	132	467	185	209	385
5	1	1	62	2	1075	634	798	457	682	595
6	1	1	62	4	1590	1284	1427	1252	943	695
7	1	1	100	0	211	139	215	0	92	157
8	1	1	100	2	1535	1121	1331	971	941	993
9	1	1	100	4	708	628	831	359	462	167
10	1	2	62	0	176	268	250	337	0	15
11	1	2	62	2	1671	1129	1286	818	667	738
12	1	2	62	4	2543	1325	1965	1488	1184	1291
13	1	2	100	0	153	94	176	84	0	5
14	1	2	100	2	1557	1149	1490	1273	1248	1158
15	1	2	100	4	1882	1293	1857	1435	1554	1087
1	2	0	0	0	312	73	138	232	0	0
2	2	0	0	2	169	57	30	0	0	0
3	2	0	0	4	65	68	16	0	0	0
4	2	1	62	0	845	1006	767	569	641	681
5	2	1	62	2	1329	788	871	441	515	656
6	2	1	62	4	2012	1295	1787	1338	1163	1302
7	2	1	100	0	2106	1270	1391	1093	834	804
8	2	1	100	2	1089	608	719	590	349	134
9	2	1	100	4	1456	791	989	626	993	1151
10	2	2	62	0	282	85	149	681	0	0
11	2	2	62	2	1396	584	907	710	650	861
12	2	2	62	4	2002	1259	1740	1239	1285	1337
13	2	2	100	0	487	230	479	338	324	445
14	2	2	100	2	2449	1833	1905	1503	1149	1288
15	2	2	100	4	2640	1550	1585	1648	1297	1602

D03 -- Alfalfa Field Experiment with Darco Loamy Fine Sand
Soil Samples taken June 1994

					Yield in lb/A					
Trt	Rep	Lime rate	ECCE	B	H1	H2	H3	H4	H5	H6
1	3	0	0	0	103	42	22	0	0	0
2	3	0	0	2	90	48	27	0	0	0
3	3	0	0	4	76	14	4	59	0	0
4	3	1	62	0	220	215	280	69	80	0
5	3	1	62	2	1403	784	1121	1240	1039	659
6	3	1	62	4	1620	1108	1429	857	858	640
7	3	1	100	0	422	465	741	504	524	559
8	3	1	100	2	2041	1638	1714	1284	1275	1031
9	2	1	100	4	1807	944	1421	1370	864	1007
10	3	2	62	0	971	783	1454	736	560	0
11	3	2	62	2	1987	1524	1680	1060	800	700
12	3	2	62	4	1411	708	1100	991	1089	741
13	3	2	100	0	953	1183	1731	1255	867	736
14	3	2	100	2	1935	1530	1827	1203	879	1001
15	3	2	100	4	2610	1425	2204	1357	1191	740
1	4	0	0	0	9	36	0	0	0	0
2	4	0	0	2	14	50	29	0	0	0
3	4	0	0	4	19	45	11	0	0	0
4	4	1	62	0	599	587	625	282	192	284
5	4	1	62	2	1324	773	863	657	346	438
6	4	1	62	4	1857	1438	1224	1075	878	1148
7	4	1	100	0	368	408	765	527	386	516
8	4	1	100	2	1774	1026	893	489	817	480
9	4	1	100	4	1882	1262	1124	1124	660	710
10	4	2	62	0	596	705	982	820	519	680
11	4	2	62	2	1869	1105	1396	1111	440	589
12	4	2	62	4	1728	1423	1518	1101	932	992
13	4	2	100	0	1319	1088	1334	861	893	980
14	4	2	100	2	1272	1008	1130	718	645	727
15	4	2	100	4	2683	2128	2718	1652	1227	1102