





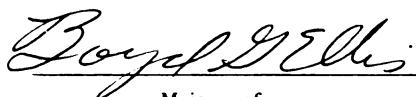
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**PRELIMINARY DRIS NORMS IN Highbush
Blueberry (*Vaccinium corymbosum* L.)**

By

Carmen Goñi Altuna de Otero

A THESIS

**Submitted to
Michigan State University
in partial fulfillment of the requirements
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Boyd G. Ellis, Advisor

ABSTRACT

PRELIMINARY DRIS NORMS IN HIGHBUSH BLUEBERRY (*Vaccinium corymbosum* L.)

By

Carmen Gofñi Altuna de Otero

The development of the Diagnostic and Recommendation Integrated System (DRIS) was a major advantage in the utilization of foliar analysis as a diagnostic tool during the past decade. But, application of DRIS is complex; consequently, there are still some controversies about its application as a means of assessing mineral nutrition of fruit crops. The present study was conducted to develop DRIS norms from 1074 observations of previously published and unpublished data of leaf nutrient composition and yield in highbush blueberry (*Vaccinium corymbosum* L.), and to compare the DRIS diagnosis with standard values previously developed for the crop to determine if relative deficiencies or excesses associated with lower yields would have been detected

routinely by DRIS analysis. Critical values were calculated for each nutrient and correlated with the DRIS indices. The first tentative set of DRIS norms developed and their diagnostic results have identified relative deficiencies of N, P, Ca, and Zn and relative excesses of K and Mn for blueberries. The most and least relative limiting nutrient for both subpopulations were identified. DRIS and the Sufficiency Range Value (SRV) were in agreement for detecting excesses of K and Mn, but DRIS detected excesses for the other nutrients where the SRV considered others sufficient. DRIS appeared to be less sensitive than the Critical Value (CV) in detecting Mn, Fe, Zn and B deficiencies. The comparison among the different diagnostic criteria used (DRIS, SRV, and CV developed from the data base and reported) showed some divergences. DRIS indices for Cu, B, Zn and Al for certain ranges of nutrient concentrations seems to be of little advantage to a ratio based diagnosis over the CV.

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To Alvaro, my husband,
for his love, care and support.

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INTRODUCTION

Although all plants require the same minerals to complete their life cycles, the quantities and balances necessary for optimum growth and production of high yields of quality product vary greatly among species. Perennial crops differ in many ways from annual plants. They need nutrients not only for the harvestable product, but also for their vegetative organs which persist from year to year. Faust (1989), said that the perennial nature of a fruit tree and the fact that it bears heavy loads of fruits regularly impose conditions not encountered in nutrition of herbaceous plants or forest trees. The nutrient requirements for fruit trees change during the year. Fruit tree nutrition often must be concerned with the nutrition of not only the whole tree but also individual organs.

Atkinson (1980), stated that the root system of fruit trees has peculiar characteristics. This includes the difficult size generalization, the low relation of length of root per area of leaves, the limited soil contact and the high inflow of water and nutrient required to overcome water and or nutrient stresses. Roger (1939), emphasized the dependence of root growth on soil temperature and the bimodal root grow

periodicity. Atkinson (1980), stated the importance of the root system in the total uptake and the extent of internal nutrient remobilization.

The above characteristics are different for fruit trees than for field crops and influence the research in fruit tree nutrition which has become a time consuming and complex task. For this reason one of the main recommendations of Commission IV at the International Society of Soil Science was "Research should be reoriented so as to consider the soil plant environment as a whole".

Hall (1905), proposed plant analysis not for determining the total quantity of nutrient removed from the soil, but as a biological method for assessing soil fertility. In 1926, Lagatu and Maume adapted this approach to which they gave the name "Diagnostic Foliare" (Lagatu and Maume, 1926). Twelve years later Batjer and Magness used this methodology (quoted by Faust, 1979). After this pioneering work the use of chemical analysis of selected tissues has given information about the nutritional status of plants.

Soil and plant analysis have been the tools most often used as a guide in the determination of nutritional limitations. Sometimes plant analysis and soil analysis have been considered as competitive, leading to a lack of integration in the use of the two techniques. The soil is almost always the source of mineral nutrients or the medium through which they are supplied, justifying the wide spread

practice of soil analysis. Analyzing the soil, however, only provides information on the amount of a nutrient available at a given moment, but not on the amount actually taken up. On the other hand, the chemical composition of plants can identify nutrient uptake problems or nutritional disorders, but it cannot identify their causes.

A number of philosophies and interpretations of the nutrient diagnosis have been used since foliar analysis began, often identified as the European or the American school; however, each has shown weaknesses and disadvantages. For instance, when utilizing tissue analysis the simplest has been to compare the observed concentration with a reference standard used to establish a sufficiency range (Kenworthy, 1961), or the use of critical values (Ulrich and Hills, 1967).

Procedures have been developed to partition yield and nutrient concentrations data into two classes that correspond to deficient and adequate zones, for example like the Cate-Nelson technique (Cate and Nelson, 1971). Kenworthy (1967, 1973), developed the Balance Indices. Webb (1972), proposed the use of Boundary Lines and Beaufils (1971-1973), developed the Diagnostic and Recommendation Integrated System (DRIS). Both, Webb (1972) and Beaufils (1971-73), recognized that crop yield is a function of many interrelated variables and that such a relationship cannot be reduced to an equation with a single independent variable. The DRIS approach has an advantage in that a large number of independent observations

at one time are utilized without strict field trials. With this system it is possible to obtain norms more rapidly with simple nutritional surveys, without the cost and time associated with replicated field trials. It could be possible to integrate nutrient interactions by themselves, as well as nutrients, metabolic activities and dry matter. The data are computerized in agreement with the limitation order among the different nutrients. The DRIS approach has gained greater recognition more recently because it minimizes the leaf age effect in the diagnosis. But, a 1990 survey of state and commercial laboratories involved in plant analysis throughout the United States concluded that both the lack of field verification and/or calibration and correlation data and the unfamiliarity of users with the DRIS system have prevented this methodology from being more widely used (Savoy and Robinson, 1990).

The DRIS system has been applied to field crops, pastures and forage crops, vegetable crops and forestry crops. However there are few reports on the use of DRIS in fruit trees (Beverly, et al., 1984; Chelvan, et al., 1984; Parent and Granger, 1989). This raises a big question about its efficacy.

Michigan is one of the most important production regions in the United States of highbush blueberry. The species differs from other fruit crops by requiring an acid soil of high water holding capacity. The availability of many

nutrient elements in such soils would be considered in either short or excess supply for the majority of fruit crops. As a consequence of the above characteristics and with the knowledge that sufficient data of leaf analysis and yield are available, blueberry will be used to develop preliminary DRIS norms. The DRIS norms developed will be compared to the standard values traditionally used and both methodologies correlated. This will allow future extension of the DRIS methodology to blueberries and to other fruit trees.

This work is important because it is the first time that DRIS Norms will be developed for blueberries and an initial correlation between DRIS and traditional methods of diagnosing nutrient deficiencies in blueberry will be made. Field verification and refinement of the DRIS Norms will need to be made in future studies.

LITERATURE REVIEW

1. Mineral Nutrition in Fruit Trees.

There are known differences between perennial and annual plants; however, with new instrumentation and team work between soil fertility and plant physiology, a better understanding of the nutritional requirements of fruit trees has developed in the last few years.

1.1 Nutrient Requirements.

Perennial species have a nutrient requirement not only for annual, commercial production but also for their vegetative organs which persist from year to year. According to Kozlowski (1991), horticulturists have grown trees, shrubs and vines for their fruit, seed or flowers. The author emphasized the need of a maximum possible allocation of photosynthates into fruits, and the importance of the flowering and fruiting process for horticultural crops.

Faust (1989), said that the perennial nature of fruit trees and the fact that they bear heavy loads of fruits, regularly impose conditions not encountered in nutrition of herbaceous plants or forest trees. The same author stated

that a fruit tree changes its nutrient requirements during the year when: (1) it sets fruits; (2) it raises fruits; (3) it grows shoots and (4) it fills its reserves. Fruit tree nutrition often must be concerned with the nutrition of not only the whole tree but also individual organs.

1.2 Root Growth Influence.

Atkinson (1986), stated that total uptake of nutrients is influenced by the type and density of orchard system, modified by effects which depend on the presence of an adequate root system, the demand for nutrients at any given time (size of and balance of fruit, leaf, wood, and root growth), and the extent of the internal remobilization of nutrients. Atkinson (1980), arrived at the same conclusion as Faust, (1989) but, he expressed the importance of elements of limited soil mobility whose total uptake was limited by available root length. The same author stated that it is difficult to generalize the root system size of fruit trees because of the dependence on the soil type, water supply, rootstock and age. He said that shallow root systems occurred occupying a soil volume between 20 to 80 cm in depth with vertical roots descending to about 3 m. However, the same author said that the length of root per area of leaves, ranged from 0.8 to 23.8 cm cm^{-2} with 2 to 6 cm cm^{-2} being the most common. These values are several orders of magnitude lower than those of

Gramineae ($100-400 \text{ cm cm}^2$) or herbs ($52-310 \text{ cm cm}^2$). Newman (1969), calculated that when the length of root per surface area of leaves (L_s) is less than 10 cm cm^2 , soil resistance at the root surface is larger than 0.2 MPa . Atkinson and Wilson, (1980) measured nutrient inflow into roots in water culture and found an inflow of $0.56 \text{ pmol cm}^{-1} \text{ s}^{-1}$ for P and $8.5 \text{ pmol cm}^{-1} \text{ s}^{-1}$ for N for apple (*Malus domestica*). These values were five to eight times larger than those given by Brewster and Tinker (1972). Fruit tree root systems have limited soil contact due to the size of root-soil interface. High inflow of water and nutrient have been required to overcome water and or nutrient stresses (Faust, 1989).

Roger (1939), stated that fruit tree root growth depended on soil temperature and indicated periods of alternance of fruit tree root growth that were more and less active. Head (1967), noted that the periodicity of the root growth was dependent on shoot growth and fruit load. Quinlan (1969), suggested that its bimodal periodicity was due to a competition between the shoot and root for carbohydrate reserves. Atkinson (1980), indicated that factors like irradiance, humidity, temperature and soil management affected the shoot and root environment and the nutrition of the tree. These factors had an indirect effect and acted by influencing the above-ground part of the tree first.

The above characteristics are different for fruit trees as compared to field crops and influence the research in fruit

tree nutrition.

2. Methodologies to Access Nutrient Requirements.

Soil and plant analysis are conventional methods for diagnosing plant requirements and making fertilizer recommendations (Walsh and Beaton, 1973; Prevel et al., 1987a). Soil tests combined with plant analyses permit a more specific evaluation of the soil-crop nutrient element status than do soil tests alone, and the combined results can be used to develop specific corrective treatments. But, few growers have adopted a system of regular testing, using both soil and plant tests, to follow and monitor changes in the nutrient element status of their soils and crops. When soil and plant analyses are used in a systematic way they can serve as a diagnostic and planning device in crop production (Jones Jr., 1985).

2.1 Soil Analysis.

The objectives of soil testing were summarized years ago by Fitts and Nelson, (1956): 1) to group soils into classes for the purpose of suggesting fertilizer and lime practices; 2) to predict the probability of getting a profitable response to the application of plant nutrients; 3) to help evaluate soil productivity; and 4) to determine specific

soil conditions that may be improved by the addition of soil amendments or cultural practices.

However, the differing abilities of plants to take up and to utilize nutrients have been reflected in the concentration of each nutrient in their tissues and the relationships between these concentrations and growth (Lundergardh, 1951).

Prevel et al., (1987b) suggested that chemical analysis of selected tissues has given information about the nutritional status of the plant. Analyzing the soil, however, only has provided information on the amount of a nutrient available at a given moment, but may not relate to the amount actually taken up. Nevertheless, although the chemical composition of the plant has identified nutrient uptake problems or nutritional disorders, it has not identified their causes. Sometimes plant analysis and soil analysis have been considered as competitive, leading to a lack of integration in the use of the two techniques.

2.2 Leaf Analysis.

As early as 1905, Hall proposed plant analysis not for determining the total quantity of nutrient removed from the soil but as a biological method for assessing soil fertility (Hall, 1905). It was not until 1926 that Lagatu and Maume adapted this approach (Lagatu and Maume, 1926). They developed the method known as "Diagnostic Foliare" (foliar

diagnosis) in France and defined it as follows: "We mean by foliar diagnosis the assessment of the chemical status at a given point in time, of suitably selected leaves" (Lagatu and Maume, 1929).

Since the first application of this methodology by Batjer and Magness twelve years later to apples (quoted by Faust, 1979), the use of chemical analysis of selected tissues has given information about the nutritional status of plants and has provided a new basis for comparison among nutritional experiments.

2.2.1. Expression Forms: Advantages and Disadvantages.

Nutrient composition relative to dry matter has been the most common expression of leaf composition, but this form is critically dependent on the physiological age of the tissue (Smith, 1962; Bould, 1966; Bates, 1971; Mengel and Kirby, 1978; Walworth and Sumner 1988). In addition, according to Beaufils (1957-73), and Sumner (1988, 1990), nutrient content concentration is also a ratio, because it is the nutrient relative to the amount in dry matter in the tissue. However, when nutrient concentration is used, the denominator has tended to be ignored by assuming that it is constant, which is not true because the percentage of dry matter tends to increase with tissue age. The most frequent method used to avoid this problem has been to sample specific plant parts at

well-defined stages of growth. There are many papers in the literature which report the seasonal variation of nutrients with the age of tissue (Rotger and Batjer, 1954; MacClung and Lott, 1956; Batjer and Westwood, 1957). In addition, others have pointed out the importance of the sampling procedure to improve leaf interpretation (Kenworthy, 1950; Chapman, 1966).

Beaufils (1971), researched alternative ways as a basis of expression that were less dependent on tissue age. Factors such as fresh matter or water content as bases of expression of foliar composition are often used by plant physiologists to great advantage. These forms of expression are very much less dependent on tissue age (Beaufils, 1971; Wilson, 1976; Leigh and Wind Jones, 1984). Leigh and Johnston, (1983a); (1983b) working with barley, showed that differences in percentage of K in dry matter for a given K treatment resulted mainly from differences in the moisture content of the plant (quoted by Walworth and Sumner, 1988). On the other hand similar advantages can be obtained by the use of nutrient ratios, which are less sensitive to changes in tissue age, because in their computation dry matter is canceled. Nutrient ratio also allows the study of nutrient interactions. (Beaufils, 1971; Sumner, 1986). The former author, calculated the coefficient of determination between these forms of expression and the age of the tissue sampled in a population of 350 healthy high yielding corn plants (*Zea mays* L.). The use of ratio basis, water and fresh basis gave lower variation than the dry matter

basis (Beaufils, 1971). In addition, the use of the expression "nutrient product" has been suggested for all nutrients with a tendency to accumulate with age relative to dry matter (Beaufils, 1971; Sumner, 1986; Walworth and Sumner, 1988). Sumner, in an earlier paper explained the reasons for different success with the use of nutrient ratios. He said that when a nutrient ratio is considered optimal any yield is possible because the actual yield level was determined for all the other resultant factors; nevertheless, when the ratio is too low, a response to an element in the numerator could be obtained only to the yield of the limiting element. If the element was in the denominator, and in excess, then a yield response could be obtained depending on the other yield factors. The reverse was considered for the situation of a nutrient ratio that was too high. He expressed also that as the number of nutrient ratios considered together increased the identification of nutrient limitation became easier and more reliable (Sumner, 1978). Besides, the expression using leaf analysis interpretation has been compared with previously determined standard values.

2.2.2. Interpretation Forms.

a. Relationships between Leaf Composition and Yield.

Successful use of leaf analysis has been dependent on the constancy of relationships between leaf composition and plant performance (Lundergardh, 1951). Prevot and Ollanier, (1956) were the first to present a graphic representation of this relationship. Years later Ulrich (1961), Smith (1962) and Ulrich and Hill (1973) showed similar curves. Although, the curves were similar, differences in the relative change in growth or yield as the elemental concentration increases from deficiency to sufficiency appeared. Ulrich (1961) and Ulrich and Hill, (1973) reported a very large linear increase in yield with a very small increase in the nutrient concentration. However, Smith (1962) found a smaller change in growth over a large range of nutrient concentration. Jones Jr. (1985), stated that Smith's curve represented the condition of macronutrients and Ulrich's curve that of a relationship from a micronutrient. The above relationships were pointed out to show differences in behavior of plants.

About that time, Kenworthy (1961), noted the similarity of leaf content over a wide range of conditions and stated that a single set of standards could be applied to large regions. He suggested that the differences in nutritional status found among regions resulted not only from differences

in the nutritional leaf content but also in variations in methodology used for sampling and analyzing. He also said that some nutrients showed the same optimum nutrient content to whole species while for other there were differences between varieties.

b. Critical Nutrient Concentration.

Ulrich and Hill, (1967) worked with curves of foliar concentration plotted against the maximum percentage of growth or yield. They divided the curve in three portions related to nutrient levels: a) deficient; b) transition; and c) adequate. They defined the "Critical Nutrient Concentration" as the nutrient concentration which was associated with 90 % of the maximum percentage of yield. Critical values have been used to separate deficient and adequate nutrient levels. In a like manner, Dow and Roberts, (1982) used a "Critical Nutrient Range" instead of single values. They stated that some of the practical problems found were not only the factors that affect the nature of plant response to the fertilizer addition but also the variation of nutrient concentration with ageing.

Another problem noted was the effect of nutrient interactions. Trazcinki (1960), stated that it was extremely difficult to define standard nutrient contents with wide application because of the variations due to species,

variety, age of plant, growth stage, climate, crop management, soil, and other growth medium. He pointed out the dependence of each nutrient and their interaction within the whole plant. The balanced nutrient concept was stated early by Kenworthy, (1950) when he expressed its similitude to a representation of a wheel with equal length of spokes. Jones Jr. (1967), considered a nutrient concentration adequate when it was in the sufficient range -- above the low limit and below the high limit of nutrient concentration. This approach had the advantage in that it considered optimum nutrient levels together with deficiencies as well as toxicity effects.

Single factor experiments have been used to establish critical values that are often dependent on the particular levels of other nutrients or treatments as well as site and seasonal effects. The use of factorial experiments rather than single factor experiments has partially overcome the limitations noted before, because a more optimal set of conditions can be establish for determining critical values (Sumner, 1988).

c. Balance Index.

Years later, Kenworthy (1967, 1973) developed a diagnosis system based on foliar optima generated by averaging tissue values of healthy plants rather than critical values derived from response curves. Survey data and associated coefficients

of variation were used to develop the "Balance Index". The deviation of each nutrient from its optimum concentration was weighted with the normal variation associated with its measurement and expressed as a fraction of the optimal value. The proposed methodology allowed the comparison of the status of various nutrients and the related effect on the plant. Walworth and Sumner (1988), defined some of the weaknesses of this approach in their review on foliar analysis. "Two problems that persist are the effects of tissue age and location and influences of nutrient interactions. Any deviation from the pattern of sampling (with respect to plant age or leaf position used in development of the standard values) may result in incorrect diagnoses. In addition, if actual nutrient levels are altered by nutrient imbalances, then incorrect diagnosis may be the result".

d. Other Methods.

Other procedures have been developed to partition yield and nutrient concentrations data into two classes that correspond to those in deficient and adequate zones, for example, the Cate-Nelson technique (Cate and Nelson, 1971). Webb (1972), proposed the use of Boundary Lines and Beaufils (1971-1973), developed the Diagnostic and Recommendation Integrated System (DRIS). Both, Webb (1972) and Beaufils (1971-1973), recognized that crop yield is a function of many

interrelated variables and that such a relationship cannot be reduced to an equation with a single independent variable.

Horticultural researchers have used the critical level or sufficiency range and the standard values extensively. Recently some attention has been given to the DRIS approach. A 1990 survey of 55 state and 371 commercial laboratories throughout the United States involved in plant analysis concluded that the sufficiency range was the most commonly identified method of interpreting plant analysis (61 % of the state and 58 % of the commercial labs) and both the lack of field verification and/or calibration and correlation data and the unfamiliarity with the DRIS system have prevented this methodology from being more widely used (Savoy Jr. and Robinson, 1990).

3. Diagnostic and Recommendation Integrated System (DRIS).

3.1 Beaufils' Idea

The classical limitations of the application of experimental methodology to field conditions (treatment factors not always isolated and/or independent, complex interactions, limited factor variations, non reproducible site conditions, uncontrollable adverse factors, replication need) and years of academic and applied research in plant nutrition

spent by Beaufils gave a new tool to the Soil Fertility and Plant Nutrition Science. After the first approach of the author called Physiological Diagnosis (Beaufils, 1957a; 1959), he developed a system called the DRIS (Beaufils, 1973a).

Beaufils' philosophy (1954-73) was to reproduce field conditions in a computer room, in a similar way as would be possible in a laboratory, with the reasonable possibility of studying the influence of a large number of yield factors in a more rapid, flexible, safe and enlarged basis. The proposed methodology made it possible to develop a diagnosis and recommendation system and to apply it to unrestricted conditions, e.g. any stage of plant development.

The considerations were that not only any plant change conditions provoked by man, deliberately or not, but also any factor of any nature involved in the whole dynamic plant/environment system must be studied without discrimination. Any set of observations obtained at a given site represents one sample of the whole phenomenon to be studied and should not be discriminated (Beaufils, 1973a).

3.1.1. Causal Relationships.

The above points led to a scheme and data base where the sites, which are the actual components of the system, are considered similar to replications of a traditional experiment, unlimited in their number and located at random.

The treatments, based on innumerable references, represent all kinds of information derived from controlled observations for which the conditions have or have not been deliberately provoked.

According to Beaufils, (1973a) this data survey permits one to study six kinds of causal relationships:

1. Soil properties -----> $f_1(\text{plant response})$ -----> Yield_1 ;
2. Climatic conditions -----> $f_2(\text{plant response})$ -----> Yield_2 ;
3. Farming practices -----> $f_3(\text{plant response})$ -----> Yield_3 ;
4. Soil treatments + Soil properties = $f_4(\text{soil response})$ etc;
5. Soil response + climatic conditions + farming practices = $f_5(\text{plant response})$ etc. ;
6. Plant response (Σ internal characters) -----> Yield.

From these relationships calibrations are progressively established on norms and refined from: a) the diagnosis of the resulting effects reflected in plant composition for a given situation; b) the diagnosis of the primary causes reflected mainly in soil composition and environmental, management factors and attempts for the observed situation; c) the dependence on the extent to which the observed situation can be explained and remedied; d) the quantities of the elements to be applied obtained from pre-established norms; and e) the new information recorded after corrections and the subsequent refined norms.

3.2 DRIS Methodology Protocol.

Beaufils (1973a), proposed the DRIS methodology following a step series.

A. The first step is to define the characters to be improved and all factors that are suspected to affect them.

B. The second step is to gather all reliable data available from field operations and experiments.

C. The third step is to study the relationship between yield and so-called external characters (i.e. light, rainfall, etc) in four operations: 1) each character must be expressed in the greatest number of possible forms (parameters); 2) each character in a parameter form is plotted against yield; 3) the spread of data of the whole population is used to divide into a number of external character classes and the class which corresponds to the highest yield determined by Fisher's test; and 4) the same operation is repeated for every possible interaction factor and the subclass within which the highest yield is found.

D. The fourth step is to study the relationships between yield and internal characters (i.e. nutrient content) where twelve operations are justified: 1) each internal plant character should be expressed in all possible forms; 2) the

whole population is divided into three subpopulations (high, medium and low yield) selected simultaneously on the basis of health, quality and yield; 3) the mean of each subpopulation is calculated for all expressions selected; 4) if necessary class interval limits between average and outstanding yielders are readjusted; 5) a x^2 test is performed; 6) variance ratios between poor and average yield populations for all modes of expression are compared; 7) every parameter that shows a significant variance ratio between the two populations is retained and the coefficient of variation for the values belonging to normal yields is calculated; 8) from the parameters retained, two core (main) characters are selected for which variance ratios were found to be significant when simultaneously referred to moisture, and chain-diagnosis of the other characters is established by simultaneous reference to these central characters; 9) as alternative core characters, three internal plant characters are selected for which variance ratios were found to be significant when expressed to one other, and chain-diagnosis of the other characters is established by simultaneous reference to these alternate central characters (used when moisture data are not available); 10) the remaining parameters are retained from operation; and 11) the diagnosis indices reflecting the resulting interactions between all nutrient considered. Each internal character is calculated from a general formula:

R index (I_R) = [$f(R/S) - f(S/R)$] / 2 where

1. If $R/S > x_{R/S}$, then $f(R/S) = 100 [(R/S - 1) / x_{R/S}] (k / CV)$
2. If $R/S < x_{R/S}$, then $f(R/S) = 100 [(1 - x_{R/S}) / R/S] (k / CV)$

R/S is the nutrient concentration ratio of R and S in the sample,

$x_{R/S}$ is the average of the nutrient concentration ratio of the high yielding population,

k is an arbitrary number, usually 10, which is used to assure that function and index are whole numbers, and

CV is the coefficient of variation of the nutrient concentration ratio from high yielding population.

E. The sixth step is to prescribe and continually refine the most suitable remedy for each particular set of conditions.

3.3. DRIS Relationships between Yield and Indices.

In the DRIS system maximum crop yields are attainable only when the values of important ratios approach an optimum value, which is approximately the mean value of the ratio in

a desirable or selected high-yielding population.

Both high or low yields can be obtained at optimum R index, e.g. N index values; however, the standard deviation about this optimum value decreases with increasing yield. This indicates that the higher the yield, the smaller is the permissible deviation from the composition required. Therefore, the known luxury consumption would not be a characteristic of high yielding plants (Beaufils, 1971).

Since important ratios must approach their optimum values for high yields to be obtained, the variance of important ratios are smaller than in a low yielding population. This is the reason that the ratio of the variance between the high and low yielding population is used to select the important ratios (Beaufils, 1973a).

The DRIS calibration system characterized by the above six functions in plant response allows one to classify yield factors in their order of limiting importance. For each nutrient it is possible to calculate a DRIS index. This index is based on the mean deviation of each important ratio (where a nutrient element could be either in the numerator or in denominator) from its optimum value. An optimum DRIS index for any nutrient element is zero. The indices give an indication of the intensity with which the plant or soil required a particular nutrient. For example, during one diagnostic, the negative DRIS index indicates the most limiting element with respect to the other nutrients tested;

a zero index indicates an element in quantities statically associated with high yield and positive DRIS index indicates the most excessive nutrient with respect to the other nutrients tested. However, plant indices only indicate the nature and degree of balance of the nutrients. Therefore, it is not possible to establish what could be the demand of the plant at a given site; thus DRIS does not give an indication of the amount of a particular element which must be added (Beaufils, 1973a).

In addition, it is possible to establish a general relationship between yield and plant internal characters that could be approximated by three separated regression equations. A positive regression coefficient will be described every time the studied character limited yield. A negative regression coefficient is found when the particular character is limiting yield because it is present in excess. A zero regression coefficient is founded when the parameter is not affecting yields (Beaufils, 1971).

Beaufils (1973a), said that optimal and normal indices are not always completely coincident. Certain characters showed a steady inclination toward either positive or negative values; thus, Beaufils (1971), suggested that this is the main reason to divide the whole population into three subclasses (high, medium and low yields). The mathematical frequency distribution of the internal characters of the high population yield was used as a guide to indicate the direction towards

optimum yields.

3.4. DRIS Advantages and Weaknesses.

Recently the DRIS approach has received considerable attention because of the multiple advantages that it offers over the other interpretation methods. According to Beaufils (1973a; 1975; 1976), the main advantage of the system is that it: 1) permits the use of a simple equation with all plant, soil, yield and quality factors; 2) classifies these factors in the order of their limiting importance on yield and quality; 3) permits one to assess relative nutritional imbalances or deficiencies or both; 4) permits one to measure deviation of certain nutrient ratios in the plant tissues from corresponding nutrient ratios previously establish as norms. By comparing the norms with sets of nutrient ratios it is possible to state the relative sufficiency or deficient of each element; 5) has unrestricted possibilities of application: different locations, age of tissue, and form of sampling; 6) has the possibility of observing, studying and remedying problems in the growing season as they occur; 7) increases the flexibility and rapidity in research work, saving time, and money; and 8) has unlimited possibility for in-depth investigation and enlarged application of results.

Some of the most remarkable DRIS papers found in the

literature will be used to show its characteristics.

3.5. Effect of Variety or Geographical Region on DRIS.

If the DRIS system norms are derived from a sufficiently large data base, it is possible to make DRIS diagnosis applicable irrespective of varietal or geographic regions (Beaufils, 1956, 1971, 1973a; Sumner, 1977a; Elwali and Gascho, 1984).

Sumner (1977a), studied the relevant literature on maize (*Zea mays* L.) published throughout the world. He selected papers from Terman's works in the United States (Terman, 1974; Terman and Allen, 1974) and Kacar' work in Turkey (Kakar, 1974). Data from the selected papers in their original form together with the same data recalculated with the standard set of norms developed in South Africa were compared. The use of one set of norms was enough to explain the responses in terms of yield and plant composition to different rates of lime and N applications. Beaufils indices were able to show differences in P uptake and to explain yield increases caused by the use of different N carriers. According to the author, in all cases Beaufils' plant calibration indices have been superior to those criteria used by the different authors in diagnosing nutrient requirements and uptake for corn. Sumner emphasized the general applicability of the DRIS system which provided a means of comparing data for a particular crop grown

at various sites in the world.

Payne et al., (1990) working with bahiagrass (*Paspalum notatum*), collected 857 pasture samples from ongoing field fertility trials in nine counties throughout central Florida. They analyzed tissue for N, P, K, Ca, Mg, Fe, Mn, Zn, and Cu. At the time of sampling forage yields were recorded. The DRIS norms developed were tested in an independent study in which bahiagrass was grown in greenhouse solution culture where known deficiencies were accurately diagnosed. The nutrients limiting bahiagrass forage yield in a fertility trial conducted under field conditions were also accurately identified by the DRIS norms. The authors concluded that DRIS can be successfully applied to bahiagrass grown under a wide range of conditions. Use of this methodology can readily and correctly identify nutrient deficiencies and DRIS methodology can be used in developing more accurate fertilization programs for pastures.

Elwali and Gascho (1984), conducted a study to evaluate the effectiveness of soil testing and foliar analysis interpreted by the Critical Nutrient Level (CNL) approach and DRIS for sugarcane (*Saccharum officinarum*) in eight fields representing the mayor sugarcane soils in south Florida. Foliar analysis interpreted by either method revealed a need for applying one or more micronutrient(s) to all fields, a practice which had not been previously been recommended in Florida. Application of N was also recommended for the first

time on Torry muck soil by foliar analysis using both methods. They found that the nutrient balance index (NBI) was the most appropriate parameter on which statistical analysis can be performed to evaluate the effect of treatments on nutrient balance. All of the interactions of field by method were not significant for all measured parameters. DRIS guided fertilization resulted in significantly better balance among nutrients than fertilization recommended by the other methods. Sugarcane and sugar yield were significantly higher for DRIS fertilization than for fertilization guided by the CNL method.

Wortmann et al., (1992), working with dry bean (*Phaseolus vulgaris* L.), arrived at a slightly different conclusion. They estimated DRIS norms from a total of 1110 records collected from Colombia, Uganda and Rwanda, and tested these on farm trials conducted in Tanzania and Uganda. The efficiency of the DRIS in predicting responses to applied fertilizers was compared to prediction using CNL determined for beans (Howeler, 1983). The CNL were found to be too low to have a good predictive capacity in the test environments. The result showed that DRIS was a superior approach for interpreting foliar tissue analysis for beans. DRIS predictions were less affected by varying plant age than was the prediction with CNL. However, the East Africa DRIS norms generally differed from those estimated from the Colombia data. When DRIS norms estimated from the two sets of data were compared with paired t-test they found that they differed

for most nutrients. The authors concluded that the accuracy of the DRIS could be improved by having different sets of norms for different bean production environments.

MacKay et al., (1987), arrived at a similar conclusion working with 1086 sets of yield and analytical data from 28 field experiments with potato (*Solanum tuberosum*) conducted over a period of 8 years on irrigated Boroll soils and 1260 data sets from 5 years of experimentation on Spodosol soils in the temperate humid area of Nova Scotia in Canada. Canadian developed DRIS norms differed from those reported for potatoes in South Africa. DRIS nutrient indices computed from nutrient ratios established as normal on Spodosol areas were reasonably suitable for diagnosing nutrient deficiencies on the Boroll soils. Indices from Spodosol norms were usually indicative when deficiencies were severe, but N indices were often negative where there was not a response to further application of N. The pattern for P and K indices indicated the same trends utilizing Boroll or Spodosol norms. Indices based on the South African norms were unsuitable for assessing leaf data from the Boroll and Spodosol area. The authors noted a discrepancy in the low value for N/K and the high value for the K/P from the South African norms in relation to both of the Canadian regions. However, they noted that the ratios from soil and climatic areas widely different from Nova Scotia and southern Alberta were still of value in predicting deficiencies in either area.

Working in wheat (*Triticum vulgaris*), Amundson et al., (1987) said that norms regionally derived and geographically restrict may enable the DRIS system to provide more accurate diagnoses than norms developed outside the local area and developed from other cultivars. Using the set of published DRIS norms developed in the Midwest, Amundson found that nutrient diagnosis calculated on irrigated winter wheat grown in Central Washington tended to over estimate N deficiencies and under estimate P deficiencies at early heading and tillering, respectively, relative to parallel diagnose by DRIS based on a corresponding set of norms.

Escano et al., (1981) suggested also that for corn (*Zea mays* L.) the use of locally calibrated norms may be more accurate in diagnosing nutrient deficiencies than norms developed from plants in other geographic regions.

3.6. Effect of Leaf Age and Position on DRIS Diagnosis

Another advantage of the DRIS system is its ability to minimize the effect of leaf age on diagnosis, enabling one to sample over a wider range of tissue age than is permissible when diagnosing by the critical value approach. Sumner said that nutrient ratios in plant tissues remain constant throughout the growing season, and correct diagnosis using the DRIS procedure is possible regardless of the physiological age of plants (Sumner, 1977b, 1977d).

Sumner (1977c), worked with a survey of published and unpublished soybean (*Glycine max*) data with a total of 1245 sets of N, P and K leaf analysis and their corresponding yields data. The effect of stage of growth and position of the leaf sampled were also analyzed. He concluded that the developed DRIS norms were able to diagnose when N, P or K limited soybean production. DRIS indices diagnosed the follow order of nutrient requirement $N > P > K$ with only two exceptions despite the fact that the N, P and K contents of the leaves varied more than twofold. At the same time, the DRIS system was able to predict nutrient imbalances even when the nutrient concentration in the plant were at or above the sufficiency level range.

Sumner, using the published set of data in corn (*Zea mays* L.), tested the hypothesis that DRIS was able to minimize the effect of the age of tissue and to detect nutrient requirement. He also analyzed the effect of leaf position and leaf part sampled on the nutrient content. The results noted that calculated DRIS indices had the same order of requirement irrespective of the position of the leaf on the plant with only one exception in which the order of P and K were reversed. This fact was true for the whole leaf and blade with midrib and margin removed. But, for the margin and midrib alone, the order of nutrient requirement was different but consistent. The author pointed out that as long as one type of tissue was sampled, DRIS diagnoses were independent of

the position of the leaf in the plant. However, it was only valid to make a diagnosis on the basis of the same type of tissue as was used in establishing the norms. Using DRIS diagnostic the position of the leaf on the plant is not very critical, particularly if a leaf or outer three-quarters of the leaf from the middle of the plant is sampled (Sumner, (1977b). Sumner (1977d), in other work, using a total set of 1108 published and unpublished data on wheat (*Triticum vulgaris*) developed DRIS norms which were applicable irrespective of variety and age at which the leaf samples were taken. Irrespective of the time of sampling the nutrient requirement diagnosis was $K > N > P$. The reason of the ability of the DRIS system to make diagnosis at different stages of growth is due to the fact that when ratios are computed, the effect of dry matter component (which are accumulated with the age and caused a dilution of the nutrient content) is reduced. The same diagnosis was made irrespective of the variety used in all but one case.

However, working with wheat (*Triticum vulgaris*), Amundson et al., (1987), derived two sets of norms, one from tissue analysis of winter and spring wheat grown in Washington State, and the other from statistical analysis of the nutrient ratios from winter wheat grown in eastern Washington which indicated that each of six ratios (N/P , K/N , K/P , N/S , P/S , and K/S) exhibited significant sampling date/time dependence. Consequently, nutrient diagnosis provided by the DRIS approach

may not always be independent of the origin and age of plant.

Hanson (1981), employed the DRIS system to evaluate N, P and K balance of soybean (*Glycine max*) using foliar analysis data from 3 experiments in Brazil where P was the responsive nutrient. DRIS was useful for calculating nutrient balance association with highest yields and the greatest nutrient imbalance at lower yield levels. This fact was true when samples were collected at the R-2 growth stage. The method was useful in the evaluation of phosphorous fertilizer materials. The author demonstrated that as the soybean plant aged the DRIS method could still predict the highest level of nutrient balance when highest yields were obtained. The greatest discrepancy occurred with samples collected later in plant maturity which suggested that plant age is still important, but less important than with the critical value method.

A similar conclusion was reached by Beverly et al., (1984), who noted that DRIS diagnoses were affected by differences in type or age of tissue sampled for Valencia oranges.

However, Sumner (1990), noted in a review about the use and application of plant analysis, that the form of expression used to calculate DRIS indices has an important effect in minimizing the effect of age in diagnosis. He pointed out that if the tissue under diagnosis was sampled at the usually accepted time, ratio forms for all nutrients would be

appropriate. On the other hand, if one samples earlier or later than the accepted time, one should use ratios for the nutrients which change in the same way with age and products for the nutrients which change in opposite directions. In the same paper he said that when Beverly's (1984) data were recalculated using the appropriate form of expression, DRIS diagnostic was appropriate.

3.7. Ability of DRIS System in Ranking Nutrient Requirement

According to Beaufils (1973a),(1973b),(1975),(1976); Beaufils and Sumner, (1976); Sumner, (1981); Elwali et al., (1985); Payne et al., (1990); Jones and Sinclair, (1991); Wortmann et al, (1992) and many other authors who have worked with the DRIS system, Beaufils methodology has an advantage because it is able to qualitatively and quantitatively classify the nutrients required by the plant in order of their limiting importance on yield, which is not possible when the critical value approach is used. The effects of appropriate and inappropriate treatments can be distinguished.

Beaufils (1973a), gave multiple examples where the proposed methodology was able to rank nutrient requirements of different crops and confirming accurate treatments.

Meldal-Jhonsen et al. (1975), applied the DRIS system to soil calibration with potatoes (*Solanum tuberosum*). The

developed norms were tested on independent soil data from a 3⁴ N, P, K, lime factorial fertilizer experiment. The DRIS calibration system showed the soil response to differential fertilizer treatments and evaluated the nature and amount of nutrient applied. A low yield was observed when the sum of the indices was high. The reverse was not necessarily true. The author noted that the norms need to be derived separately for the different soils series. Clay percentage was used as a basis for deriving soil indices, and it separated soils according to their inherent fertility patterns.

Sumner (1977c), working with soybean (*Glycine max*) stated that the developed DRIS norms were able to detect K as the most limiting nutrient required for the crop. The order of nutrient requirement was $K > N > P$. When the developed norms were tested with literature trial data and appropriate treatments were used, the results were always an increase in yield.

Vigier et al. (1989), working with the same crop, compared the results made from the sufficiency range method, the American DRIS norms, eastern Canadian DRIS norms and a modified version of the DRIS system (which used the whole population data rather than the high yield data). Data analyses were divided according to soybean cultivars in three trials under research where fertilizer effects were significant on some of the plant nutrient contents. The diagnosis made on all trials showed some differences among the

methodologies used. Nevertheless, the advantage of the DRIS diagnosis was quite apparent in all trials. The American DRIS was equal or superior to the sufficiency range in 5 out of 6 sets of data. While the Quebec and the modified DRIS were equal or superior in only 3 out of 6 sets. The overall yield gained with the Quebec DRIS was 685 kg/ha compared to 402 for the American DRIS and 537 for the modified DRIS while the sufficiency range diagnosis gave 50 % less increase on yield when compared to the mean results of all DRIS diagnosis.

Elwaly and Gascho (1984), noted for sugarcane that the DRIS approach was a better guide for fertilization than the soil testing method. The high cane and sugar yields obtained by DRIS guide fertilization were attributed to the better nutrient balance as revealed by DRIS indices late in the season.

However, Caron et al. (1991), developed DRIS norms for greenhouse tomatoes (*Lycopersicon esculentum* L.) which were evaluated in nutrient solution trials with different rates of N concentration and salinity levels. The critical nutrient range (CNR) was also used as another diagnostic approach. Dry matter index was included in the modified DRIS (M-DRIS) approach to separate between excessive or deficient nutrients. Both DRIS and M-DRIS were found to be effective in managing N fertilization while CNR arrived at a wrong diagnosis. However, using the nutrient imbalance index as a critical level for intervention was not sufficient to handle salinity

problems. High salinity caused a constant increase in the NII, but, the calculated NII values did not correspond with the low yields obtained and were found ineffective as an indicator of any salinity effect on yield in both DRIS and M-DRIS.

Jones and Sinclair (1991), developed DRIS norms for white clover (*Trifolium repens* L.) in New Zealand. The developed N, S, P, K and Ca DRIS norms were used for testing, ranking and comparing S and P deficiencies and responses under field conditions. DRIS indices derived from N, S and P ratios and with a common set of norms had the same interpretation in highly contrasting environments (lowland and high country pasture areas). The inclusion of K, Ca and DM in the calculation of S and P index values made the S and P indices more negative in the high country data set, but did not alter the interpretation of the lowland data set. A uniform interpretation of the indices was impossible. DRIS indices using N, S and P only and with lowland norms identified S and P deficiencies in high country and lowland situations using a single criteria for nutrient adequacy (DRIS index ≥ -2). DRIS made a successful ranking of S and P deficiencies in order of severity.

Evanylo et al. (1987), used DRIS for identification and correction of nutrient limitation on soybean (*Glycine max*) production. They used a large data base with yield and soil analysis throughout the southeastern United States to develop

the norms. Diagnostic norms based on Mehlich 1 extractable P, K, Ca and Mg were developed for coarse and fine textured Ultisols. Differences in optimum nutrient ratios between soils were done with regional liming and fertilization practices based on the amount of clay in the plow layer. DRIS soil norms accurately diagnosed nutrient limitations at low yield levels, but were unable to correctly diagnosis at high yield levels. Soil nutrient balance was not critical for determining yields on the highly weathered soils of the area at levels less than 3000 kg soybean/ha except when the level of some nutrients were excessive. They concluded that differences in optimum nutrient ratios may be greater for regional cultural practices rather than for nutrient balance requirements.

Beverly (1993), researched the agreement of diagnosis between the DRIS and sufficiency range for wheat (*Triticum vulgaris*), corn (*Zea mays* L.), and alfalfa (*Medicago sativa*). According to the proposed methodology of the author, for wheat both methods showed agreement but only DRIS predicted S deficiency satisfactorily. For corn, P and K diagnoses were acceptable; however, N and S showed marginally accurate diagnoses of yield response to fertilization. The DRIS approach was similar for P and K, and inferior for N and S. For alfalfa, the proposed methodology showed little agreement between the DRIS and sufficiency range diagnoses. The author concluded that neither the sufficiency range nor the DRIS

diagnoses were consistently superior or even acceptable for the crops researched.

3.8. DRIS Limitations and Proposed Modifications.

Beaufils (1973a), noted that the amount of data recorded is the limitation of the proposed system. Even so, all the pioneering work done in rubber trees was achieved without the help of electronic computers.

Jones (1981), said that the complexity of the DRIS methodology has discouraged its use; nevertheless, many workers have found that the DRIS approach was more accurate in diagnosing nutrient element deficiencies than conventional methodologies. To overcome part of the limitation, he proposed three modification to Beaufils methodology that have facilitated the successful use of DRIS in the Hawaiian sugar industry. The proposed modifications include the following:

- 1) a simplification in the logic and calculation of the intermediate DRIS functions. (He proposed the use of the simplified equation: $f(R/S) = (R/S - x_{R/S}) / (SD_{R/S})$;
- 2) the use of the mean and variance significance in the selection of important parameters; and 3) a prediction of yield response to additional fertilizer whenever the DRIS index for a particular nutrient falls below zero.

Letzsch and Sumner (1983), developed a computer program, written in FORTRAN, for calculating nutrient indices for the

DRIS. The program is comprised of a main program and four subroutines (INDICE, CVR, KKN and RREV); the main program handles the input/output. The following crops are covered: corn, soybean, sorghum, potatoes, wheat, rubber, sugarcane, sunflower and alfalfa.

Although DRIS was considered an improvement over the CVM, it has a disadvantage in that each time it is used, it predicts that one or more nutrients are limiting. But, it does not necessary define all limiting nutrients. Therefore, when one limiting nutrient is corrected one or more nutrients may become limiting even though they were not originally detected as limiting.

A team of researchers worked to compare the CVM and the DRIS in confirming P and K deficiencies on soybean (*Glycine max* L.) and to determine if including nutrient concentrations in DRIS can be useful in separating limiting from non-limiting nutrients. They introduced the following modification:

a) nutrient concentrations were introduced as:

(nutrient x 100/d.m.);

b) dry matter was treated as a nutrient, and its index value calculated for each treatment;

Whether $N/D.M. > n/d.m.$ or $N/D.M. < n/d.m.$

$f(N/D.M.) = (N/D.M. - n/d.m.)10 \times 1/S$ where

$N/D.M.$ = nutrient concentration in the sample tissue;

$n/d.m.$ = nutrient concentration of DRIS data base; and

S = standard deviation of respective nutrient concentration.

A P-K-lime soil fertility trial was used to confirm the accuracy of nutrient deficiency diagnosis among the methods. DRIS was slightly better than the CVM in confirming K deficiencies and much better in detecting P deficiencies. The CVM failed to detect P deficiencies. DRIS was biased in favor in diagnosing K insufficient and against detecting P deficiencies. Each time DRIS was used it predicted at least one nutrient as limiting but, incorrect diagnoses were still made. When nutrient concentrations were included in the calculation of a dry matter index value, it helped to separate between limiting and non-limiting nutrients. But DRIS and the modified DRIS (M-DRIS) were biased against detecting P deficiencies. The authors concluded that further work is needed to determine if detection of P deficiencies can be improved by adjusting P in the M-DRIS data base (Hallmark et al., 1987).

Beverly (1987a), using a factorial N, P, K experiment, with over 4000 samples of soybean (*Glycine max* L.), made a comparison among alternative diagnostic methods in foliar analysis. The comparison involved the following: a) sufficiency range (SR); b) the traditional DRIS approach; c) DRIS, with only negative index values taken to indicate probability of response; d) DRIS incorporating dry matter (M-DRIS); e) DRIS used with logarithmic transformation

$$(\log([R]/[S]) = \frac{\log([R]) - (\log([R]))_x}{(\log([R]/[S]))_{SD}} - \frac{\log([S]) - (\log([s]))_x}{(\log([R]/[S]))_{SD}} ;$$

f) DRIS using the whole population with the simplified calculation of the "Jr Index" $J_R = \frac{\log([R]) - (\log[R])_x}{(\log([R]))_{SD}}$;

and g) the K_R value, similar to one proposed by Kenworthy, (1973) calculated by the equation: $K_R = \frac{([R] - [P])_x}{[R]_{SD}}$.

All methods diagnosed the same most limiting nutrient. But, the SR method did not make the correct diagnoses on 5 week-old samples. The traditional DRIS were the least conservative, indicating only the order in which N, P and K would likely limit yield. The two methods based on concentration of nutrients rather than ratios were similar to the DRIS when the dry matter index was used. The K_R method was almost identical to M-DRIS. The yields in the test data set increased with nearly every nutrient application and the least conservative DRIS showed the greatest yield advantage. No diagnostic method consistently identified the nutrient causing the greatest yield response as most limiting. The author concluded that the demonstration of fundamental equivalence and functional similarity of the ratio and concentration based diagnostic methods was a remarkable result of the investigation.

The same author working with Valencia oranges (*Citrus sinensis*) found that a derivation and interpretation of the DRIS diagnoses could be simplified by the following: 1) using a logarithmic transformation of the nutrient ratio data; 2)

using population parameters rather than high yield subpopulation values; 3) using a simple index calculation

$$"I_{jr}" = [\text{Ln}(A) - \text{Ln}(a)] / a_{sd}$$

where: A = is the concentration of any nutrient.

a = is the mean of the all population for the particular nutrient.

a_{sd} = is the standard deviation of the mean; and

4) incorporating the probability of yield response to a treatment (Beverly, 1987b).

Knowing that the most accurate DRIS norms were ideally developed with very large data bases, Walworth et al., (1988) compared norms for corn (*Zea mays* L.) developed from a set of 10 observations of field-grown corn with yields greater than 18 Mg/ha with norm generated from 8494 observations throughout the world. The P, K, Mg, S, Mn and B norms calculated from the two data bases were significantly different, while N, Ca, Fe and Cu were not. The norms developed from both data bases were tested using a factorial $N^3P^3K^3S^3$ greenhouse experiment. Those developed from the limited data base were slightly better in predicting yield increases than those from the larger data base. The use of a few extremely high yields in the data base was noted as an efficient, accurate, reasonable and inexpensive option for generating nutrient norms.

3.9. DRIS Reports

The Physiological diagnosis, later called DRIS system, was first applied to rubber trees (*Hevea brasiliensis*) (Beaufils, 1957a), and then to agronomic crops.

3.9.1. Agronomic Crops.

For field crops DRIS has been used on: corn (*Zea mays* L.) (Beaufils, 1974; Sumner, 1977a; Escano et al., 1981; Elwali et al., 1985; Walworth et al., 1988; Beverly, 1993), sugarcane (*Saccharum officinarum*) (Sumner, 1975; Beaufils and Sumner, 1977a; 1977b; Meyer, 1981; Jones and Bowen, 1981; Elwali and Gascho, 1983a; 1983b; 1984), soybean (*Glycine max*) (Sumner, 1977c; Beverly, 1979; 1986; Vigier et al., 1989), wheat (*Triticum aestivum*) (Sumner, 1977d; 1981; Amundson and Koehler, 1987), tobacco (*Nicotiana tabacum*) (Evanylo et al., 1988), sunflower (*Helianthus annuus*) (Grove and Sumner, 1982), sorghum (*Sorghum bicolor*) (Sumner et al., 1983), and oat (*Avena sativa*) (Chojnacki, 1984).

3.9.2. Pasture and Forage Crops.

The DRIS approach has been used for a few species of pasture and forage crops, for example, alfalfa (*Medicago*

sativa L.) (Erickson et al., 1982 and Walworth et al., 1986), bermudagrass (*Cynodon dactylon*) (Tarpley et al., 1985), bahiagrass (*Paspalum notatum*) (Snyder and Kretschmer Jr. 1988; Payne et al., 1990), and subterranean clover (*Trifolium subterraneum*) (Jones et al., 1986).

3.9.3. Vegetable Crops.

For vegetable crops reports on application of DRIS exist for potato (*Solanum tuberosum*) (Meldal-Johnsen and Sumner, 1980; MacKay et al., 1987), celery (*Apium graveolens*) (Tremblay et al., 1990), lettuce (*Lactuca sativa* L.) (Sanchez et al., 1991), and tomato (*Lycopersicon esculentum*) (Caron and Parent, 1989; Caron et al., 1991).

3.9.4. Forest Trees.

Application of DRIS to trees was first reported for rubber trees (*Hevea brasiliensis*) already mentioned (Beaufils, 1957a) followed by radiata pine (*Pinus radiata*) (Truman and Lambert, 1981), poplar (*Populus spp.*) (Leech and Kim, 1981 and Kim and Leech, 1986), eucalyptus (*Eucalyptus deglupta*) (Yost et al., 1987), loblolly pine (*Pinus taeda*) (Needham et al., 1990), and fraser fir (*Abies fraseri*) (Hockma et al., 1989 and Kopp and Burger, 1990).

3.9.4. Fruit Trees.

The DRIS reports found for fruit crops were the following: pineapple (*Ananas comosus*) (Langenegger and Smith, 1978; Angeles et al., 1990), oranges (*Citrus sinensis*) (Beverly et al., 1984; Beverly, 1987b; Sumner, 1986), grape (*Vitis vinifera*) (Chelvan et al., 1984), sweet cherry (*Prunus avium*) (Davee et al., 1986; Righetti et al., 1988a, 1988b), peach (*Prunus persica*) (Sumner, 1986), hazelnut (*Corylus avellana*) (Alkoshab et al., 1988; Righetti et al., 1988a, 1988b), apple (*Malus domestica*) (Fallahi and Righetti, 1984; Parent and Granger, 1989; Szucs et al., 1990; Goh and Malakouti, 1992), pecan (*Carya illinoensis*) (Beverly and Worley, 1991), walnut (*Junglans regia*) (Klein et al., 1991), and mango (*Mangifera indica*) (Shaffer and Larson, 1988).

Angeles (1990), working with pineapple (*Ananas comosus* L.), stated that the derived DRIS norms were able to make correct diagnoses where critical values failed to make any diagnoses of deficiencies for N, P and K. The DRIS norms revealed nutrient deficiencies in the range normally considered to be sufficient. Increased precision was found in the evaluation of nutrient balance in the DRIS approach, which was ignored in the case of the critical values.

Angeles et al. 1993, developed DRIS norms for banana from 915 observations. Except for K and its ratios and products with other nutrients, the DRIS norms were very similar to the

average critical values. But, the validity of the DRIS norms and their superiority over the critical values in making correct diagnosis were partially confirmed and further field experiments are required.

With Valencia oranges (*Citrus sinensis* L.), where the sufficiency range method made a diagnosis, DRIS agreed with the diagnosis. It indicated not only the most limiting nutrient, but also the order in which factors would likely become limiting. DRIS diagnoses were found to be affected by differences in type or age of tissue sampled (Beverly, 1984).

Sumner (1986), reported that despite the rather substantial differences between non-fruiting and fruiting nutrient levels of citrus leaves, DRIS makes essentially the same diagnosis of the order of nutrient requirement. The DRIS approach reduces but does not eliminate the differences between leaf composition as affected by rootstocks.

For sweet cherry (*Prunus avium* L.), Davee et al. (1986), stated that independent sufficient ranges were derived from commercial orchard data selecting a sufficiency range that produced the best agreement with DRIS evaluations. Trees with high nutrient imbalance indices were consistently low-yielding. In mulching treatments where unfavorable nutrient imbalances indexes were improved, yields were increased. The nutrient imbalance index was more strongly correlated with relative yield increase than any other mineral parameter. He said also that it was possible to develop useful DRIS

standards and DRIS-derived sufficiency ranges from survey data, even though conventional statistical approaches did not reveal strong relationships between mineral concentration and yield.

Righetti et al. (1988a), working with samples of hazelnut (*Corylus avellana*) and sweet cherry (*Prunus avium*) evaluated if biases in DRIS formulas could prevent the detection of some deficiencies or excesses, using one and two equation calculation procedure. When they used one equation the data showed limits on maximum or minimum values that the index could obtain for Mn in hazelnut and Zn in sweet cherry but not for others elements. The sum of DRIS indices regardless of sign masked some relative deficiencies or excesses. When they used two equations the bias were not eliminated but were less. Regardless of the procedure utilized, the relationships between DRIS indices and their concentration varied with the elements -- some of them showed a clear dependence on the concentration of other elements -- which limits the use of the index in diagnostic. DRIS has served best as a supplement to sufficiency range, and DRIS has provided additional information when extreme imbalances exist.

The same authors (1988b) in a complementary work, used the same crops and the lowest nutritional imbalance index calculated in the previous work as a new artificial data base. They determined which nutritional values could be most accurate with the DRIS evaluations. When all but one element

concentration were at an ideal level and constant and one was changed, severe imbalances could be identified and related to the concentration of the given element. In addition to providing a ratio base diagnoses, DRIS norms were a supplement to sufficiency range when severe imbalances were detected and it provided a means of independent evaluation of current critical values.

Szücs (1990), working with representative apple orchards (*Malus domestica*), in three consecutive years, found that the DRIS indexes related to lower yields in crops were correlated to oversupply of K and undersupply of P, while N status was neutral. Norms estimated by quadratic regression analysis for N, P and K showed a general oversupply of K and a relative undersupply of N and P, indicating that norms obtained by regression analysis reflect the extremes in nutrition-crop relations. In the case of apple trees with low values of nutritional imbalance index, these imbalances were not correlated with low yields.

For apples (*Malus domestica*), Parent and Granger (1989), derived DRIS norms from a 7-year fertilization trial on dwarfing rootstock with McIntosh. They stated that after the 6th year of planting, annual yield can be used instead of cumulative yields to generate DRIS norms. When leaf samples were collected at the appropriated sampling period, incorporating the dry matter index M-DRIS into the nutrient balance equation of orchard trees helped to separate limiting

from non-limiting nutrients and also integrated numerical information on nutrient concentration and nutrient ratios. These concentration and ratios were diagnosed independently or concomitantly with the sufficiency range approach and with the DRIS, respectively. In this case, M-DRIS was particularly useful when available critical values were not fully satisfactory.

Goth and Malakouti (1992), working with apples (*Malus domestica*) compared DRIS diagnoses from derived DRIS norms with mean sufficiency nutrient levels and published DRIS norms. Both calculated norms and indices from sufficiency range provided highly accurate ordering of the nutrient requirements of apples. High N and low Ca were identified as major nutrient problems. Calculated norms diagnosed Ca while published norms diagnosed P and Mg as limiting nutrients. For the experimental data conditions and the problems of the area the authors concluded that norms derived were better than those published.

Fallahi and Righetti, (1984) worked with fruits and samples collected in August from apple (*Malus domestica*) orchards. They related the mineral composition to yield using the DRIS and critical value approaches. Fruit DRIS B, Zn, Mn, and Al correlated better with most storage quality factors than the original mg/kg values. Both methodologies were similar for fruit micronutrients. Leaf DRIS values correlated better with yield and storage problems than the original

values; however, DRIS indices were more strongly correlated with yield and quality factors than original leaf values when the methodologies used resulted in different diagnoses.

Alkoshab et al. (1988), working with 624 mineral samples of hazelnuts (*Corylus avellana*,) compared the DRIS diagnoses and the sufficiency range approach. Both diagnoses methods agreed, specially if sufficiency range for some element were made more narrow. However, when the sum of DRIS indices were used, some nutrients were never identified by DRIS as a mayor relative deficiency or excess in any of the trees judged severely imbalanced. Nitrogen and Mg deficiency were not detected unless lower nutritional imbalance index thresholds were used. When they lowered the nutritional imbalance index threshold enough to detect N and Mg deficiencies, it was possible to detect not only N and Mg deficiencies but also imbalanced high yielding trees. The authors concluded that the DRIS did not detect all deficiencies or excesses. DRIS should be viewed as complementary to sufficiency range diagnoses that provided additional information when imbalances were detected.

Beverly and Worley (1992), compiled more than 3000 data points for 11 elements and yield for pecan (*Carya illinoensis*). Mean and variation coefficient for each element and ratios corresponding to more than 58 kg/tree yield were established. The authors considered these values as the preliminary norms for the crop.

Shaffer and Larson (1988), used DRIS to identify mineral deficiencies associated with mango decline, a disorder of unknown etiology on mango (*Mangifera indica* L.). Nutrient deficiencies associated with this problem were associated with the nutrition of the whole orchard and not with individual trees. The orchards with more decline were associated with the largest nutrient imbalance index. The most deficient nutrients in declining trees according with DRIS were Mn and Fe or a combination of both elements. The concentration of these elements were below the critical value in two over three of the decline orchards. Magnesium concentration was higher in the declining orchards, and P had the most negative DRIS index. DRIS was a useful tool for detecting nutritional deficiencies associated with the disorder.

Klein et al. (1991), using canopy photosynthetic photon flux (PP) density exposure as a primary external determinant of leaf mineral content characterized the spur leaf macroelement profile of walnut (*Junglans regia*), cvs "Harley" and "Serr". Spur N, P, Ca, and Mg contents were linearly correlated with PP and specific leaf weight (SLW) when they were expressed on the basis of leaf area (A). Potassium content was linearly correlated with SLW on a percent of dry weight basis (W). All mineral ratios were calculated using all possible combinations of A and W and correlated with spur leaf SLW. All ratios based on weight per weight and area per area were not related to light exposure and SLW. Calculated

DRIS indices of gradually less exposed and less productive spurs showed a strong exponential increasingly positive imbalance for K or N and K in both cultivars. But, Ca and Mg revealed a reverse pattern. Phosphorus DRIS indices were opposite in sign in the cultivars as spur light exposure decreased. The nutritional imbalance index value of spur exposed to decreasing light intensities increased exponentially. The authors proposed a modification of the DRIS system that take into account the effect of light exposure of the leaf.

Chelvan et al., (1984) used the DRIS methodology for examining nutrient imbalances and poor yields in Thompson Seedless vine grapes (yielding less than 15 kg/vine) receiving different levels of N and K₂O. Petioles were sampled at the bloom time. Vines yielding more than 20 kg/plant were used to develop DRIS norms. The P index was high for the low yielding plants, while K index was low. Low K and high P indices were associated with low yields. Low K and N indices were counteracted by high Ca and Mg indices. The authors concluded that N, K and Mg indices at bloom time worked in a pivotal way in determining the yield in Thompson Seedless grape.

4. Blueberry.

Blueberries belong to the genus *Vaccinium* in the family Ericaceae. Four taxa of *Cyanococcus* are cultivated in North

America: *Vaccinium corymbosum* L. (highbush), *Vaccinium myrtilloides* Mitch., *Vaccinium angustifolium* Ait. (lowbush), and *Vaccinium ashei* Reade (rabbiteye) (Hancock and Draper, 1989). Highbush blueberries are cultivated in the northern latitudes of the United States, extending from the Atlantic Coast states to the Mississippi Valley and northward into Canada. The species tolerates cold temperatures and requires as much chilling as a peach for normal development of flower buds (Ryugo, 1988).

4.1. Potential Yield.

Potential yields vary greatly among the types of blueberries, although climatic conditions and cultural practices are more important than genetic differences. Highbush plants can achieve yields of 25-30 t/ha, with 4.5 to 5.5 t/ha being the norm. Fruit size varies among blueberry types and is strongly influenced by environmental conditions. Highbush cultivars have the largest fruit, often reaching 3-4 g/berry. Most highbush cultivars fall in the range of 1-2 g/berry (Hancock and Draper, 1989). Siefker and Hancock (1986), working with 9 highbush blueberry cultivars indicated that yield was more strongly determined by canes per bush and berries per cane than by berry weight. High numbers of berries per cane were associated with low berry weights in all cultivars.

4.2. Root System and Soil Characteristics.

The blueberry is a shallow rooted plant that lacks root hairs (Holmes, 1960). The fibrous roots of the blueberry require an open, porous soil for easy growth (Cain and Slate, 1953). According to (Kramer et al., 1941, Shutack et al., 1949 and Laycock, 1967) root distribution of blueberries are concentrated in the organic soil horizons of the surface applied mulches, with more specific localization occurring with the lower decomposing organic layers. Blasing (1985), indicated that poor soil aeration status is implicated in poor highbush blueberry growth. A greater part of the variation in rooting depth and pattern between *Vaccinium* species is related to the depth to the water table or fluctuating water table (Korcak, 1986).

Organic mulches received early attention due to the physical benefits derived in field blueberry plantings. Organic mulches improved the water holding capacity, soil tilth, weed control and reduced temperature fluctuations (Shutak and Christopher, 1952). Cummings et al. (1981), noted that organic mulches were more effective than S in acidifying soils. Fry and Savage (1968), said that chemically mulching maintained a more constant media pH.

Townsend (1973a) and Korcak, (1986,1989), noted no consistent relationship between foliar Ca levels of highbush blueberry and Ca saturation percent over a range of soils.

Eck (1966), applied Ca, K and Mg to a H-bentonite clay in a ratio of 6:2:1 at 3 different percent saturation that induced 3 different pH levels. Highbush blueberry growth increased with increased saturation (50 % to 90 %) and that coincided with the pH of the media increasing from 3.3 to 5.8. But, when total cation levels ranged from 22.5 to 90 meq/100g clay, growth was greater at low level. However, Korcak (1988), said that blueberries can grow over a fairly broad range of relative K, Mg and Ca saturation percentage and any of the three saturation percentage may not represent a critical level.

4.3. Soil Reaction.

As early as 1910 it was established that blueberries required an acid growing medium (Coville, 1910). Johnston (1934), indicated that blueberries grew better at pH 4.4 than at pH 3.4, 5.5 or 6.8. Death of plant and marginal leaf scorch was observed at pH below 3.4 (Merril, 1939). Harmer (1944), changed the pH of an organic soil with addition of S and limestone and found that a pH range between 4.0 to 5.2 was satisfactory and pointed out that a range of 4.5 to 4.8 as optimum.

Cain (1952), indicated that the lack of ammoniacal N may be responsible for the appearance of Fe deficiency showing chlorosis on highbush blueberry plants growing at high pH. He

induced Fe chlorosis on plants on sand grown culture by changing equivalent amounts of N in the form of $\text{Ca}(\text{NO}_3)_2$ for NH_4NO_3 in a nutrient solution where the pH was maintained below 5.5. Only when a complete substitution of NH_4NO_3 was made did the chlorosis appear.

Holmes (1960), changing the acidity and P concentration in a nutrient solution achieved the best growth at pH between 4 and 5. When the pH was above this range, Fe chlorosis was more severe and plant growth poorer. Iron deficiency was more severe at high P levels. But, the Fe content of the older leaves didn't change with increasing pH despite the Fe chlorosis development, while in young leaves the Fe content diminished. He noted that an increasing pH may affect Fe metabolism. However, it was possible to maintain the green color in plants grown at pH 7.0 with the use of Fe chelate (FeEDDHA) instead of inorganic salts.

Norvell (1972), noted that at low pH (4.5) Fe sources, sulfate or EDTA (ethylenediaminetetraacetic acid) had no effect on dry matter production, but a high rate of Fe chelate restricted plant growth in peat or soil at pH 6.5. The growth limitation was due to a decrease in leaf Mn levels. As a result of the known characteristics of the FeEDTA complex which becomes unstable near pH 6.0 and the higher stability of the MnEDTA near neutrality. Arnold and Thompson (1982), suggested that chlorosis of highbush blueberries grown at the upper pH limit (5.2) was a consequence of Fe inactivation by

excessive P. But, Brown and Draper, (1980) hypothesized that there is an Fe efficient gene in blueberry. Iron efficient blueberries were found to be capable of lowering pH by a proton release from roots, but Fe inefficient plants did not change the solution pH. All the Fe efficient crosses contained less Ca than the Fe inefficient crosses, but neither of the two crosses released a reductant.

4.4. Leaf Sampling and Seasonal Variation.

Leaf analysis is used to diagnose the blueberry nutritional status. Bailey et al. (1962), suggested that when several elements need to be studied, leaf samples should be taken just prior to fruit harvest. However, Ballinger (1966a), said that the time of leaf sampling and the selection of leaf samples should correspond to a period of relatively stable element concentration in the plant, and preferably a minimum concentration. He noted that for blueberry this occurred during the midseason, following fruit harvest. The midshoot leaves of lateral shoots immediately below the fruit cluster are representative of leaves that will reflect the stress of fruit bearing and be indicative of the nutritional status of the plant at its maximum need.

Doughty et al. (1981), measured the changes in element content of blueberry leaf during the growing season. He found that the N concentration decreases rapidly early in the

growing season and levels off to a steady state by mid-July to early August. The P concentration was also highest in young leaves, declining as the leaf matured and stabilizing by midseason. Changes in K were rising and falling as the season progressed. The Ca, Mg and trace elements tended to increase slowly during the growing season. Similar trends were also found in different cultivars of highbush blueberry by others researchers (Bailey et al., 1962; Eaton and Meehan, 1971; Ballinger, 1966a; Chuntanaparb and Cummmings, 1980).

4.5. Plant Composition and Response to Nutrient Elements.

Korcak (1986), noted in his review of the nutrition of blueberry and other calcifuges that one of the most surprising differences in the nutritional status of the Ericaceae compared to other plants is the general low concentration of essential elements required for adequate growth. With the possible exceptions of Fe, Cu and S, highbush blueberry requires lower levels of all nutrients than other fruit producing plants.

4.5.1. Nitrogen.

As reported above, blueberry roots are concentrated in the more decomposed organic material (Kramer et al., 1941).

Ericaceous plants are higher in phenolic compounds, on the order of six to eight fold higher than corn (Dirr et al., 1972). It is known that several compounds including phenolics inhibited strongly the nitrification process (Rice and Pancholy, 1974).

a. Ammonium vs Nitrate source.

Rorinson (1980), using a nitrate free environment, reported that the combination of $\text{NH}_4\text{-N}$ and high soil Al was less toxic than high levels of $\text{NO}_3\text{-N}$ and high Al. Stribley and Read, (1974) researched the effect of mycorrhizal infection on the utilization of soil N other than NH_4^+ or NO_3^- by Ericaceae. It was reported that mycorrhizae may aid not only in NH_4^+ uptake but also in the utilization of proteins and peptides (Stribley and Read, 1976; Bajwa and Read, 1985).

Cain (1952), said that $\text{NH}_4\text{-N}$ may be essential for normal blueberry growth. However, Ballinger et al. (1972), using a constant flow gravity drip system of nutrient culture in sand, reported that "Wolcott" blueberry grow equally well either with a NO_3^- or NH_4^+ source of N.

Townsend (1967), demonstrated that shoot and root growth were distinctly favored by $\text{NH}_4\text{-N}$ and a combination of NO_3^- and $\text{NH}_4\text{-N}$ as compared to a nutrient solution containing only $\text{NO}_3\text{-N}$. The same author demonstrated NO_3^- reductase activity in the leaves and roots of lowbush blueberry (Townsend, 1971).

Dirr et al. (1972), reported the presence of NO_3 reductase in the leaves of highbush blueberry; therefore, to be able to assimilate $\text{NO}_3\text{-N}$. No visual differences in growth between $\text{NO}_3\text{-N}$ and $\text{NH}_4\text{-N}$ in "Jersey" plants was found. All plants appeared healthy and vigorous without any symptoms of chlorosis or toxicity. The activity of the NO_3 reductase in the root of "Jersey" plants were similar to that reported by Townsend, (1971).

Havill et al. (1974), reported low NO_3 reductase activity in the Ericaceae; and Routley (1972), said that the activity level varies within the Ericaceae. Lee and Stewart (1978), noted the existence of a general correlation between the growth rate and the NO_3 reductase activity levels. They found that lower growth was correlated with low NO_3 reductase activity.

Eck (1988), said that blueberry appeared to utilize both NH_4^+ and NO_3^- forms of N. He said that at a pH below 5.0 blueberries respond equally well to both forms of N and above a soil pH 5.0 the NH_4^+ form appears to be favored, mainly due to the NH_4^+ influence on the cation and/or organic acid or anion content of the leaf and on the Fe metabolism in the plant.

Generally, among the different N sources, $\text{NH}_4\text{-N}$ has produced better growth than NO_3^- for highbush blueberry (Cain, 1952; Herath and Eaton, 1968). But, Oertli (1963), noted the opposite if Fe was supplied in a chelated form. A similar

conclusion was reached by Doehlert and Shive, (1936) with the use of low P in sand cultures.

Hanson and Retamales (1992), reported for "Bluecrop" highbush blueberries that split applications of urea (half applied at budbreak, half at petal fall) resulted in 10% higher yields than the same amount of N applied at budbreak. They tested two controlled-release fertilizers which were as effective as urea as N sources. The dissolution rate of the fertilizers used did not affect yields or leaf N levels.

b. Critical Level.

Kramer and Schrader (1942), were the first to describe a N deficiency symptom in highbush blueberry. Eck (1977), has suggested that the critical level for N in highbush blueberry is 1.65 percent of the dry matter. This level agreed with the values observed by Ballinger and Kushman (1966), for optimal production of "Wolcott" cultivar. However, in a Michigan survey the blueberry yields were directly proportional to the N content of the leaves up to 2.1 percent of the dry weight basis (Ballinger, 1957).

Townsend (1973b), reported that over a six year sampling period the average N content was 2.21 percent for treated plants compared to 1.88 percent for those not receiving N fertilizer. The application rates used were 32 kg N/ha in the first year to 228 kg N/ha in the seventh year.

c. Interactions.

Nitrogen fertilization has been reported to affect other essential element in the plant. Eck (1977), observed that N fertilization to 135 kg N/ha increased not only the leaf N but also decreased leaf K. Leaf Ca and Mg were also decreased as the N rate increased over 68 kg N/ha. He reported also a strong biannual bearing pattern developed at all the levels of N application by a consistent change in leaf Ca level as the yield fluctuated from year to year. Townsend (1973b), also reported that increased N nutrition resulted in decreased leaf Ca levels in "Blue-ray" plant in three of six years sampled. Leaf Ca levels correlated positively with yield more than other foliar nutrients (Cain and Eck, 1966).

Cummings (1978), found that increasing N fertilization decreased Ca and Mg in the plant but a difference with Eck's results (Eck, 1977), was that the K concentration increased. He noted also that an increase in N fertilization increased the foliar concentration of Fe and decreased those of Cu and Zn.

4.5.2. Phosphorus and Potassium.

All the descriptions of P deficiency in blueberry have been based on induced deficiency by nutrient cultures from which P was omitted. No P deficiency symptoms have been

reported in field planting of highbush and rabbiteye blueberry (Eck, 1988).

Blueberry growth response to P fertilization has been reported on muck soils by Van de Geijn (1967), quoted by Eck (1988). Cummings et al. (1971), found that increasing the P fertilization in a low available P sand soil significantly increased the vegetative growth of young plants. The same author increased the available soil P with continuous application of superphosphate at rates of 25 to 50 kg P/ha and noted an increase in the P levels but a decreased in Cu and Mg levels in the leaf (Cummings, 1978).

Ballinger, et al. (1958), proposed leaf K content of 0.53 percent on a dry weight basis as a standard for blueberry planting in the Michigan area. A similar content was reported for North Carolina conditions where leaf K ranged from 0.42 to 0.91 in "Wolcott" cultivar, with a mean of 0.61 percent. For "Murphy" cultivar the range reported was 0.46 to 0.88 percent, with a mean of 0.58 percent. Eck (1983), found that the optimum leaf K concentration ranged between 0.45 to 0.55 percent.

Eck (1977), noted that increasing N fertilization was associated with a decrease in the leaf K concentration in a field fertilizer experiment using bearing "Bluecrop" plants.

Blueberry yields have been increased by K fertilization on different soil types. As early as 1920, it was reported that for a Berryland sand blueberry yields were doubled by the

application of 45 kg K/ha, as K_2SO_4 , made in split applications. In addition, Johnston (1934), reported the need of K for organic soils. Cummings (1978), said that the application of 47 kg/ha of K increased the crop yield; however, yield did not increase with further application to 94 kg K/ha. Eck (1983), working with the "Bluecrop" cultivar on a Berryland soil, found that application of 40 kg K/ha was associated with maximum yields.

Potassium sulfate was the most favored source of K for blueberry (Eck, 1988). Townsend (1973a), noted that the use of KCl treatments not only increased the winter injury but also reduced the fruit size. Potassium sulfate-magnesia used at a dose of 0.4 kg/plant reduce yield (Bailey et al., 1966).

4.5.3. Manganese.

The Ericaceae represent a special group of plant in relation to Mn, with the exception of *V. uliginosum* (Popp, 1983). Values of Mn in excess of 2000 to 4000 mg/Kg have been noted for *V. angustifolium*; however, high tissue Mn levels have not been associated with toxicity symptoms (Hall et al., 1964; Townsend, 1969). The fact that excess Mn affects the tops more severely than roots suggest that a mechanism reducing upward translocation of Mn confers a degree of tolerance (McGrath and Rorinson, 1982). It is known also that Mn levels in roots tend to be lower than foliar levels (Foy et

al., 1978). But, a range of blueberry progenies grown on a number of soils tended to have either higher or similar root Mn levels compared to those of shoot levels (Korcak et al., 1982). There are few reports of Mn deficiency. Kender and Anastasia (1984), were the first to report Mn deficiency for lowbush blueberry. It was suspected by Ballinger et al. (1958), in field samples of highbush blueberry leaves with interveinal chlorosis on leaves containing 230 mg Mn/kg. However, Doughty et al. (1981), said that the normal range in blueberry leaves is 50 to 350 mg/kg, and deficiency symptoms appeared when the concentration dropped to 23 mg Mn/kg. He noted also that toxicity symptoms can be expected to develop at concentration above 450 mg/kg. High Mn uptake has been noted to reduce the activity of the NO_3 reductase, which is an indication that $\text{NH}_4\text{-N}$ is the preferred N source in soils of high Mn content (Jones and Menary, 1974).

4.5.4. Aluminum.

Aluminum is considered to be the most growth limiting factor associated with soil pH levels of 5.0 or below (Adam, 1981). Peterson et al. (1987), acidified a sandy loam with elemental S or $\text{Al}_2(\text{SO}_4)_3$, with or without the addition of sawdust. They found that the growth of Rabbiteye blueberry was more restricted by $\text{Al}_2(\text{SO}_4)_3$, compared with elemental S. However, the application of sawdust overcame the restricted

growth. Hargrove (1986), noted that the growth of Ericaceae near neutral conditions may be influenced by Al, due to the influence of Al-organic matter complexes solubility in the pH range 5 to 7. Reich et al. (1982), reported that the Al levels in roots of "Jersey" highbush blueberries were not affected by soil porosity with or without mycorrhizal infection, but found that the root concentrations decreased with increased fertility level in sand cultures. Korcak et al. (1982) and Korcak, (1986), noted that the root Al levels of a range of blueberry progenies compared over a variety of soils had a trend similar to that reported in the commercial blueberry area of New Jersey, where the root Al levels were about 700 mg/kg from plants grown in sand culture and about 360 mg/kg for the control plants grown on Berryland soils. The same author reported the distribution Al pattern within blueberries. He said that the tops had a higher Al level than the roots (Korcak et al., 1982). However, Townsend (1969, 1971), found an opposite trend for the Al distribution.

4.5.5. Calcium and Magnesium.

Loneragan and Snowball (1969), reported that the Ca requirement of blueberry is low and that it agreed with the functional Ca requirement of some herbs and legumes. The foliar Ca levels of highbush blueberry has been shown not to be affected by a pH range between 3.4 to 6.0 (Herath and

Eaton, 1968). Ballinger et al. (1958), reported a standard Ca value of 0.74 % of dry matter by the analysis of fruiting shoot leaves of high yielding highbush blueberry plant grown under Michigan condition. Doughty et al. (1981), reported 0.13 % as the Ca deficient level in the blueberry leaf. The standard range varied from a minimum of 0.40 % to a maximum of 0.80 %, where 1.0 % was noted as an excess value. But, blueberries grown in the coastal plain soils of the eastern United States tend to have Ca levels in the low part of the standard range (Cummmings et al., 1971). The same authors reported a foliar range of Ca concentration from 0.34 % when no lime was applied to 0.38 % when lime was applied to "Wolcott" variety grown on Leon sand. Eck (1977), found that the Ca concentration in "Bluecrop" range from 0.30 % at high levels of N fertilization to 0.33 % at low levels of fertilization. Townsend (1967), found that Ca concentration in the blueberry leaf were significantly lower with an NH_4^+ rather than a $\text{NO}_3\text{-N}$ source.

Bailey (1941) and Cain (1952), reported a lime induced chlorosis (Fe deficiency) in blueberry leaf developed when the pH of the medium was raised to about 5.5 by Ca applications. Cummings et al. (1971) and Cummings (1978), reported that the application of less than a metric ton of lime per hectare raised the pH to 4.5 and depressed growth. However, this dose did not effect fruit yield. Eck (1977), reported that when a high load of fruit is observed, leaf Ca concentration was

high. He said that this occurred when available Ca reserves were distributed throughout a smaller amount of secondary vegetative growth. The foliar Ca levels were more closely associated with blueberry yield than any of the other foliar nutrients (Townsend, 1973b).

The Mg requirement for blueberries is also relatively low. The first reported field Mg deficiency in highbush blueberry was corrected by either MgSO_4 or dolomitic limestone. A level below 0.20 % was reported as deficient by Mikkelsen and Doehlert (1950), and Bailey and Drake (1954), reported deficiency symptoms at a value below 0.10 %. They said that variation in the Mg concentrations were influenced by the K content in the leaf. Any growth response to applied Mg was observed without the presence of deficiency symptoms (Bishop et al., 1971).

4.5.7. Sulfur and Chloride.

Kramer and Schrader (1942), experimentally developed a S deficiency in "Cabot" blueberry. The foliar symptoms, although similar to those of N deficiency, affected only the young leaves. The S toxicity was found when the air SO_2 concentration exceeded 7.0 mg SO_2/kg and leaf defoliation was noted when the concentration in the air exceeded 15 mg SO_2/kg (Brennan et al., 1970).

Ballinger (1962), reported in a North Carolina blueberry

survey that the S leaf content varied from 0.05 to 0.50 % of the dry matter with more than two-thirds of the plants sampled between 0.16 and 0.35 %. He also found that the S leaf content increased when the S in the nutrient solution was increased. Doughty et al. (1981), suggested an optimum S leaf range between 0.125 to 0.20 % of the dry matter.

Harmful effects of KCl on blueberry growth have been reported by Merrill (1944); Slate and Collinson, (1942) and Ballinger, (1962). Ballinger reported a decrease in the Ca uptake by plants when the nutrient solution had a S to Cl ratio of 4:1, while a high Cl to SO_4 ratio favored Ca uptake. The author noted that lower Ca uptake was a desirable condition for blueberry plants. A high S to Cl ratio in fertilizer was favored the blueberry growth. Toxicity symptoms were associated with leaf Cl level of 0.89 percent. Leaf Cl contents in normal field plants of North Carolina ranged from 0.02 to 0.14 percent of the dry matter (Ballinger, 1962).

Townsend (1973b), reported significantly reduced yields of "Blueray" cultivar when the soil saturation extracts were between 1.68 to 2.28 mmhos/cm.

4.5.8. Boron, Copper and Zinc.

Boron, Cu and Zn deficiencies were developed experimentally by Doughty et al. (1981), who placed the

optimum B concentration in blueberry in the range between 30 and 70 mgB/kg, and the deficiency at 20 mgB/kg and toxicity levels about 200 mgB/kg respectively.

The same authors reported that a level below 5 mgCu/kg in leaf was associated with deficiency, 5 to 20 mgCu/kg was a sufficiency range and an excess level was 100 mgCu/kg. The deficiency concentration for Zn was established at 8 mgZn/kg, the sufficiency range was 8 to 30 mgZn/Kg and the excess level was 80 mgZn/kg (Doughty et al., 1981).

HYPOTHESIS AND OBJECTIVES

In the last few years Beaufils' approach has been successfully applied to some fruit crops. The fact that blueberry is a perennial crop, which allows for periodic tissue sampling and adjustment of fertilization practices to improve production, increases the desirability of developing Diagnostic and Recommendation Integrated System (DRIS) norms.

The research hypothesis is: DRIS is superior to the Critical Value approach as a means of assessing the mineral nutrition of highbush blueberry (*Vaccinium corymbosum* L.). The hypothesis will be tested in two stages. The first step is to develop the DRIS norms and the second is to test these norms in field experiments. The purpose of the present research is to achieve the first hypothesis stage.

The objectives are to: a) compile a DRIS data base from existing published and unpublished data of leaf analysis and yields, b) develop DRIS foliar diagnostic norms for eleven nutrients (N, P, K, Ca, Mg, Fe, Mn, Zn, Cu, B, and Al), c) compare and correlate the preliminary DRIS norms with the critical value approach published in the literature and calculated from the data base used to develop the DRIS norms.

MATERIALS AND METHODS

The DRIS technique consists of describing the nutrient ratios status of a high-yielding population, and then identifying variation from ratios in unknown samples. A data bank comprising 1074 observations of leaf nutrient concentrations and yields of highbush blueberry (*Vaccinium corymbosum* L.) was developed as described previously by (Beaufils, 1973a; Sumner, 1977d).

The data used for developing DRIS norms came from several different sources: the number between the rectangular brackets means the number of data points from each source. ([66] and [9] Ballinger, 1957; 1969; [30] Bailey, 1966; [2] Brown, 1988; [6] Cummings, 1978; [625] Dale, 1973; [15] and [4] Eck, 1977; 1985; [180] Widders et al., 1994; [11] Lareau, 1989; [15] Martin, 1983; [10] Naumman, 1985; [12] Popenoe, 1952; [15] Rosca, 1985; [8] Scibisz, 1990; [16] and [8] Townsend, 1973a; 1973b).

The observations were divided into high and low-yield subpopulations, using 5 kg berries/bush to separate the subpopulations. The yield used to divide between low- and high-yielding population was 31.5% of the highest yielding highbush blueberry. Thus, the high-yielding sub-population

reflected conditions that were considered desirable for the crop (Beaufils, 1973a).

For the two sub-populations the mean ($\bar{x}$), standard deviation (SD) and variance (s^2) were calculated for each nutrient concentration as well as for all ratios between nutrient concentrations. A variance ratio (s^2 for low-yield population/ s^2 for high yield-population) was calculated for each nutrient concentration ratio. Of the two ratios involving each pair of nutrients, the one with the larger variance ratio was selected. The mean and coefficient of variation (cv) values in the high-yield population for the selected ratios were used for calculating DRIS indices using the standard equation (Beaufils, 1973a). The nutrient with the most negative index was considered the most limiting or most relatively limiting.

A nutritional imbalance index (NII) was calculated as a measure of balance among nutrients for each DRIS evaluation. It was obtained by adding the values of DRIS indices irrespective of sign (Beaufils, 1973a; Sumner, 1977e). The larger the NII, the greater the imbalance intensity among nutrients.

The same data bank was used to compare DRIS diagnosis with the standard values developed by Ballinger et al., (1958) and Doughty et al., (1981) to determine if relative deficiencies or excesses associated with lower yielding bushes would have been detected routinely. Critical values for each

nutrient were calculated as was described by Ulrich and Hill, (1967) and both diagnostic results correlated.

RESULTS and DISCUSSION

1. Characterization of the Highbush Blueberry Population.

The blueberry data base show a wide range in yield values (0.01 to 15,9 kg berries/bush) and foliar nutrient concentrations. Statistical characterization of the data base shows not only high coefficient of variation for all parameters but also high differences in the number of points recorded for each nutrient (Table 1). Highbush blueberries ranged between 3 and 15 years old, with a big proportion of the points of the data base (81.9 %) from Ontario and Michigan areas (Ballinger, 1957, 1969; Dale, 1993; Hancock and Hanson, 1993), as a consequence, results and conclusion may be most applicable to these regions (Appendix Table 1).

1.1 Yield Values.

Blueberry yields should increase until the plants are 6 to 8 years old. An average mature bush should produce 2.5 to 3.5 kg of berries, although higher yields are possible (Hoffman, 1978). The yield frequency polygon shows that the distribution is positively skewed and that approximately 60 %

of the samples are concentrated below the mean value of the population 3.15 kg/bush (Figure 1). Although there is a tendency to increase yields with age and the yields in the data base follow the expected age pattern, exceptionally very high yields were found on some research trials. The very high yields were results of not only more controlled conditions but also yield record found for the crop that bias the average yield per age of bush (Figure 2). Generally, a very good yield for most blueberry growers is considered to be near the 5 kg/bush in mature bushes. Thirty one percent of the yields in the data base were higher than 5 kg berries/bush. Another reference for comparison is the average yield of mature blueberries 2.4 kg/bush in Michigan (Hanson, 1993).

1.2 Nutrient Concentrations.

Unequal number of data points were available for the different nutrients. Macronutrients with the exception of P have more data points than micronutrients. The dissimilar number of points is a consequence of the different information available from each source (Table 1).

A comparison of the total number of samples which have a nutrient available with the suggested critical values found in the literature (Eck, 1988), shows that P has the greatest number of samples in the deficiency range (55.7%) in contrast to Mg with a high percentage (90.6%) in the high range. The

Table 1. Statistical characterization of yield and foliar nutrient concentrations of the Blueberry population.

	Range of observation	Mean	Standard deviation	CV %	n
Yield (kg/bush)	0.01 - 15.9	3.15	2.58	81.9	1074
N %	0.42 - 3.8	2.09	0.41	19.6	1040
P %	0.05 - 0.8	0.12	0.06	48.0	122
K %	0.10 - 1.8	0.57	0.18	31.6	1055
Ca %	0.10 - 1.3	0.51	0.16	30.9	1041
Mg %	0.14 - 0.5	0.19	0.06	30.2	1056
Mn mg/kg	16 - 3500	369	324	87.9	748
Fe mg/kg	7 - 44	77	41	53.3	736
Zn mg/kg	4 - 86	15	9	63.8	391
Al mg/kg	38 - 309	109	34	81.6	190
Cu mg/kg	1 - 79	7	9	125.7	299
B mg/kg	10 - 121	35	16	46.1	247

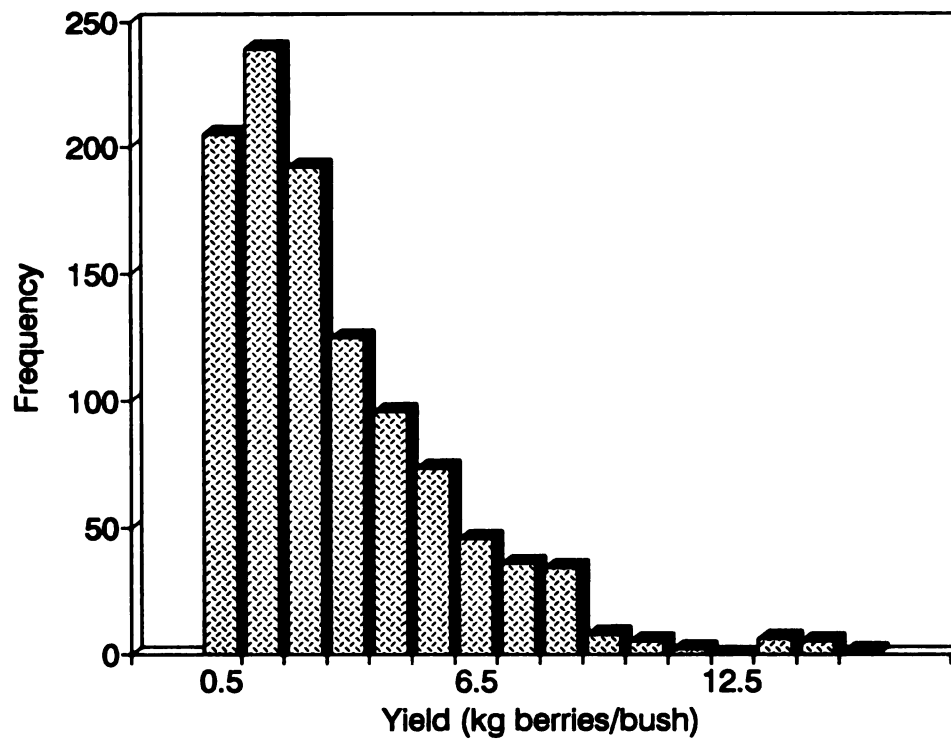


Figure 1. Frequency distribution of Blueberry Yield (kg berries/bush).

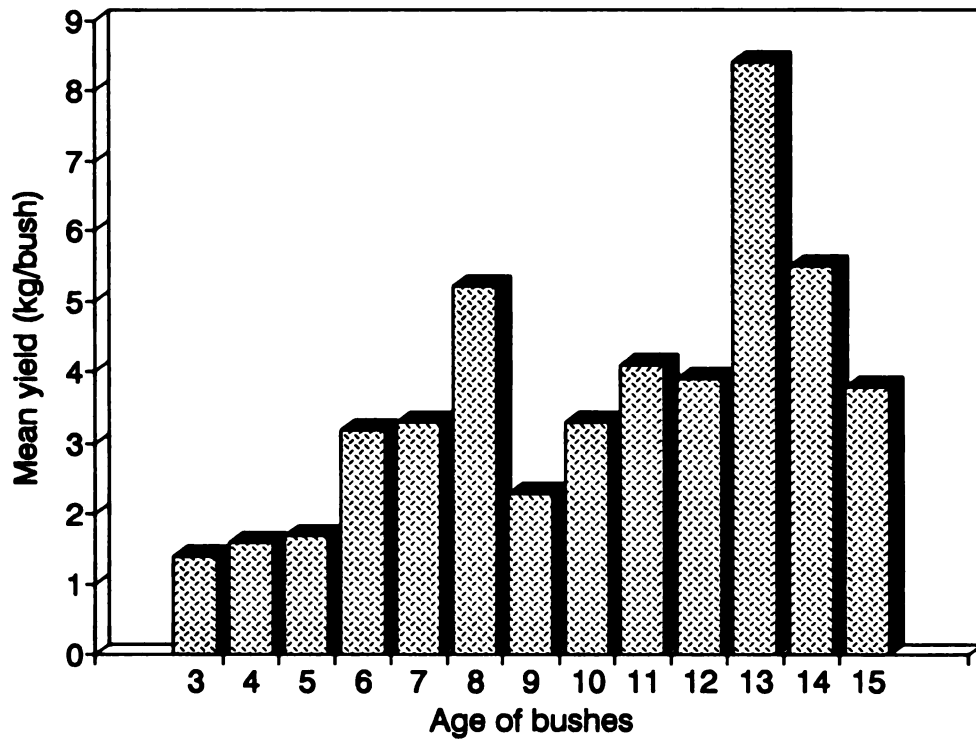


Figure 2. Frequency distribution of Mean Yield (kg berries/bush) with Age of Plant.

surprising high percentage of samples with P in the deficiency range contrast with the known assumption that "no P deficiency symptoms have been reported in field plantings of highbush or rabbiteye blueberry" (Eck, 1988), and also that given a high percentage of samples with high level of Mg it would have been anticipated that K levels would have been low. But, more than 60% of samples had K and Ca in the normal range. Nitrogen levels in samples were uniformly distributed among the different ranges of reference.

Micronutrients show different patterns in range of distribution. Copper and B had approximately the same number of samples below and above the normal range. Iron had two-thirds of the samples in the normal range and the other one-third in the deficiency range. But, Mn and Zn contrasted with Fe by having a high proportion of samples between normal range and high range values (Table 2).

Critical values have certain limitations when they are developed for some elements under one set of conditions and then are applied to another or when the stage of plant development and leaf sample specified differ from those to be compared. Diagnosis of a deficiency may not be possible under these conditions (Walworth and Sumner, 1988).

To partially avoid this scenario the same data base was compared with standards developed for Michigan conditions. The new comparison shows that the percentage of samples in the range of deficiency decrease drastically for P, N and Ca. For

practical purposes the same diagnosis was obtained for K and Mg. But, an increase was found in the percentage of samples in the low range for all the microelements (Table 3).

The effect of time of leaf sampling was not considered because I assumed that the type and time of tissue sampled was standardized.

1.3 Relationship between Yield and Nutrient Concentrations.

Usually the relationship between leaf composition and yield under unrestricted conditions reported in the literature showed a wide range of nutrient concentrations in low yielding plants and this range narrows as the yield increases until with very high yielding plants this range is very narrow, in other words a triangle shape is obtained, with an optimum nutrient closely related to the vertice range. The highest yield class is surrounded by two zones of limitation, one of insufficiency and the other of excess. This is the most common pattern. Another pattern occurs when the highest yield class is at the extremity of one zone of limitation. The shape reflects the idea of balanced composition, thus unless a plant has a balanced composition it can not reach a high yield; however, if it has a balanced composition a high yield may still not be obtained because the yield could be limited by other factors (Beaufils, 1973a).

Table 2. Blueberry nutritional characterization compared to the suggested Critical Nutrient Levels (Eck, 1981).

Percentage of samples in range					
Nutrient	Deficient	Low	Normal	High	Excess
N %	19.7	5.2	26.7	33.8	14.6
P %	55.7	13.0	30.6	0.7	-
K %	1.5	4.5	65.1	17.3	11.6
Ca %	0.2	22.9	73.3	2.7	0.9
Mg %	0.3	4.4	4.5	90.6	0.2
Mn mg/kg	1.2	11.0	42.1	13.9	31.8
Fe mg/kg	32.8	-	66.3	0.8	0.1
Zn mg/kg	10.5	-	84.9	4.3	0.3
Al mg/kg	N.A.	N.A.	N.A.	N.A.	N.A.
Cu mg/kg	51.9	-	44.8	3.3	-
B mg/kg	17.8	27.9	52.3	2.0	-

Sources: Ballinger et al., (1958), Doughty et al., (1981)
N.A.= not available.

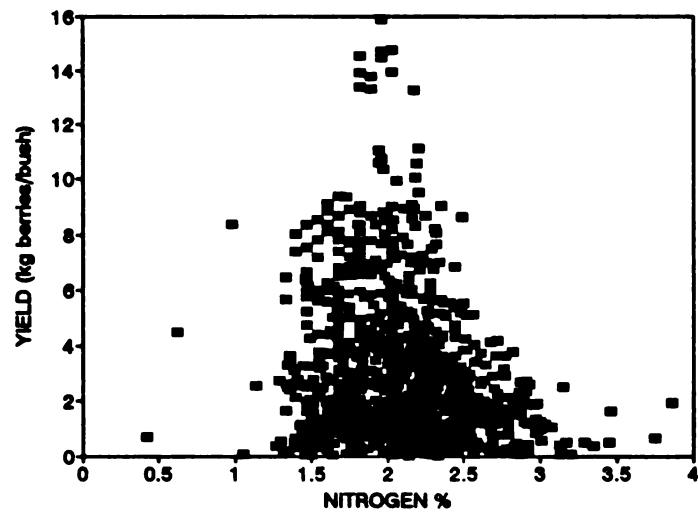
Table 3. Blueberry nutritional characterization using Michigan Standard Values (Hancock and Hanson, 1986).

Nutrient	Standard	% Below Standard
N %	1.65	13.85
P %	0.10	34.80
K %	0.35	6.07
Ca %	0.34	12.68
Mg %	0.12	4.64
Mn mg/kg	168	30.70
Fe mg/kg	150	95.80
Zn mg/kg	20	73.90
Cu mg/kg	15	87.00
B mg/kg	49	82.60

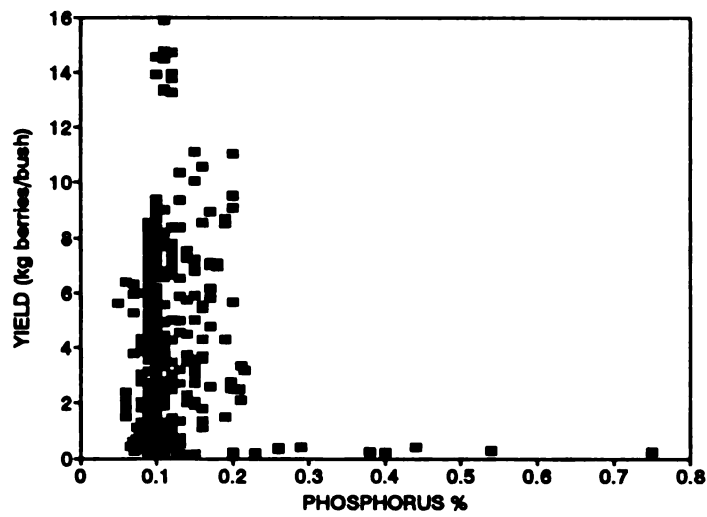
Modified from A. L. Kenworthy. Nutrient trend in Michigan Fruit Plantings. Research report 379. Michigan State Agr. Exp. Sta.

Regardless of the number of points available, the scatterdiagram of the relationships between yield and leaf composition for each nutrient shows two different patterns (Figures 3 to 6). Nitrogen and Ca are rather close to the expected most common pattern. They show a wide dispersion of the element concentrations in the low yields and a narrower range in the higher yields. They have an "optimum" in the average of the range of sufficiency used for highbush blueberry (near 2 % for N and 0.6 % for Ca).

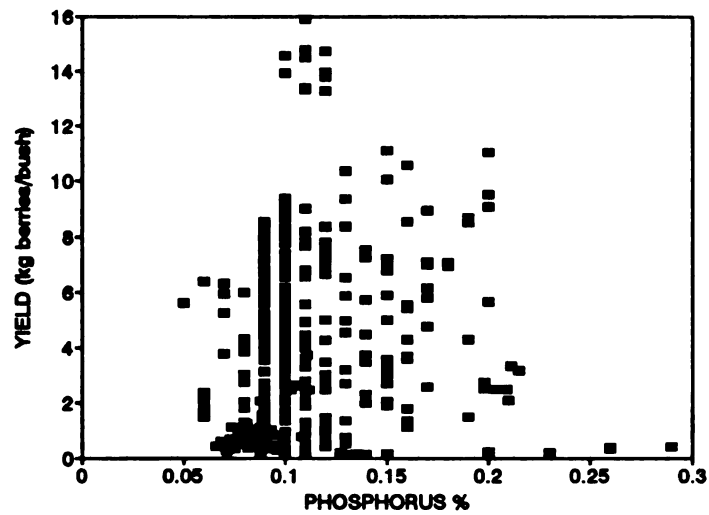
Potassium and Mn are good examples of the second pattern. Even though there are different number of points for K and Mn, both show a rapid increase in yield with increasing leaf content followed by a slower rate of decline in yield with excess (higher leaf composition). The optimum range for K and Mn is close to the lower limit of the sufficiency range (0.25 % for K and approximately 40 to 50 ppm for Mn). Both elements have low linear correlation with yield ($r = -0.45^{***}$ and $r = 0.37^{***}$). Eck (1983), states that the interpretation of foliar K levels in terms of yield response is complicated due to the strong influence of fruit load on leaf K. Hancock and Nelson (1988), found a significant correlation between leaf K and yield in only one of the three years studied. In several other studies, no association was observed between leaf K and yield even though foliar K values ranged widely (Ballinger and Goldston, 1967; Bailey et al., 1966). Results from state-to-state and year-to-year may be variable because



a



b



c

Figure 3. Scatter diagram of Leaf Nutrient Concentration with Blueberry Yield. a) N% ; b) P% ; c) split data set $P < 0.3\%$.

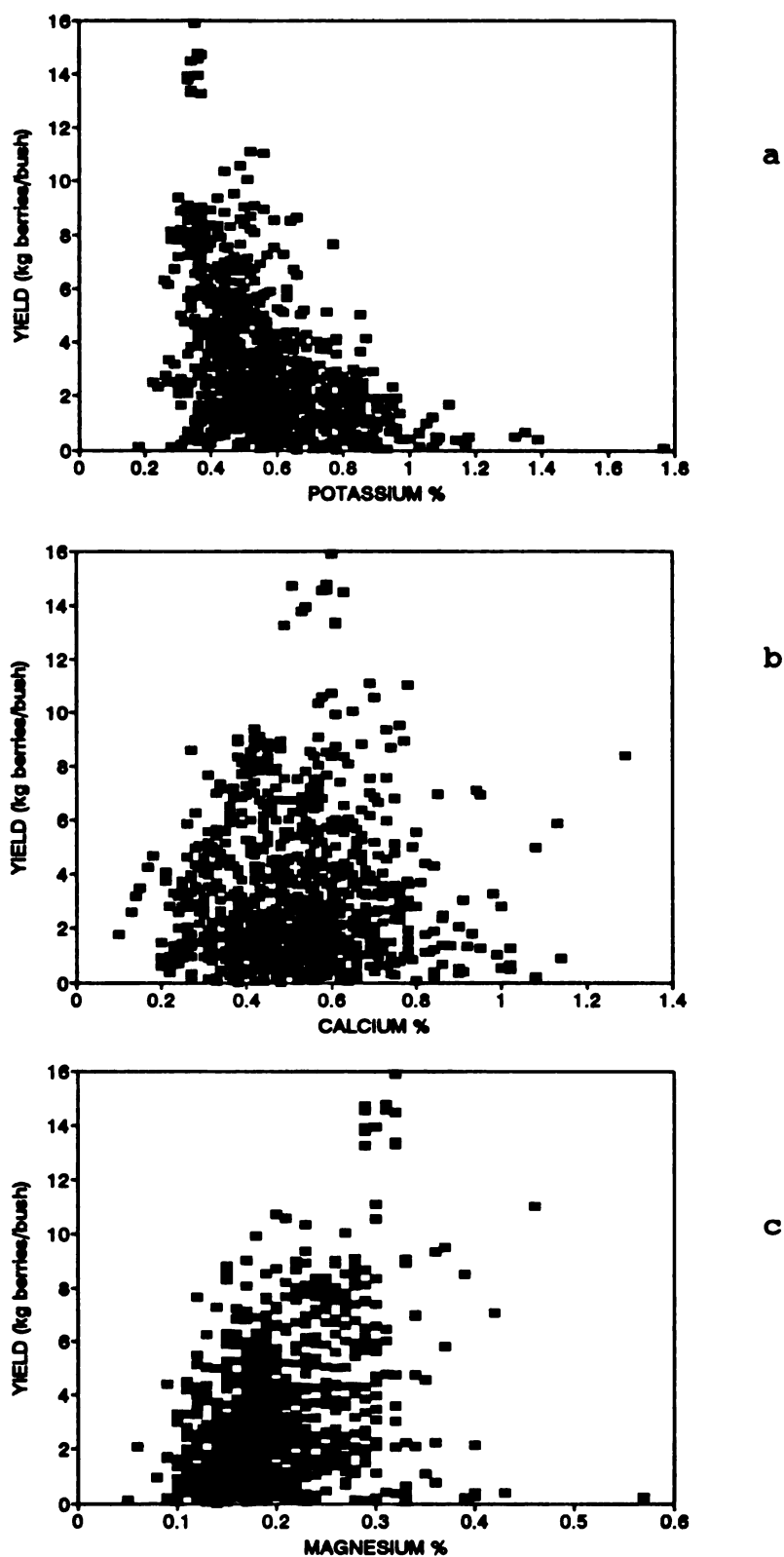


Figure 4. Scatter diagram of Leaf Nutrient Concentration with Blueberry Yield. a) K% ; b) Ca% ; c) Mg% .

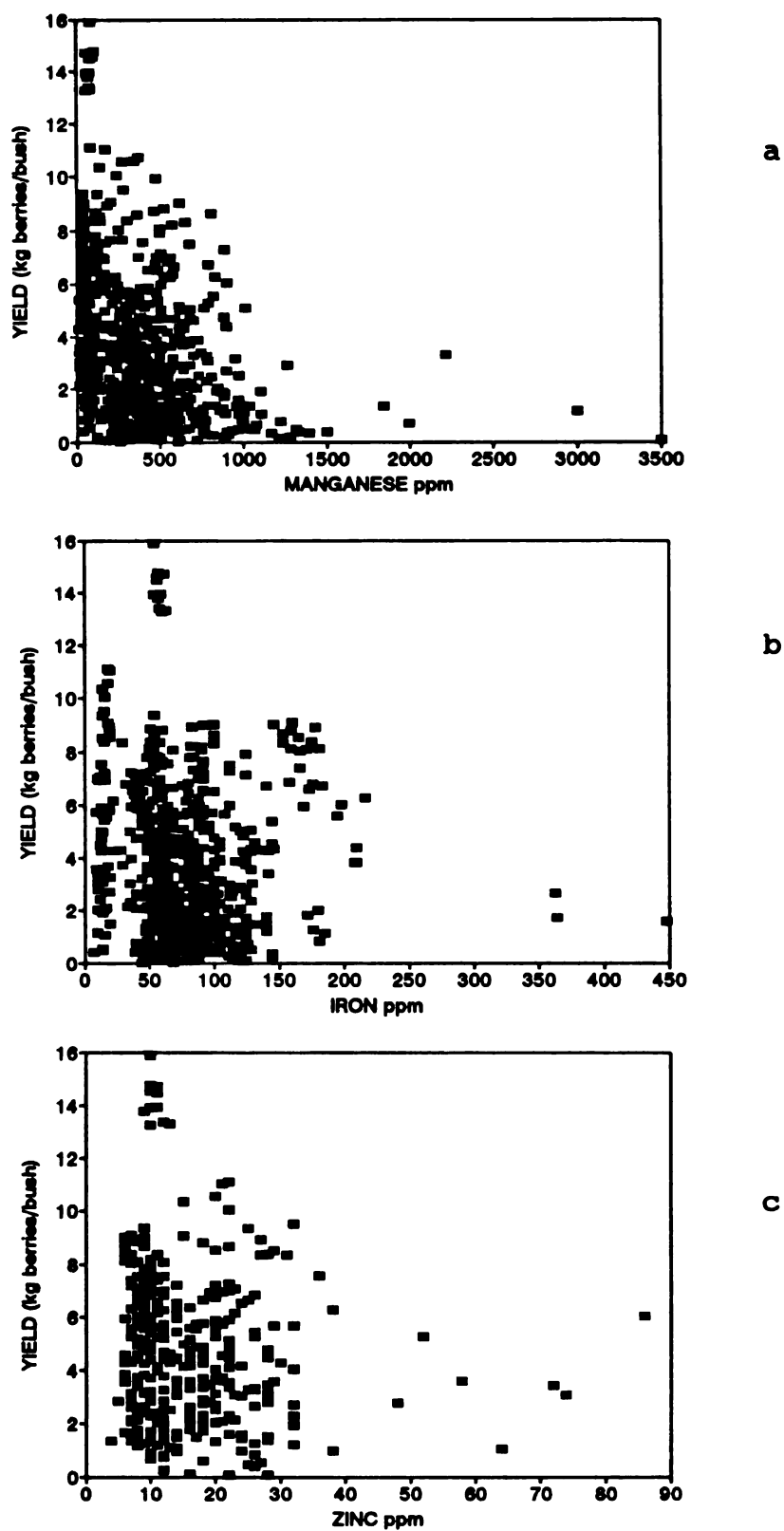


Figure 5. Scatter diagram of Leaf Nutrient Concentration with Blueberry Yield. a) Mn mg/kg; b) Fe mg/kg; c) Zn mg/kg.

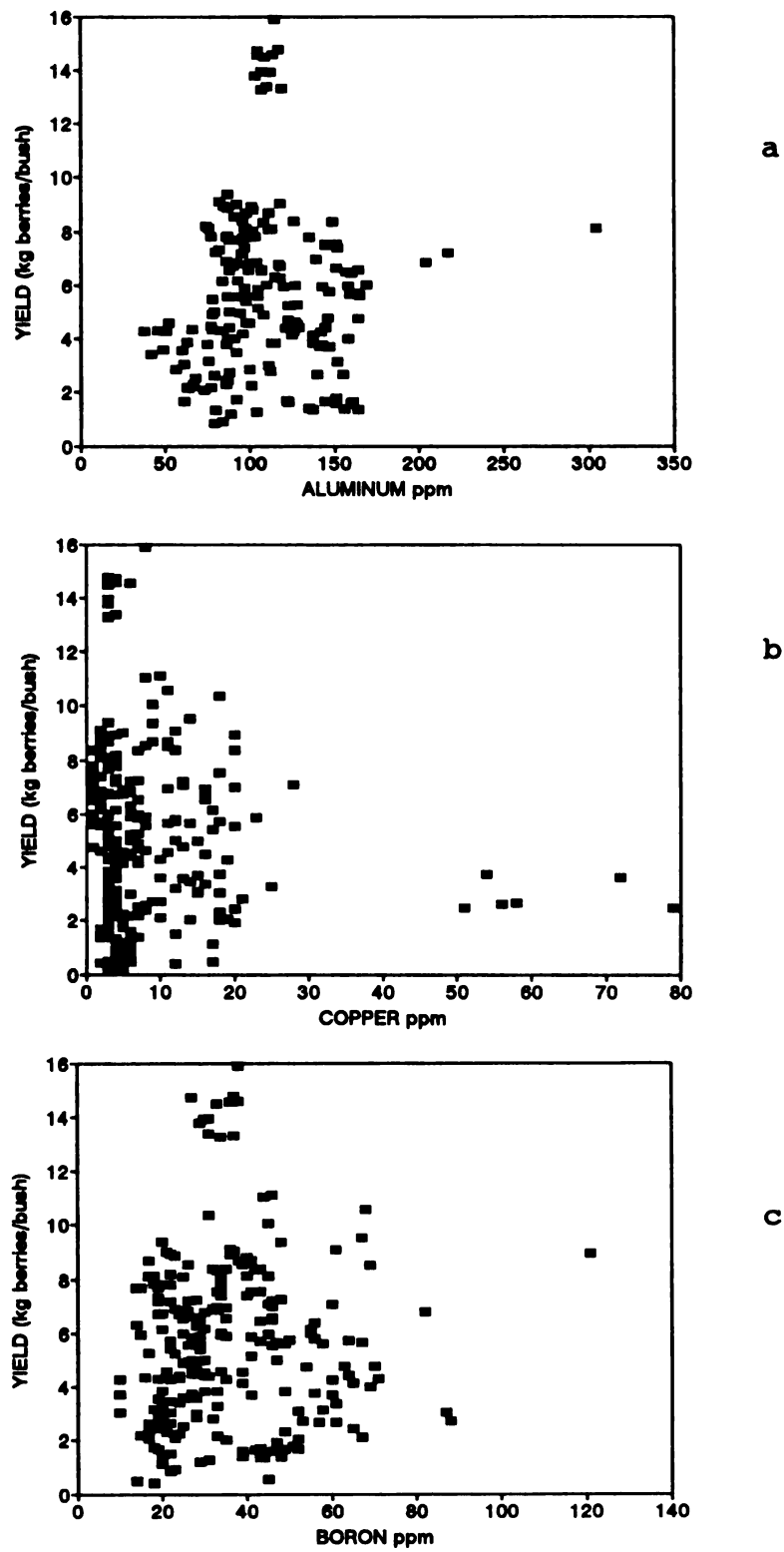


Figure 6. Scatter diagram of Leaf Nutrient Concentration with Blueberry Yield. a) Al mg/kg; b) Cu mg/kg; c) B mg/kg.

of differences in overall nutrient availability and in leaf to fruit ratios (Hancock and Nelson, 1988).

Low levels of manganese seems to be associated with high yield on highbush blueberry. This observation agrees with data that plants of *V. corymbosum* usually contain lower Mn levels than other plants (Korcak et al., 1982). The Mn critical deficiency levels are surprisingly narrow among plant species, cultivar and environmental conditions, in contrast to the wide range commonly found for Mn toxicity (Marschner, 1986). From the scatter of points and the variability of nutrient concentration of the data base it appears that a high proportion of samples have some degree of limitation, probably by excesses. But, most ericaceous plants are Mn accumulators and do not exhibit Mn toxicity symptoms at foliar levels up to 15,000 $\mu\text{g.g}^{-1}$ (Miller, 1987).

The pattern for Fe, Zn and Cu are similar to the patterns of K and Mn, even though they have few points. Copper in contrast to Mn has a narrow range between deficiency and toxicity levels (Marschner, 1986), which could explain not only the shape of the scatter of points but also the distribution of points observed. Copper availability has a strong relationship with soil organic matter content which may make it difficult to explain relationships between yield and Cu leaf content in a large data base with different organic matter content of soils.

Phosphorus levels are very concentrated for a wide range

of yields and very low P concentration appears to be optimal for blueberry production. High yields are obtained at a P concentration less than the limit suggested by the literature, which can explain the high percentage of blueberry samples diagnosed in the low ranges (Figure 3b and 3c).

The pattern for Mg (Figure 4c) is similar to K and Mn but reversed. This might suggest an interaction between Mg and K exist in the data base confirming prior literature (Bailey and Drake, 1954). Magnesium, in contrast, has an optimum yield associated with Mg levels above the normal sufficiency range near 0.3 %. There is a low positive correlation between Mg content and yield ($r = 0.40^{***}$). Boron and Al have few points and could be similar to the shape of N and Ca.

2. Development of Blueberry DRIS Norm.

2.1 Subdivision of the Population.

The blueberry population was divided in three subpopulations according to their yields. The C subpopulation with yield values between 15 and 10 kg of berries/bush; the B subpopulation between 10 and 5 kg/bush; and the A subpopulation with yield values less than 5 kg/bush. Since the C subpopulation has only 1.76% of the points of the data base, the C + B subpopulation was used as the high population for the purpose of the development of the DRIS norm. Thus,

the criteria for dividing the population in two subpopulations was a yield value of 5 kg/bush. The result was a low yielding population with yields below the 5 Kg of berries/bush

(A population) with 857 points (79.8 % of the total data base), and a high yielding population (B population) with yields greater than or equal to 5 kg/bush (20.2 % of the total data base) (Table 4). Yield greater than 5 kg berries/bush is still considered a high yield for field conditions.

According to Walworth et al.(1988), who compared corn nutritional diagnosis from DRIS norms derived from a set of 10 observations, with another generated by 8494 points, stated that the use of extremely high yield observations was not only accurate but an inexpensive means of generating plant tissue nutrient optima. The C subpopulation should be considered as a valuable set of points due to the record yields contained in that subset and the validity of the values tested in the future.

The A and B populations have differences in the number of points for each elements; however, the difference is less than the total population before analyzed. Both populations have a different number of observations for N, K, Mg and Mn mean leaf concentration. With the exception of Mn both populations (high and low yielding) have a similar average of microelement concentrations. High yields seem to be associated with low Mn concentration (229 ppm vs 423 ppm for the A population), which agrees with the pattern of the relationship between yield and

Table 4. Characterization of the high and low Blueberry population.

	Mean	Standard Deviation	CV%	n
B¹ Population (high yield)				
Yield (kg/bush)	7.29	2.17	29.7	217
N %	1.93	0.27	14.2	211
P %	0.11	0.03	26.2	139
K %	0.44	0.11	22.1	212
Ca %	0.52	0.14	27.4	214
Mg %	0.23	0.05	25.4	217
Mn mg/kg	229	219.20	95.6	213
Fe mg/kg	71	43.70	61.4	208
Zn mg/kg	14	9.20	65.2	171
Al mg/kg	114	33.30	29.5	104
Cu mg/kg	6	5.35	90.0	137
B mg/kg	35	15.05	42.7	137
A Population (low yield)				
Yield (kg/bush)	2.01	1.30	61.9	857
N %	2.13	0.43	20.1	829
P %	0.12	0.06	55.5	283
K %	0.60	0.18	30.4	843
Ca %	0.51	0.16	31.7	827
Mg %	0.18	0.05	29.7	839
Mn mg/kg	423	341.78	80.6	535
Fe mg/kg	79	39.74	50.1	528
Zn mg/kg	16	10.08	62.1	220
Al mg/kg	102	34.41	33.5	86
Cu mg/kg	9	11.64	134.5	162
B mg/kg	35	17.35	50.0	110

B¹ = (B + C population)

nutrient concentration shown in Figure 5a. The low yielding population could have been limited by a Mn accumulation.

2.2 Ratios of Nutrient Elements.

A total of 110 nutrient ratios were calculated that included all possible combinations among N, P, K, Ca, Mg, Mn, Fe, Al, Zn, Cu and B. The DRIS approach relies on the use of nutrient ratios (Beaufils, 1973a) to avoid the problem of changing nutrient concentration with leaf age. On the other hand, nutrient products were used with elements like Ca and Mg, which tend to increase with the age of tissue, to reduce the problem generated with variation in sampling time (Beaufils, 1973a; Sumner, 1988).

Finally, the biggest ratio of variance between the low over the high yielding populations was used as a selection criteria for discrimination among ratios (Beaufils, 1973a).

The results of the selected criteria are shown in (Table 5). It was noted before that not all samples had the same number of nutrient analysis available; as a consequence, the number of points per ratio was dissimilar. However, all ratios were used as a way of assuring symmetrical DRIS indices with the sum equal zero (Beaufils, 1973a).

Nutrients that varied greatly in concentration were usually in the numerator. This was the case generally for Mn and Cu and probably could have some effect on DRIS diagnosis.

Table 5. Mean, variance and coefficient of variation among nutrient ratios selected.

Nutrient ratio	A population (low yielding)			B Population (high yielding)			S^2_A/S^2_B
	X	S^2	CV%	X	S^2	CV%	
N/Fe	0.036	9.9×10^{-4}	86.98	0.044	0.0016	91.15	0.61
N/Zn	0.157	0.0049	44.75	0.163	0.0035	36.74	1.38
N/Al	0.019	8.3×10^{-5}	45.60	0.016	2.1×10^{-5}	28.09	3.89
N/B	0.064	0.0010	50.92	0.059	0.0005	39.62	1.98
N*Ca	1.091	0.199	40.90	1.011	0.105	32.09	1.90
N*Mg	0.392	0.021	37.53	0.440	0.013	6.79	1.56
P/N	0.064	0.0006	39.19	0.063	0.0001	21.26	3.48
P/K	0.256	0.0146	47.03	0.284	0.0023	16.97	6.29
P/Fe	0.002	1.3×10^{-5}	124.30	0.003	1.5×10^{-5}	110.47	0.86
P/Al	0.001	1×10^{-7}	38.59	0.001	5×10^{-8}	25.33	2.93
P/B	0.003	4.3×10^{-6}	53.69	0.004	1.5×10^{-6}	34.52	2.76
P*Ca	0.057	0.002	83.91	0.062	0.001	51.12	2.26
P*Mg	0.025	0.001	133.40	0.029	1.6×10^{-4}	45.83	6.05
K/N	0.283	0.0060	27.40	0.230	0.0018	18.52	3.32
K/Fe	0.009	7.9×10^{-5}	94.30	0.010	0.0001	103.59	0.67
K/Zn	0.036	0.0002	44.98	0.036	0.0001	33.31	1.96
K/Al	0.004	3.3×10^{-6}	40.13	0.003	6.6×10^{-7}	23.82	5.00
K/B	0.015	6.6×10^{-5}	52.01	0.013	1.8×10^{-5}	33.62	3.55
K*Ca	0.307	0.021	47.44	0.233	0.008	38.75	2.61
K*Mg	0.109	0.002	43.47	0.101	0.001	31.70	2.20
Ca/Al	0.004	1.7×10^{-6}	29.71	0.004	6.7×10^{-7}	19.17	2.64
Ca/B	0.017	0.0001	60.39	0.016	2.8×10^{-5}	32.38	3.99
Mg*Ca	0.096	0.002	50.02	0.123	0.002	43.54	0.80
Mg/Al	0.002	1.1×10^{-6}	46.37	0.002	2.9×10^{-7}	24.54	3.89
Mg/B	0.008	1.9×10^{-5}	54.55	0.008	7.3×10^{-6}	33.64	2.64
Mn/N	192.3	22857.1	78.60	109.9	9532.93	88.83	2.40
Mn/P	3162.3	17419386	131.90	826.9	346317.4	71.16	50.29
Mn/K	739.8	340331.8	78.85	466.6	167401.8	87.67	2.03
Mn/Fe	6.150	28.912	87.42	4.493	20.717	101.30	1.40
Mn*Ca	225.3	50413	99.64	122.8	14323	97.45	3.52
Mn*Mg	77.70	5775.16	97.79	48.07	1802	88.30	3.20
Mn/Al	0.806	0.667	101.20	0.615	0.4823	78.47	2.87
Mn/Cu	58.57	6787.06	140.60	30.89	1636.26	130.94	4.15
Mn/B	2.759	7.1527	96.92	2.618	2.0808	55.09	3.44
Fe*Ca	39.50	516.0	57.49	34.81	423.7	59.12	1.22
Fe*Mg	14.63	68.12	56.41	16.52	145.3	73.00	0.47
Fe/Al	0.945	0.5405	77.77	0.773	0.2261	61.53	2.39
Fe/B	2.439	4.7696	89.51	2.267	3.0670	77.24	1.56
Zn/P	108.3	1733.31	38.40	105.52	1190.56	32.70	1.46
Zn/Mn	0.127	0.011	82.79	0.145	0.0069	57.29	1.62
Zn*Ca	9.432	47.80	73.29	8.261	47.32	83.27	1.01
Zn*Mg	3.405	4.512	62.37	3.384	5.269	67.82	0.86
Zn/Fe	0.448	0.3486	131.72	0.428	0.2904	125.76	1.20
Zn/B	0.426	0.1075	76.85	0.378	0.0295	45.39	3.64
Al/Zn	12.55	29.591	43.31	12.69	17.150	32.63	1.73

Table 5. (cont'd)

Cu/N	5.131	53.128	142.03	3.355	8.8777	88.81	5.98
Cu/P	80.06	1026.9	131.15	50.18	1423.6	75.18	7.75
Cu/K	19.87	671.38	130.39	14.40	123.93	77.28	5.42
Cu/Fe	0.282	0.2140	163.95	0.269	0.1886	161.41	1.13
Cu*Ca	5.571	89.20	169.50	3.693	21.98	126.90	4.06
Cu*Mg	1.663	3.321	109.50	1.589	2.515	99.78	1.32
Cu/Zn	0.554	0.0766	49.96	0.483	0.1596	82.55	0.48
Cu/Al	0.041	0.0003	46.33	0.035	0.0007	74.48	0.54
Cu/B	0.256	0.0701	103.20	0.182	0.0203	78.34	3.45
B/Al	0.313	0.0085	29.59	0.269	0.0051	26.69	1.65

Righetty (1988a), found that the high variability of Zn and Mn in sweet cherry has a hidden effect in the detection of other deficiencies.

A DRIS system requires as a norm the mean and the coefficient of variation of each of the selected ratios that belong to the high yielding population. As a consequence those values were used as the first tentative set of DRIS norms for highbush blueberry (Table 6). Further calculation of intermediate functions and DRIS indices will make possible a nutritional diagnosis. These preliminary DRIS norms need to be calibrated in future field trials and refined in successive diagnostics.

2.3 DRIS nutrient index.

Nutrient functions were calculated according to Beaufils DRIS protocol, and used for the final calculation of nutrient indices which were related to the respective yield values (Appendix Table 2). The scatter diagram of DRIS indices and yield show divergences with those of nutrient concentrations and yield (Figures 3 to 10).

DRIS indices vary more for some elements than for others. It may be that DRIS indices calculated from intermediate functions are not independent of the variability of their components. The nutrient content for some elements varies more than for others (Table 1). Many factors can affect the

Table 6. DRIS NORM for highbush Blueberry (*Vaccinium corymbosum* L.).

Form of Expression	Mean	CV%	Form of Expression	Mean	CV%
N/Fe	0.044	91.15	N/Zn	0.163	36.74
N/Al	0.016	28.09	N/B	0.059	39.62
N*Ca	1.011	32.09	N*Mg	0.440	26.79
P/N	0.063	21.26	P/K	0.284	16.97
P/Fe	0.004	110.47	P/Al	0.001	25.33
P/B	0.004	34.52	P*Ca	0.062	51.12
P*Mg	0.029	45.83	K/N	0.230	18.52
K/Fe	0.010	103.59	K/Zn	0.036	33.31
K/Al	0.003	23.82	K/B	0.013	33.62
K*Ca	0.233	38.75	K*Mg	0.101	31.70
Ca/Al	0.004	19.17	Ca/B	0.016	32.38
Mg*Ca	0.123	43.54	Mg/Al	0.002	24.54
Mg/B	0.008	33.64	Mn/N	109.9	88.83
Mn/P	826.9	71.16	Mn/K	466.7	87.67
Mn/Fe	4.493	101.30	Mn*Ca	122.8	97.45
Mn*Mg	48.07	88.30	Mn/Al	0.615	78.47
Mn/Cu	30.89	130.94	Mn/B	2.618	55.09
Fe*Ca	34.81	59.12	Fe*Mg	16.52	73.00
Fe/Al	0.773	61.53	Fe/B	2.267	77.24
Zn/P	105.5	32.70	Zn/Mn	0.145	57.29
Zn*Ca	8.261	83.27	Zn*Mg	3.384	67.82
Zn/Fe	0.428	125.76	Zn/B	0.378	45.39
Al/Zn	12.69	32.63	Cu/N	3.355	88.81
Cu/P	50.19	75.18	Cu/K	14.41	77.28
Cu/Fe	0.269	161.41	Cu*Ca	3.693	126.90
Cu*Mg	1.589	99.78	Cu/Zn	0.483	88.55
Cu/Al	0.035	74.48	Cu/B	0.182	78.34
B/Al	0.269	26.69	-	-	-

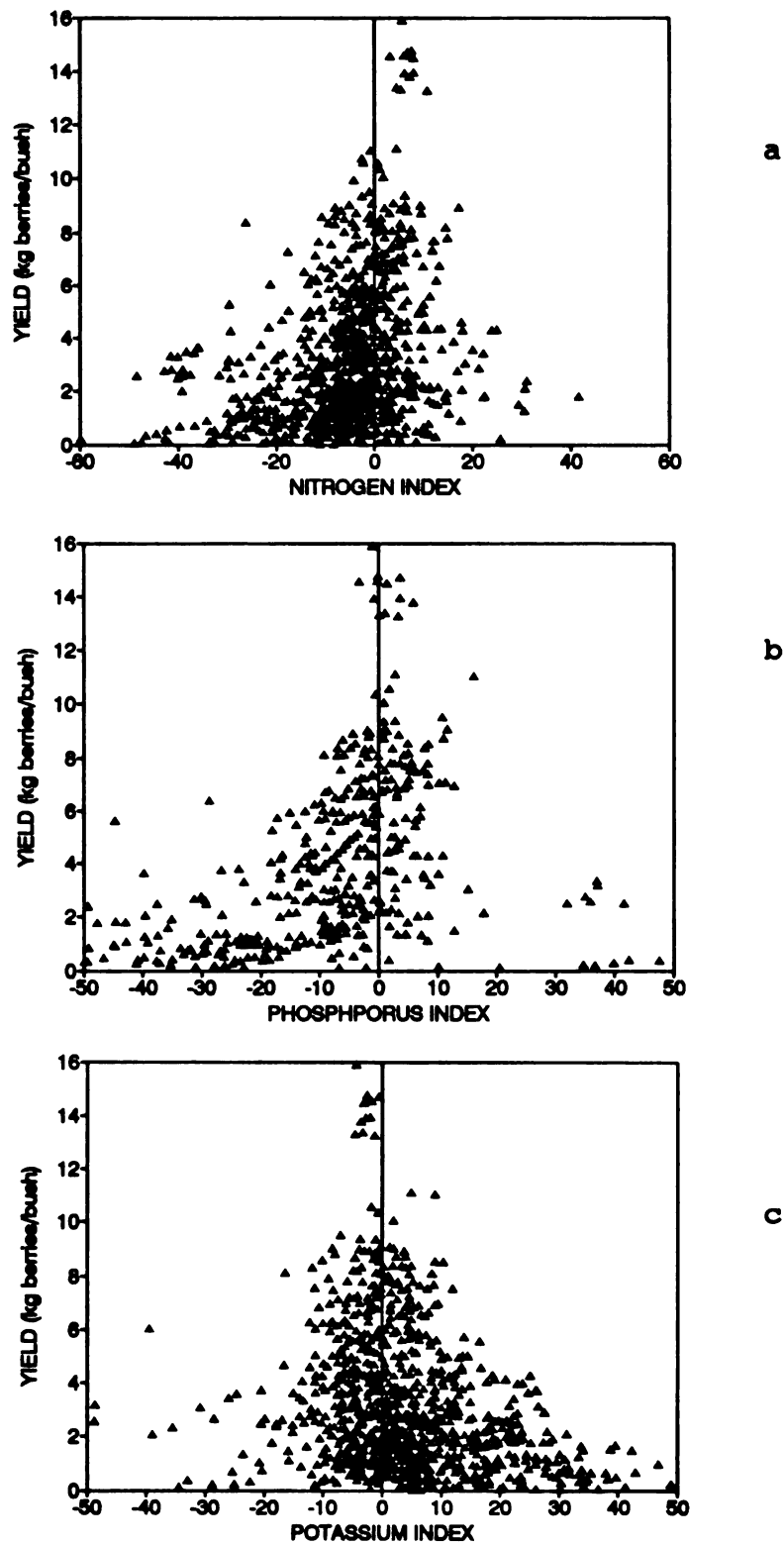


Figure 7. Relationship between DRIS Index and Blueberry yield.
a) I_N ; b) I_P ; c) I_K .

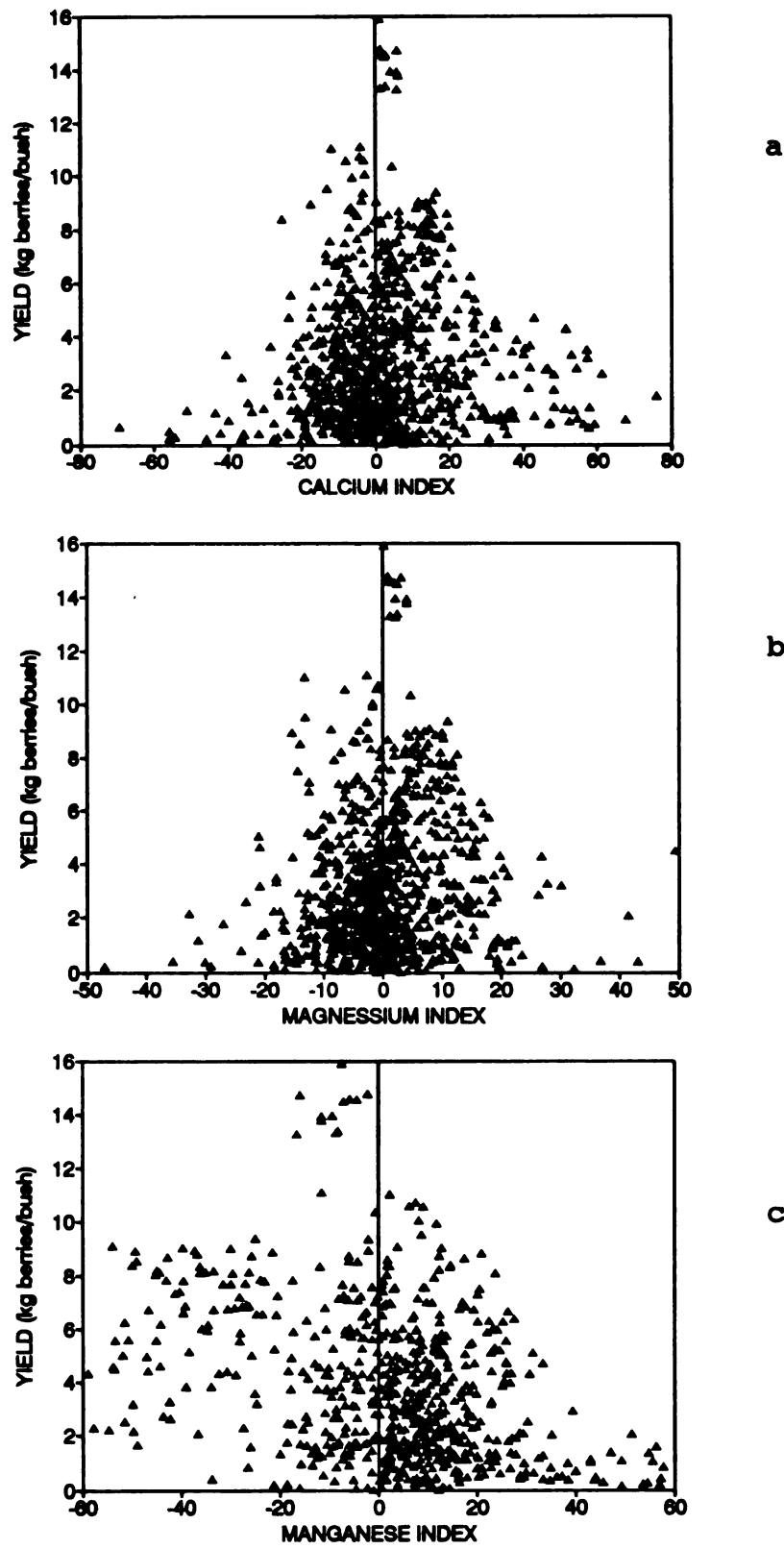


Figure 8. Relationship between DRIS Index and Blueberry yield.
a) I_{Ca} ; b) I_{Mg} ; c) I_{Mn} .

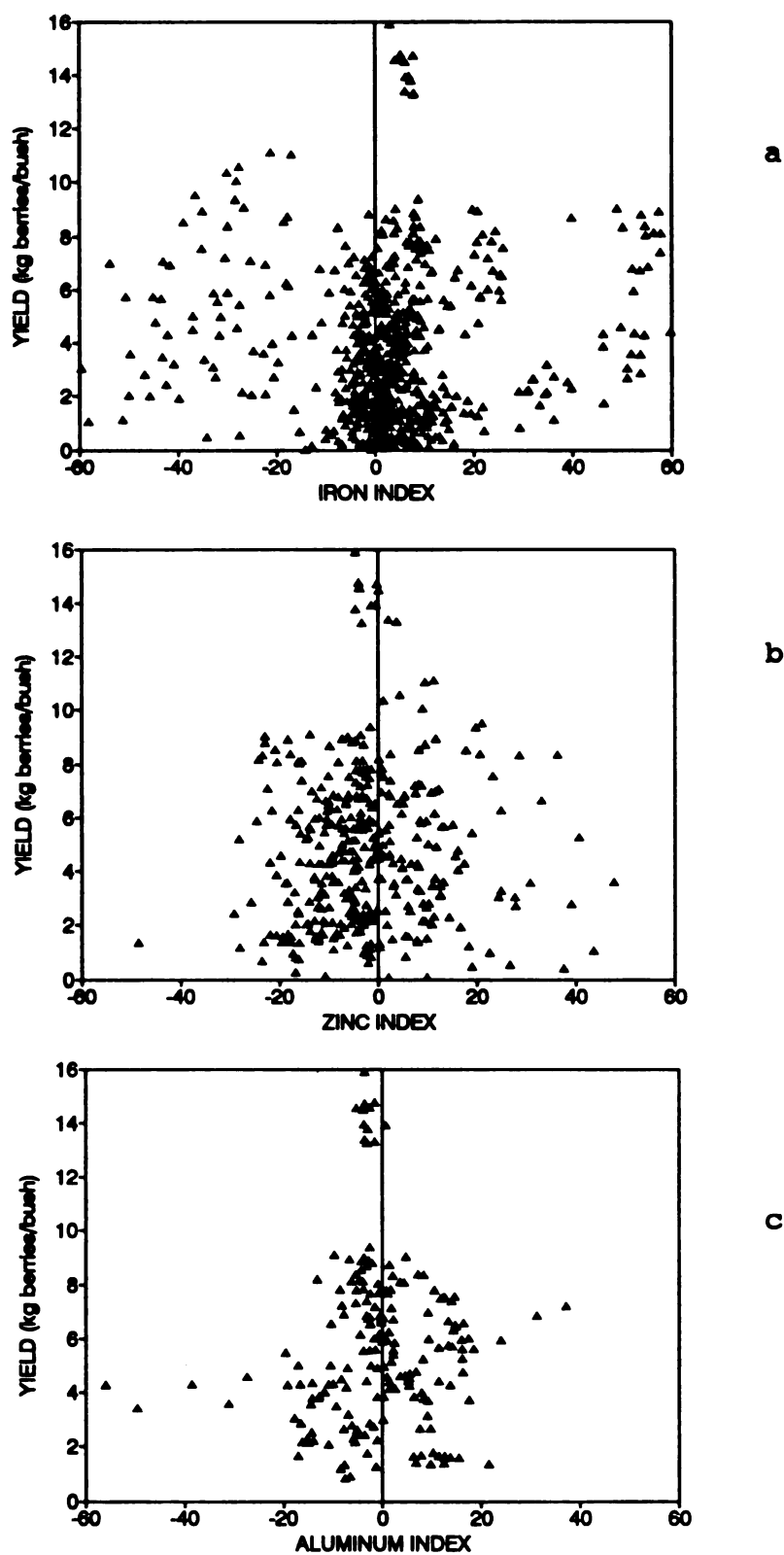


Figure 9. Relationship between DRIS index and Blueberry yield.
a) I_{Fe} ; b) I_{Zn} ; c) I_{Al} .

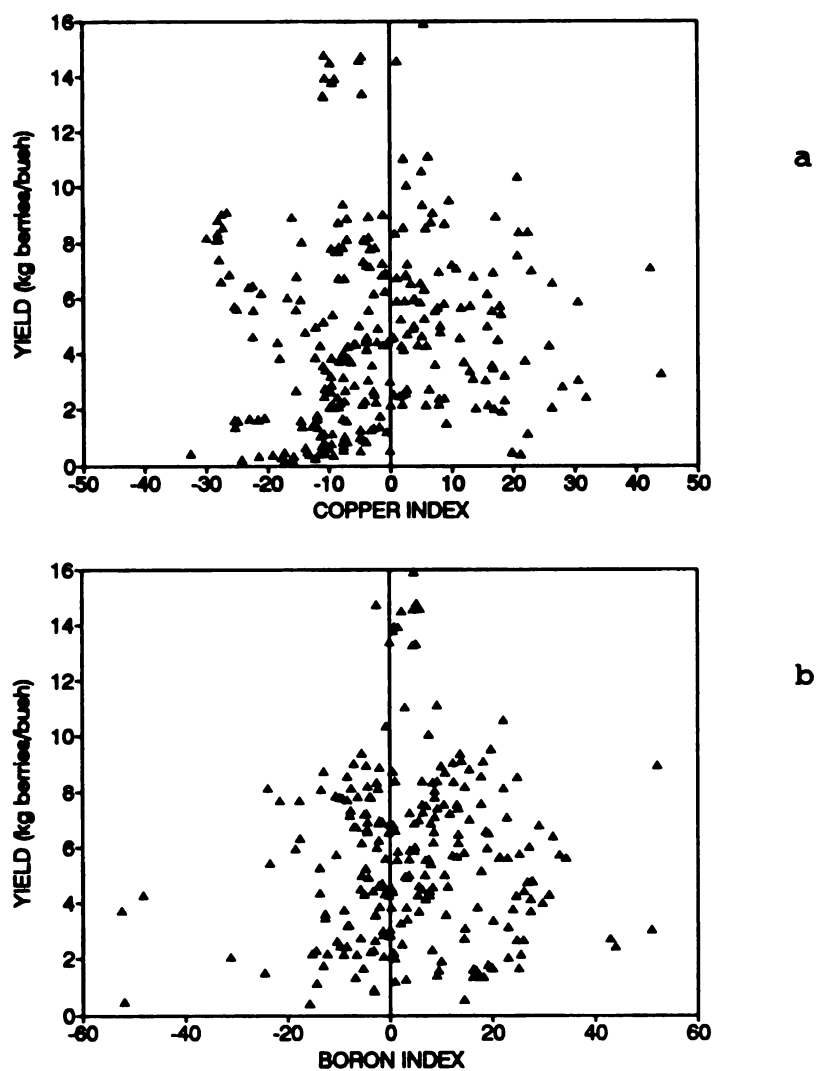


Figure 10. Relationship between DRIS Index and Blueberry yield. a) I_{Cu} ; b) I_B .

possible variability of a nutrient element in a large population: plant genetic; plant age; soil and management. It was noted, as an example, that Mn is the only nutrient element that shows consistent soil and progeny differences for leaves, roots and shoots in highbush blueberry (Korcack, 1989). DRIS indices from nutrients with a wide nutrient concentration variation have a wider range of values than indices from elements that are less variable and the differences in concentration variation between elements also affects the ratio selection (Righetti, 1988a).

2.4 Identification of Unbalances.

The nature of the DRIS system is to always make a relative diagnosis (Beaufils, 1973a). Since DRIS indices are symmetrical (their sum equal zero) there are no problems in identification of unbalances when few elements are included in the DRIS data base, but when more elements are included in the system, indices with large variation can mask the detection of a deficiency or excess of an index with a narrow range (Righetty, 1988a). DRIS always makes a relative diagnosis, but not an absolute measurement of the nutrient status. DRIS identifies the order of limitation, even if all the nutrients are present in a normal range of concentrations. A low index means for that particular nutrient compared with the other nutrients present in the same sample, that it is lower than

the same nutrient compared to those in the reference population.

From the scatter diagram of each DRIS index and yield it is possible to say that DRIS has identified relative deficiencies of N and P, relative excesses of K and not only deficiency but also excesses for Mn and Fe. Relative deficiencies and relative excesses were detected also on Sweet Cherry by Davee et al., (1986).

A DRIS index could be considered sufficient if it falls within 1.33 units of zero for indices calculated from N, P and K concentrations (Beaufils, 1973a). Using this criteria for delimiting relative excess and deficiency the diagnosis change a little (Figure 11). Seven percent or more of the total samples show deficiency not only for N and P but also for Mn, Fe and Cu. Similar percentages were found for excess in K, Ca, Fe and Zn. Iron and Al have similar percentage in both zones of limitations. Nitrogen and P indices have a high and wide dispersion of points in the deficiency area for the low yielding plants--an indication that they are limiting factors for blueberry production. Ballinger, (1969) reported that the N status of the plant appears to play a major role in the production of blueberries. High application of N was associated with low berry acidity and a high soluble solids to acid ratio. Too little N was associated with slow ripening and too much N with small berries. The level of N affected positively the number of leaves per plant, the ripening date

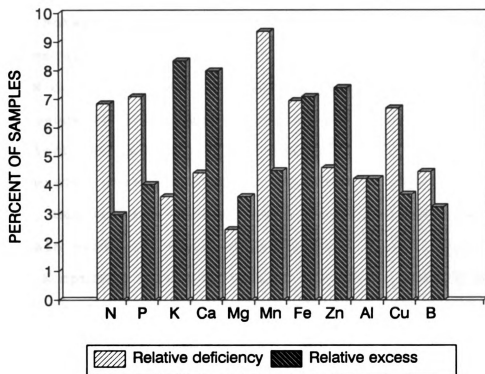


Figure 11. Relative DRIS Deficiencies or Excesses (values greater or fewer than the mean Index ± 1.33 standard deviation). (The following are means and standard deviation for each DRIS Index a) $I_N -5.9 \pm 14.4$; b) $I_P -7.5 \pm 20.8$; c) $I_K 3.9 \pm 13.8$; d) $I_{Ca} 1.9 \pm 16.9$; e) $I_{Mg} 0.18 \pm 12.8$; f) $I_{Mn} 2.1 \pm 25$; g) $I_{Fe} 3.3 \pm 18.5$; h) $I_{Zn} -1.9 \pm 14$; i) $I_{Al} -0.11 \pm 13$; j) $I_{Cu} -4.3 \pm 24.4$; k) $I_B 4.3 \pm 15.6$).

and the fruit to leaf ratio and negatively the fruit size and the acidity. Low level of P was associated with few leaves, a high fruit to leaf ratio and low berry weight.

Potassium index shows a wide scatter of points in the excess area which may be due to a negative interaction with the N content of the low yielding population or to the strong influence of crop load on leaf K, and also to differences in nutrient availability among locations. Eck (1987), found that increasing yield created an important K sink. On the other hand, Hancock and Nelson (1988), reported that there exist a certain ambiguity about K sufficiency range. They said that leaf K optimum is closer to 0.43 % of dry matter than the 0.53 % reported. If there is no relationship between leaf K and yield (Ballinger and Kushman, 1966; Eck, 1983), the use of leaf levels at harvest may not be a good indicator for generating recommendations.

Calcium levels in foliage are known to have the best relationship with blueberry yield (Townsend, 1973b). In a study made to evaluate the adaptability of different progenies from essentially pure highbush to interspecific hybrids containing varying amounts of evergreen, lowbush, black highbush and rabbiteye over four typical soils for the crop (Berryland sand, Galestown sandy clay loam, Manor clay loam and a Pope sandy clay loam) planting with or without the addition of peat moss, it was found that foliar Ca varied among soils. For the Berryland soil and peat, most amended

soils showed elevated leaf Ca levels. The positive effect of the peat may be due to the relative high Ca of the material compared to the K content (Korcack, 1989). Most of the samples analyzed in this data base came from similar soils. However, Cummings (1978), noted a negative effect of high K on the foliar content of Ca. Elevated Zn foliar levels were also reported as a consequence of K applications (Cummings et al., 1971).

2.4.1 The Nutrient Imbalance Index (NII)

Beaufils (1973b), said that another technique to determine imbalances is to only consider the relative deficiencies or excesses when the sum of DRIS indices, irrespective of sign (NII), is excessive (Appendix Table 2). The scatter of points of the NII and yield for the whole population shows that there was no relationship between NII and yield (Figure 12). However the general pattern usually found in other works is also present (Davee et al., 1986; Szucs, 1990; Klein et al., 1991). As a consequence, when there is not a relationship between both variables, it was assumed that samples which fall in a range greater than the mean of all the NII plus 1.33 times the standard deviation are considered extremely unbalanced (Figure 11). Both populations have points far from this limit. The high yielding population has 12.4 % of its samples and the low yielding 8.63 % in

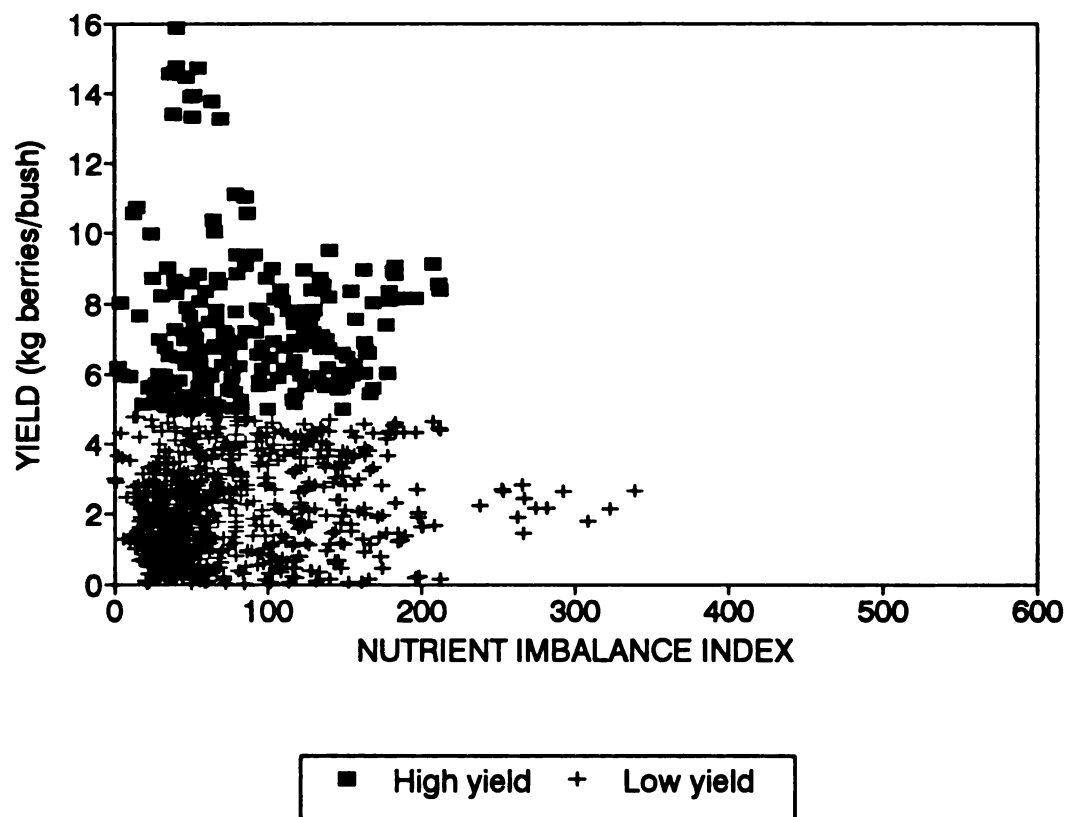


Figure 12. Relationship between DRIS Nutrient Imbalance Index (NII) and Yield for the High and Low Yielding Population.
+ Low yielding, A Population, ($x < 5$ kg berries/bush).
■ High yielding, B Population, ($x \geq 5$ kg berries/bush).

unbalanced conditions. There is no reference in the literature which supports the difference found in percentage of unbalances between both populations of high and low yielding plants. However, two factors might induce such variability: the mix of plant age, and the number of nutrient analyses available per sample in each of the subpopulations. But, low yields were always associated when the sum of DRIS indices was very high. A similar conclusion was arrived at by Meldal-Johnsen et al., (1975).

2.4.2 Relative Order of Nutrient Limitation.

One of the advantages noted for the DRIS approach was its ability to rank the nutrients in their order of relative limitations. When DRIS indices were placed in increasing order for all samples, limiting elements with both relative deficiencies or excesses were identified (Appendix Table 2). When only the most and least relative limiting nutrient were analyzed a close similitude with the nutrients before noted as unbalanced were found. From the total of samples that belong to the high yielding population the relative most limiting (deficient) nutrients were Mn, Fe and Cu and the relative least limiting (excess) were Mn, Fe and Ca. In contrast the most limiting nutrient for the low population were N, P, Ca and Zn and the relative least limiting nutrient were K, Mn and B (Figures 13 and 14).

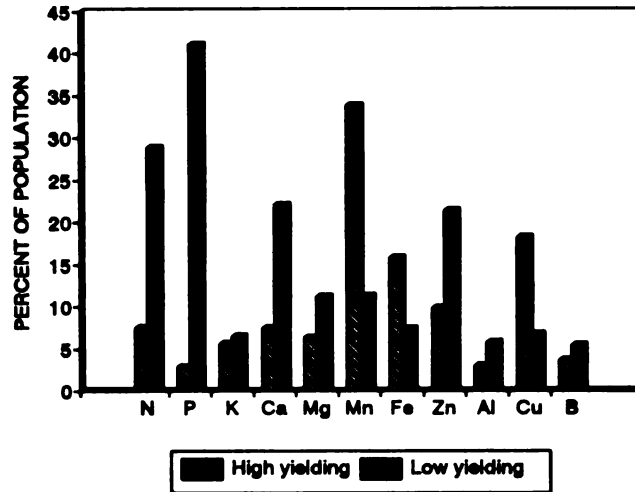


Figure 13. Relative most limiting nutrient (percentage of the Blueberry population with the lowest DRIS index for all the DRIS indices available per sample).

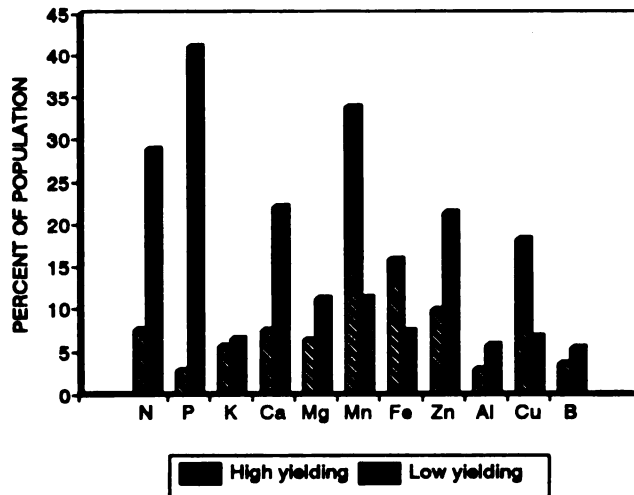


Figure 14. Relative least limiting nutrient (percentage of the Blueberry population with the biggest DRIS index for all the DRIS indices available per sample).

Finally, considering the whole information that the DRIS could bring in detecting nutritional limitations it is clear that the whole population can be characterized by the presence of deficiencies in N, P, Ca and Cu and excesses in K and Mn. Future calibration of the DRIS norms in field trials would bring more information about the accuracy of detection limitations and in the possible masking effect that some nutrients could have.

2.5 Comparison of Different Approaches in Diagnosing Nutritional Limitations.

Diagnosis made by traditional methodologies, Sufficiency Range Value (SRV) and Critical Level (CL), for the whole population have also diagnosed a high proportion of samples with N, P and Ca and micronutrients like Fe, Mn, Zn, Cu, and B as limiting nutrients (Table 2 and 3).

There appears to be a close agreement between the SRV and DRIS in detecting a high proportion of samples with excess of both K and Mn. The SRV has detected 28.4 % of samples in the higher ranges for K and DRIS has detected 24 %. Similarly for Mn the SRV has detected 45.7 % and DRIS 40.9 %. With the other nutrients DRIS seems to indicate excess where the SRV consider the nutrient as sufficient with two exception -- N and Mg where only DRIS detect a very small percentage as relatively in excess.

DRIS is in a total agreement with the percentage of samples below the Michigan Standard for K but, again DRIS detected deficiencies for N, Ca, Mg and Cu where SRV and CV standards usually placed samples in the normality range. However, the DRIS approach seems to be less sensitive in detecting deficiencies of Mn, Fe, Zn and B. This data is in agreement with the general concept that DRIS reveals nutrient deficiencies in the range normally considered to be sufficient (Angeles et al., 1990), and with the possible bias effect that some nutrients with a wide concentration variation have in the ratio selection and in masking limitations (Righetty, 1988a).

2.6 Some limitations found in the DRIS.

Usually the few applications of DRIS found for fruit crops have used independent sets of data from field experiments with a narrow range of plant age and uniform number of nutrients per sample to make comparison with other diagnostic systems like the SRV and or the CL (Angeles, 1990; Beverly et al., 1984; Goh and Malakouti, 1992; Righetti et al., 1988b). As mentioned before, two possible factors could have caused the relative unbalances found between the low and high yielding population--the plant age and the number of nutrient analysis available per sample.

The effect of the number of nutrients analysed available per sample shows a trend of increasing the average of NII

(Figure 15). The discrimination of possible samples in a data base using the criteria of the number of nutrients analysed goes against one of the principles of DRIS, the indiscriminate use of any sample (Beaufils, 1973a), but it could simplified calculations.

Plant age is a known factor related with fruit productivity (Leopold, 1964; Westwood, 1988; Kozlowski, 1991). However, the productivity is also related to the plant density, the total uptake of nutrients, the importance of an adequate root system, the demand for nutrients at any time, and the extent of the internal remobilization of nutrients (Atkinson, 1986). Most of these important factors were not included in this preliminary data base, but an approximation of the effect of plant age was examined.

A simple way to observe the effect of plant age on the nutrient balance index was to split data among age range of bushes and to observe the distribution of NII versus yield. The general pattern observed for the whole population is still present; however, when a range between 0 to 100 of NII was analyzed a difference among the average of NII and plant age appears (Figures 16 to 18). As plant age range increased the NII is displaced to the higher limit. This suggests a new hypothesis that DRIS could be dependent on plant age.

To overcome some of the possible factors that may contribute to the observed pattern, the population was

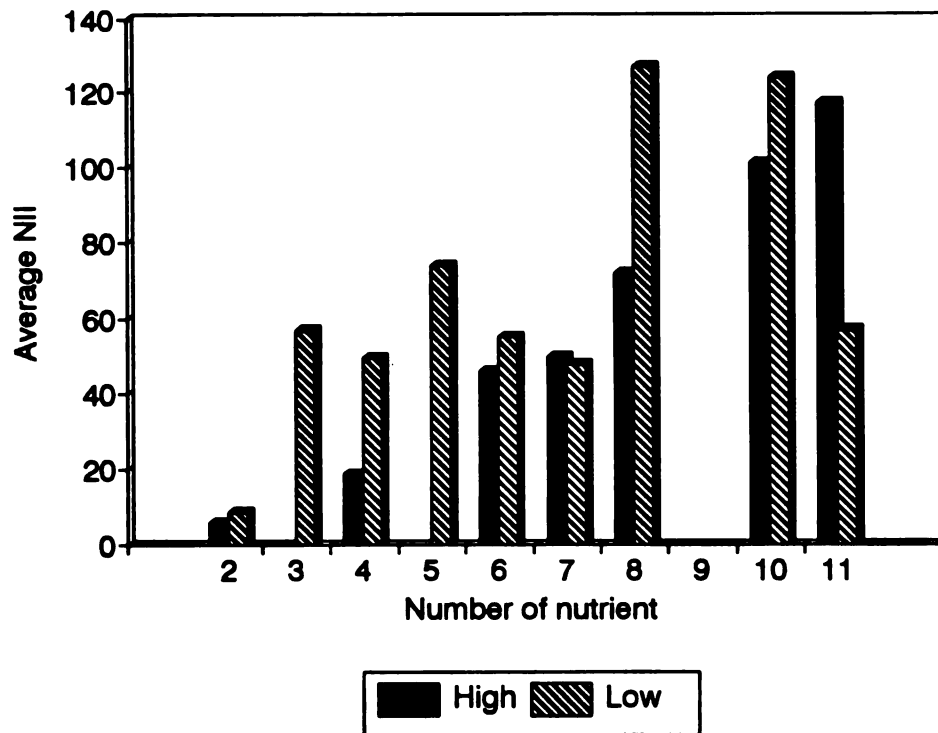
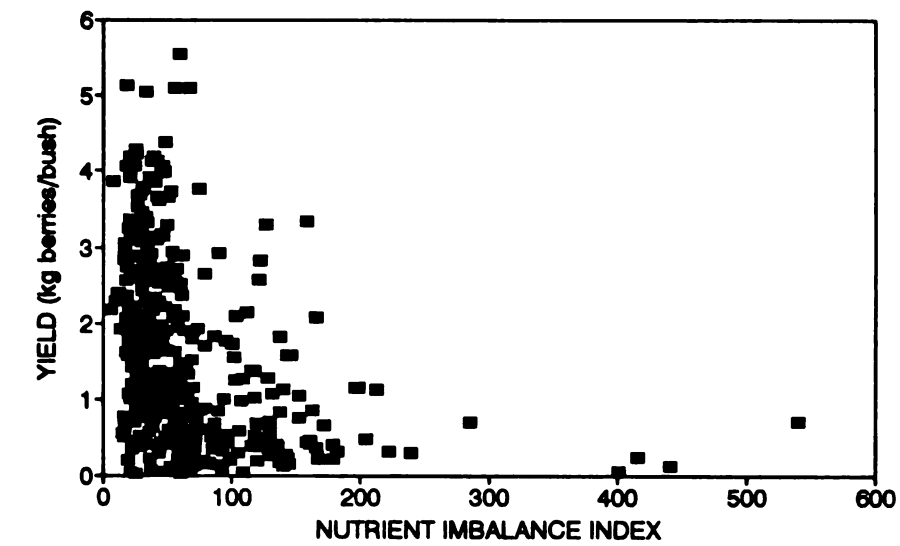
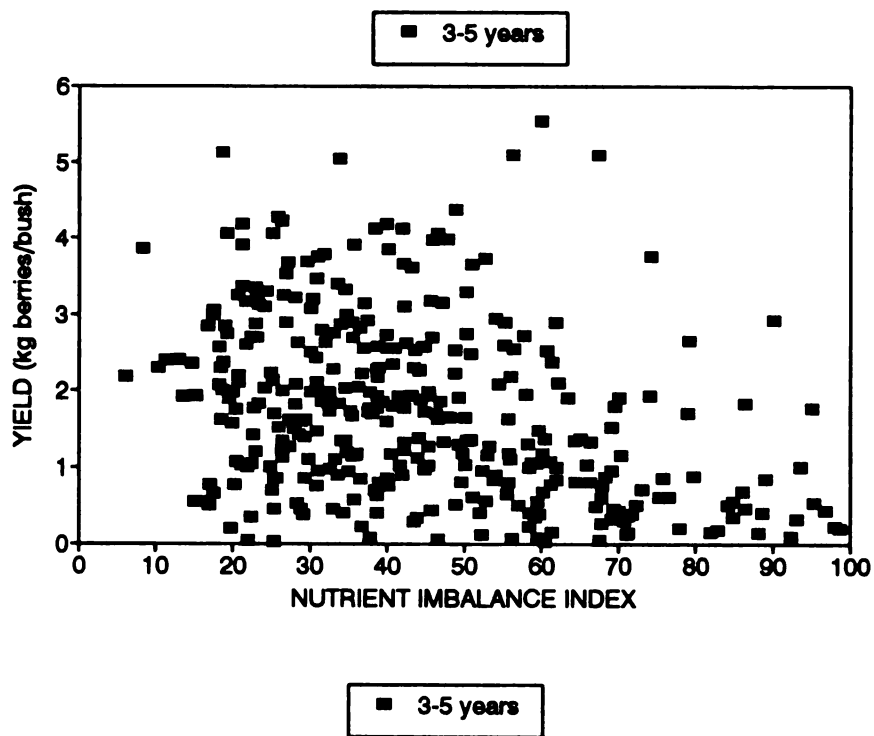


Figure 15. Relationship between the average Nutrient Imbalance Index (NII) for the high and low yielding population and the number of nutrient availables per sample.



a



b

Figure 16. Relationship between the Nutrient Imbalance Index for the plant age 3 to 5 years old and Yield. a) scatter diagram for the whole NII range; b) scatter diagram for NII between 1 to 100.

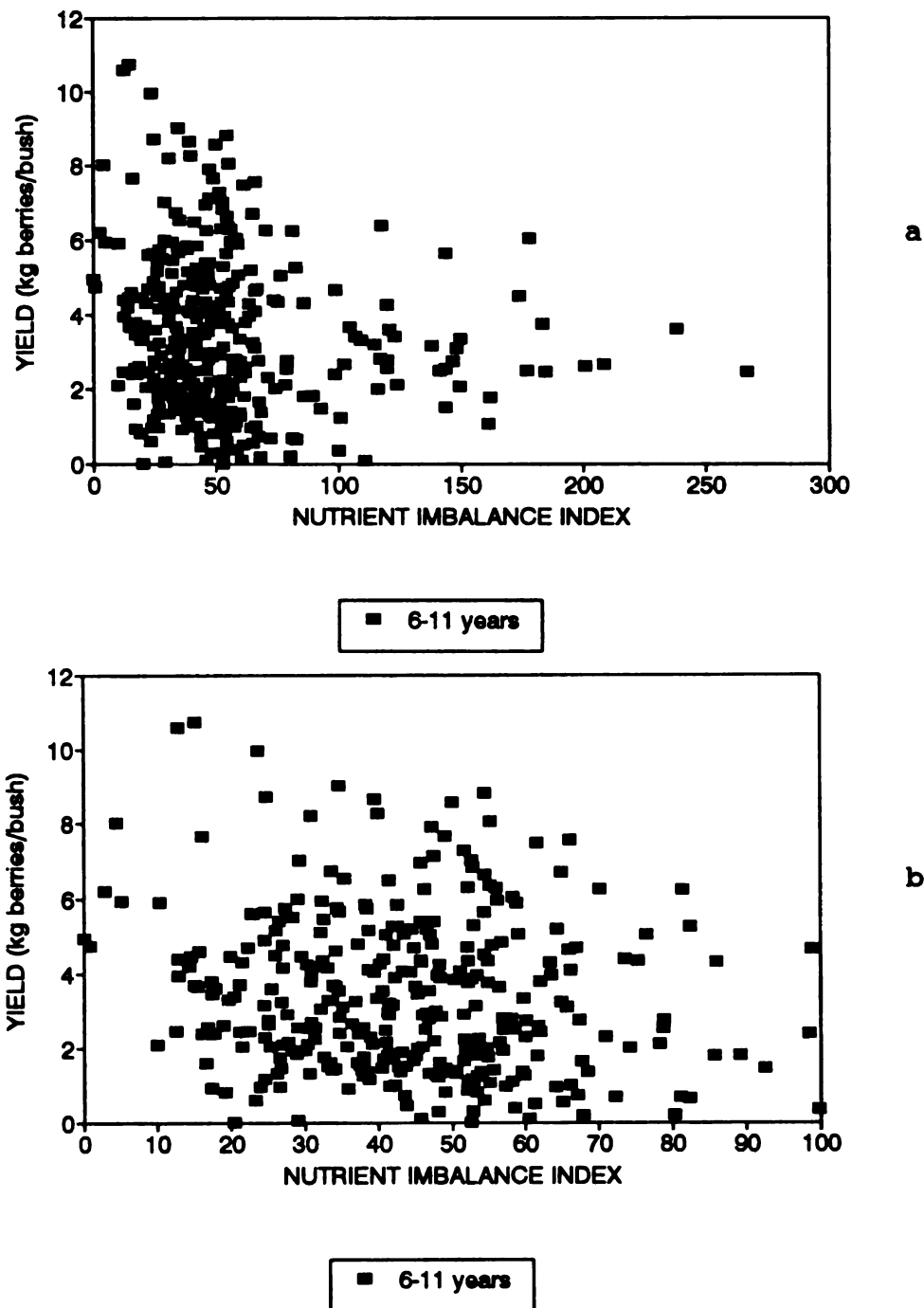


Figure 17. Relationship between the Nutrient Imbalance Index for the plant age 6 to 11 years old and Yield. a) Scatter diagram for the whole NII range; b) Scatter diagram for NII between 1 to 100.

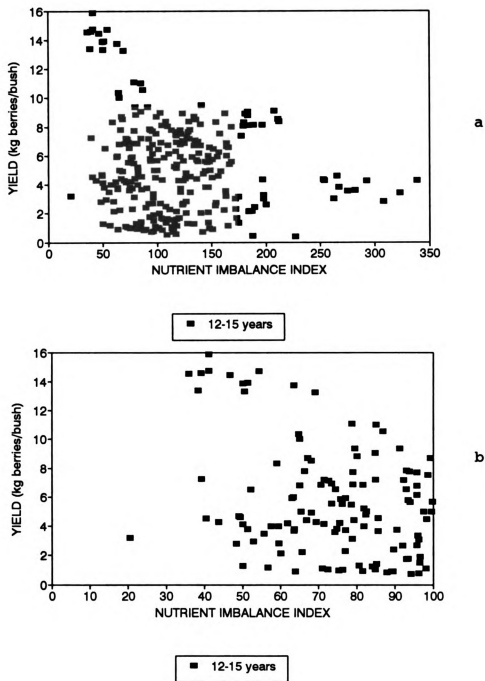


Figure 18. Relationship between The Nutrient Imbalance Index for the plant age 12 to 15 years old and Yield. a) Scatter diagram for the whole NII range; b) Scatter diagram for NII between 1 to 100.

analyzed by plant age range and only samples which have equal number of nutrients were included (Table 7). A clear difference of the effect of plant age among nutrient optimum and nutrient ratios appears. The nitrogen mean decreases as plants age. This confirms studies where heavy crop loads can decrease the N content of leaf (Ballinger and Goldston, 1967; 1969). The potassium content decreases with age, as was mention before since increasing yield creates an important K sink (Eck, 1983), and the expected increases in Mg as plant developed was observed (Parent and Granger, 1989).

There are controversial reports about the independence of the DRIS diagnostic on the tissue age (Sumner, 1977a, 1977b, 1977d; Admunson, 1987; Beverly et al., 1984; Hanson, 1981). The effect of plant age was shown only in the significant year to year variation that DRIS norms has in the report of Parent and Granger (1989). They derived DRIS norm for apple trees on dwarfing rootstocks from a seven years fertilization trial and conclude that, although the cumulative yields were used to define the norms, the relationships between cumulative and annual yields and DRIS parameters gave similar DRIS norms after the 5th and the 6th years of plantation due to the strong influence that tree development stage has on leaf nutrient composition.

The wide range of plant age used in this work allowed the derivation of DRIS norms for the ranges noted before (Table 8)

Table 7. Effect of age of bushes for three high yielding subpopulations on the optimum of nutrients and nutrient ratios.

Std	Range age of bushes					
	3-5		6-11		12-15	
	Mean ¹	Std	Mean	Std	Mean	
Yield (kg/bush)	4.13 C	0.51	7.78 B	0.67	13.16 A	1.76
N %	2.25 A	0.26	2.22 AB	0.14	1.99 B	0.13
P %	-	-	-	-	0.13	0.03
K %	0.63 A	0.11	0.51 AB	0.09	0.40 B	0.07
Ca %	0.55 ab	0.12	0.49 b	0.14	0.60 a	0.07
Mg %	0.19 BC	0.03	0.18 C	0.04	0.31 A	0.04
N/P	-	-	-	-	16.29	2.18
P/N	-	-	-	-	0.06	0.01
N/K	3.70 B	0.76	4.44 AB	0.57	5.14 A	0.67
K/N	0.28 A	0.05	0.23 BC	0.04	0.20 C	0.03
N/Ca	4.42 A	1.55	4.91 AB	1.45	3.35 B	0.40
Ca/N	0.25 AB	0.06	0.22 B	0.07	0.30 A	0.04
N/Mg	12.29 A	3.01	12.64 A	2.75	6.60 B	0.96
Mg/N	0.09 B	0.02	0.08 B	0.02	0.16 A	0.03
P/K	-	-	-	-	0.32	0.02
K/P	-	-	-	-	3.17	0.22
P/Ca	-	-	-	-	0.21	0.03
Ca/P	-	-	-	-	4.88	0.63
P/Mg	-	-	-	-	0.41	0.08
Mg/P	-	-	-	-	2.50	0.41
K/Ca	1.24 A	0.51	1.15 A	0.47	0.66 B	0.08
Ca/K	0.91 C	0.27	1.00 BC	0.36	1.54 A	0.18
K/Mg	3.41 A	0.95	2.98 A	1.11	1.31 B	0.28
Mg/K	0.31 C	0.08	0.37 BC	0.12	0.79 A	0.14
Ca/Mg	2.94 A	0.70	2.75 AB	0.85	1.98 B	0.24
Mg/Ca	0.37 B	0.14	0.40 AB	0.12	0.51 A	0.06
N*Ca	1.23 NS	0.30	1.09 NS	0.32	1.20 NS	0.18
P*Ca	-	-	-	-	0.08	0.03
K*Ca	0.34 A	0.09	0.25 BC	0.06	0.24 C	0.07
Mg*Ca	0.10 BC	0.03	0.09 C	0.03	0.19 A	0.05
N*Mg	0.42 BC	0.07	0.41 C	0.10	0.61 A	0.09
P*Mg	-	-	-	-	0.04	0.01
K*Mg	0.12 a	0.02	0.09 b	0.02	0.12 a	0.04

¹ Means followed by different capital letters are significantly different at (P = 001) by Duncan's Multiple Range Test.

Means followed by different minor letters are significantly different at (P = 005) by Duncan's Multiple Range Test.

NS = not significantly difference.

Table 8. Blueberry DRIS NORM related to age range for equal number of nutrient per observation.

Age Range	3-5		6-11		12-15	
Form of Expr.	Mean	CV%	Mean	CV%	Mean	CV%
N/P	-	-	-	-	16.29	13.40
K/N	0.28	14.88	0.23	15.33	0.20	15.66
K/P	-	-	-	-	3.17	6.83
Ca/N	0.25	26.10	-	-	-	-
N*Ca	-	-	1.09	29.66	1.20	15.09
Mg/N	0.09	22.31	0.08	22.71	-	-
N*Mg	-	-	-	-	0.61	14.42
K*Ca	-	-	0.25	25.21	-	-
P*Ca	-	-	-	-	0.08	33.29
P*Mg	-	-	-	-	0.04	36.16
Ca/K	0.91	29.92	-	-	-	-
K*Ca	-	-	-	-	0.24	30.80
K*Mg	0.12	20.13	0.09	16.71	0.12	30.72
Ca*Mg	0.10	29.22	0.09	37.01	0.19	26.28
n	402		315		287	

Although there are only few nutrient ratios for comparison and there were not always coincidence with the selection of the important ratios with the previous derived DRIS norms, it appears that there is a close similarity of the DRIS norms derived from the whole data base with those in the range of 12 to 15 years old blueberries. However, discrepancies between norms from the whole data base and those of young plants seems to be greater. Future analysis will be required to determine if plant age will affect the DRIS norms. It seems reasonable that a more accurate diagnosis could be made if DRIS norms are derived for very young plants before stabilization of crop yield is found.

3. Correlation between DRIS and the Critical Value.

The use of the CV as a diagnostic tool has been applied extensively since the concept was developed by Ulrich and Hill (1967); however, little information about correlation with DRIS is available in the literature (Needham et al., 1990). The possible reasons for the lack of this information is that most researchers are interested in the development of DRIS norms and in the evaluation of the impact of its multiple nutrient composition in diagnosis and fertilizer recommendations.

There is information available about CV levels for the different nutrient elements on highbush blueberry (Eck, 1988;

Table 9. Comparison of Blueberry DRIS nutrients and Critical Level estimated and reported in the literature.

Nutrient	DRIS		CRITICAL		LEVEL
	Norm	Optimum	Estimated ¹ from data	Eck	Reported MI
N %	1.93	1.92	1.96	1.80	1.65
P %	0.11	0.12	0.11	0.12	0.10
K %	0.44	0.43	0.34	0.35	0.35
Ca %	0.52	0.45	0.63	0.40	0.34
Mg %	0.23	0.23	0.32	0.12	0.12
Mn mg/kg	229	452	83	50	168
Fe mg/kg	71	127	56	60	150
Zn mg/kg	14	13	11	8	20
Cu mg/kg	6	13	3	5	15
B mg/kg	35	33	33	30	49

1 Estimated as described by Ulrich and Hill, (1967).

Table 10. Comparison between DRIS and Critical Value.

Coefficient of determination (R^2)					
Correlation			DRIS	Critical value ¹	
				Estimated range,	Reported Literature,
N %	-	I_N	n.s.	n.s.	n.s.
P %	-	I_P	0.64**	0.53**	0.70**
K %	-	I_K	0.44**	n.s.	n.s.
Ca %	-	I_{Ca}	0.62**	0.49**	0.46**
Mg %	-	I_{Mg}	n.s.	n.s.	n.s.
Mn mg/kg	-	I_{Mn}	0.64**	0.47**	0.61**
Fe mg/kg	-	I_{Fe}	0.61**	0.89**	0.48**
Zn mg/kg	-	I_{Zn}	0.75**	0.54**	0.52**
Cu mg/kg	-	I_{Cu}	0.73**	0.69**	0.79**
B mg/kg	-	I_B	0.74**	0.73**	0.71**

n.s. = Not significant.

** = $P > 0.01$.

1_a Values between the estimated optimum DRIS index and DRIS index.

1_b Values between the suggested by Eck, (1988) and the DRIS index.

Kenworthy, 1979; Ballinger et al., 1969; Hancock and Hanson, 1986) however, these reference values need to be used for similar conditions to those under which they were established to get accurate diagnosis. It was noted by Bates (1971), that many factors can affect the critical concentrations of a tissue (age, cultivar, interactions among nutrients, fraction of nutrient to be measured, environment); however, any factor that reduces yield has the potential of interacting in the growth response and consequently affecting the CV (Walworth and Sumner, 1988).

It was mentioned before that the DRIS data base was a pool of samples from different cultivars, plant age, nutrient interactions, soil conditions and crop managements; thus it may be expected that more than one factor at a time could have influenced in the productivity and in the possible evaluation made by a CV approach.

DRIS diagnosis makes a relative diagnosis, taking into account all internal and external factors that affect yield. As a consequence, the two approaches are conceptually different. Therefore, to make a correlation between both methodologies requires some adjustment. I agree with the criteria given by Needham (1990), in his work for loblolly pine. A foliar nutrient optima was defined by averaging the concentrations of each respective nutrient element of all high yielding bushes that exhibit simultaneously optimum DRIS index (mean plus/minus 1.33 standard deviation) as a new tentative

critical level (Table 9).

There is agreement in the N nutrient concentrations among all diagnostic approaches with the exception of the Michigan standard value; however, a total agreement was found for the P values.

The K values derived from DRIS are equal to the last critical value 0.43 % K reported for Michigan condition (Hancock and Nelson, 1988). The optimum Ca value is close to that reported by Eck, (1988). Magnesium and Mn show values with the poorest agreement among diagnostic criteria. The Fe DRIS optimum value is close to the Michigan value; however, those values which belong to the DRIS norm, or estimated from the data base and that reported for Eck are closer. Zinc and B values developed from the same data base are close to those reported by Eck, (1988). Developed DRIS optimum values and the Michigan values for Cu tend to agree; but, the Cu DRIS norm and the calculated critical value are in concordance with those reported by Eck, (1988).

Except for the agreement found for P values, it appears that the differences among values are probably due to the lack of uniformity among data and methodologies used to establish those values. The interpretation of these results would require calibration with further trials, thus under more uniform conditions.

To aid in visualization of the possible relationship between each DRIS index and the nutrient concentration,

scatter diagrams were constructed (Figures 19 to 22). The relationship between DRIS indices and its respective nutrient concentrations vary with the elements. With the exception of N and Mg all nutrients show some degree of association. All nutrients with the exception of Mg and Ca are positively associated and all micronutrients could be described by a linear relation. DRIS indices for Cu above 10 ppm, B above 20 ppm, Al above 50 ppm, and Zn in all the range studied seem to be so dependent on their concentrations, that it may be of little advantage to use a ratio based diagnosis over a CV approach. The lack association for N and Mg, in contrast, shows that DRIS indices could be dependent on others nutrients or others factors. The Mn scatter and to some degree that of P show an exponential form.

The coefficient of correlations calculated between DRIS index and the nutrient concentration, the DRIS index and the defined foliar nutrient optima and the DRIS index with the normal range suggested for highbush blueberry (Table 10) show that with the exception of N and Mg noted before, all nutrients have medium to high correlation ($r > 0.6$). The coefficient of determination of these relationships were highly significant. The degree of association of the estimated critical value and DRIS indices show variations among nutrients and a decrease in the relationships was observed for Mn and an increased for Fe. This could indicate that variation in Mn concentration affected the ratio

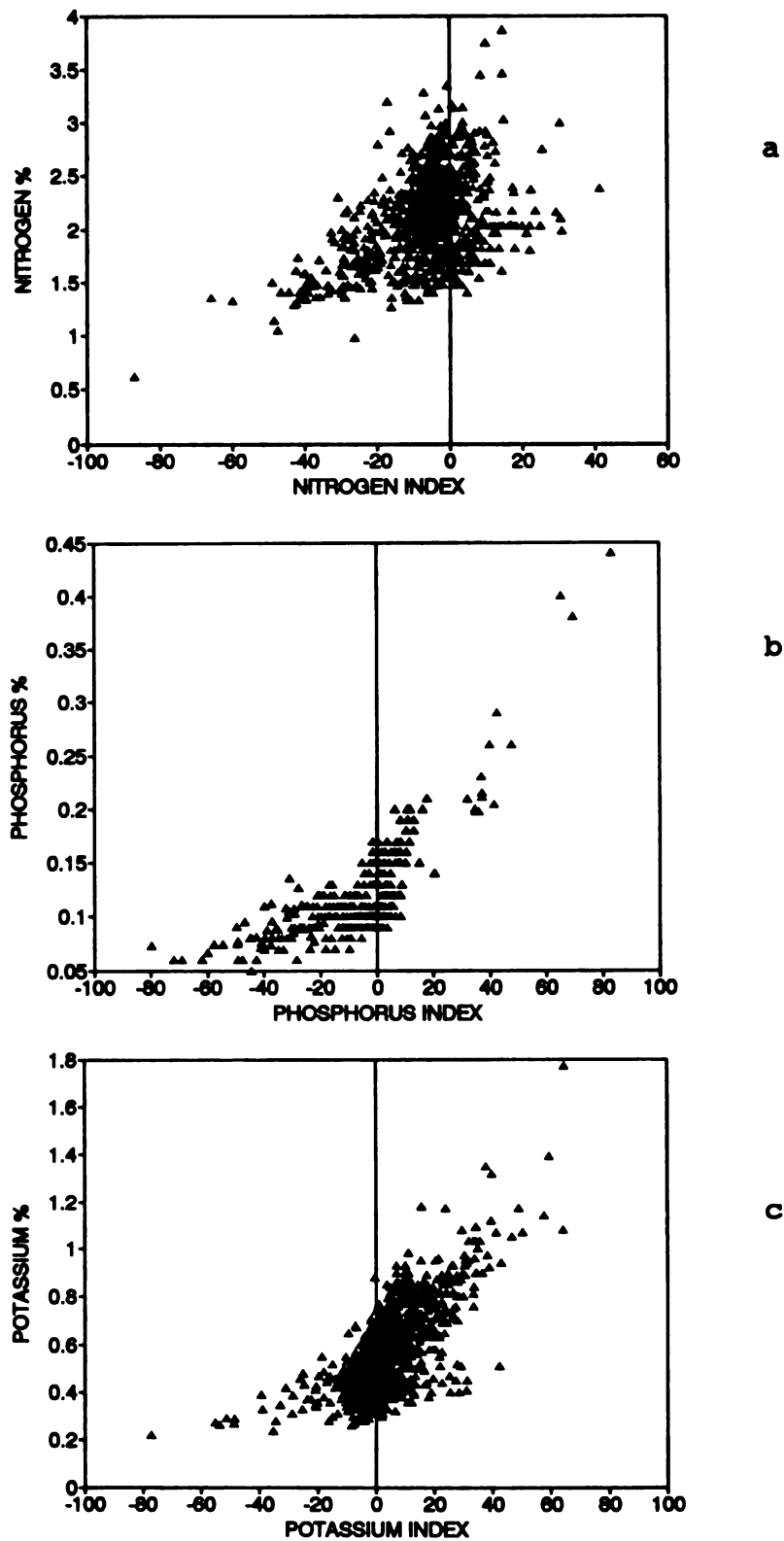
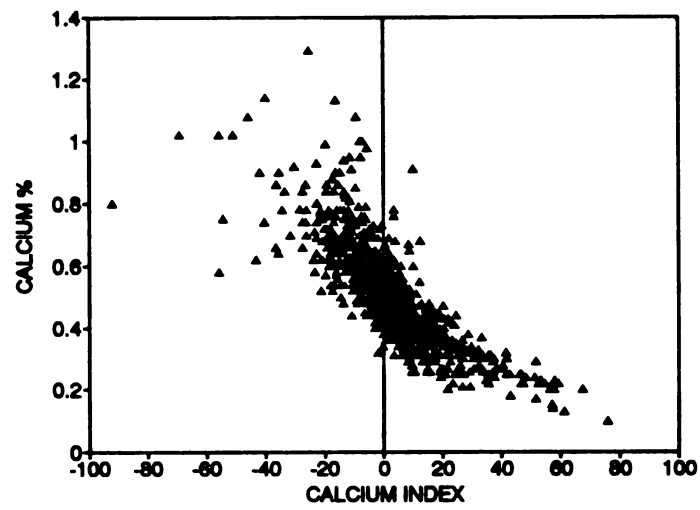
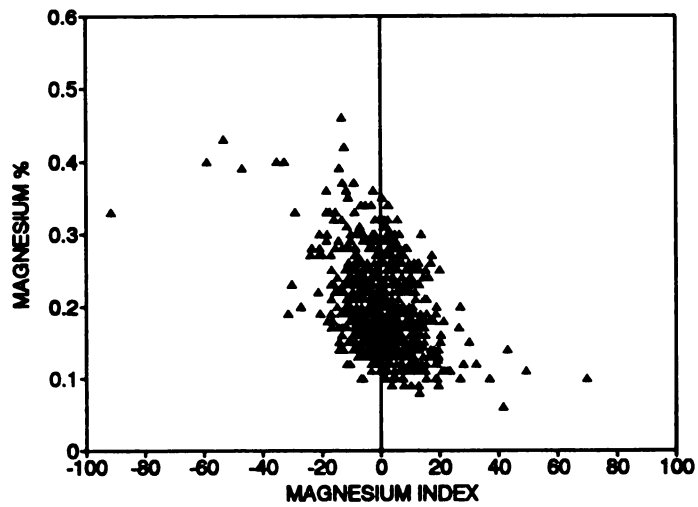


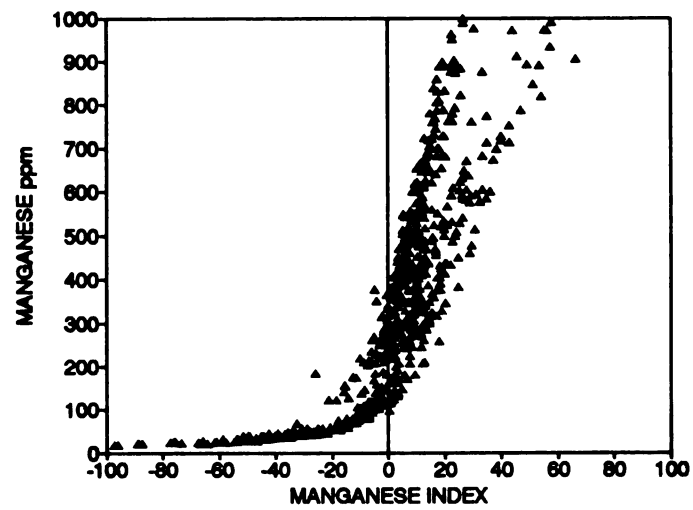
Figure 19. Relationship between DRIS Index and leaf nutrient concentration. a) N; b) P; c) K.



a

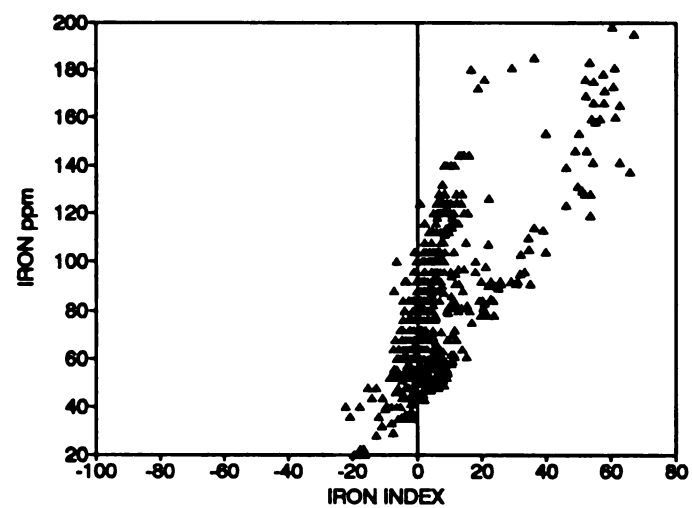


b

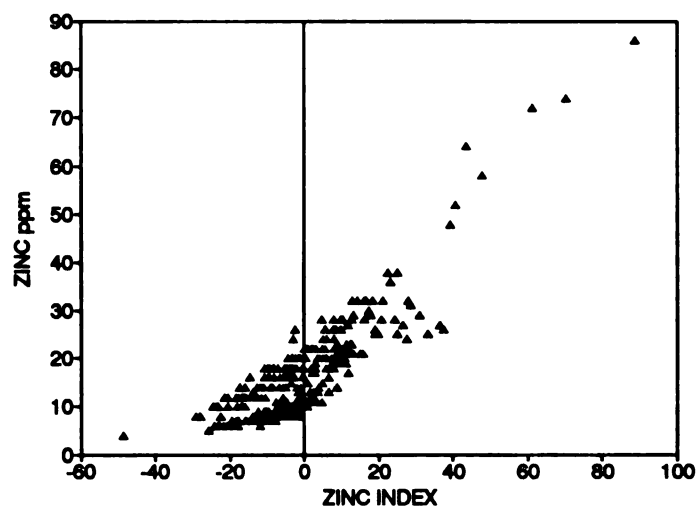


c

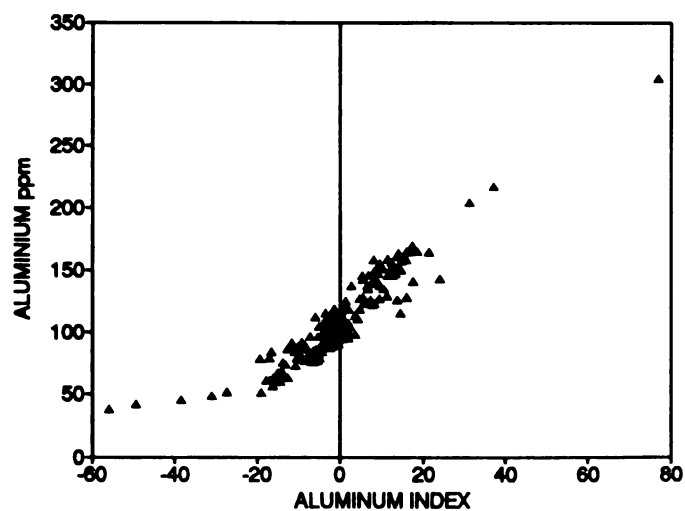
Figure 20. Relationship between DRIS Index and leaf nutrient Concentration. a) Ca; b) Mg; c) Mn.



a



b



c

Figure 21. Relationship between DRIS Index and leaf nutrient Concentration. a) Fe; b) Zn; c) Al.

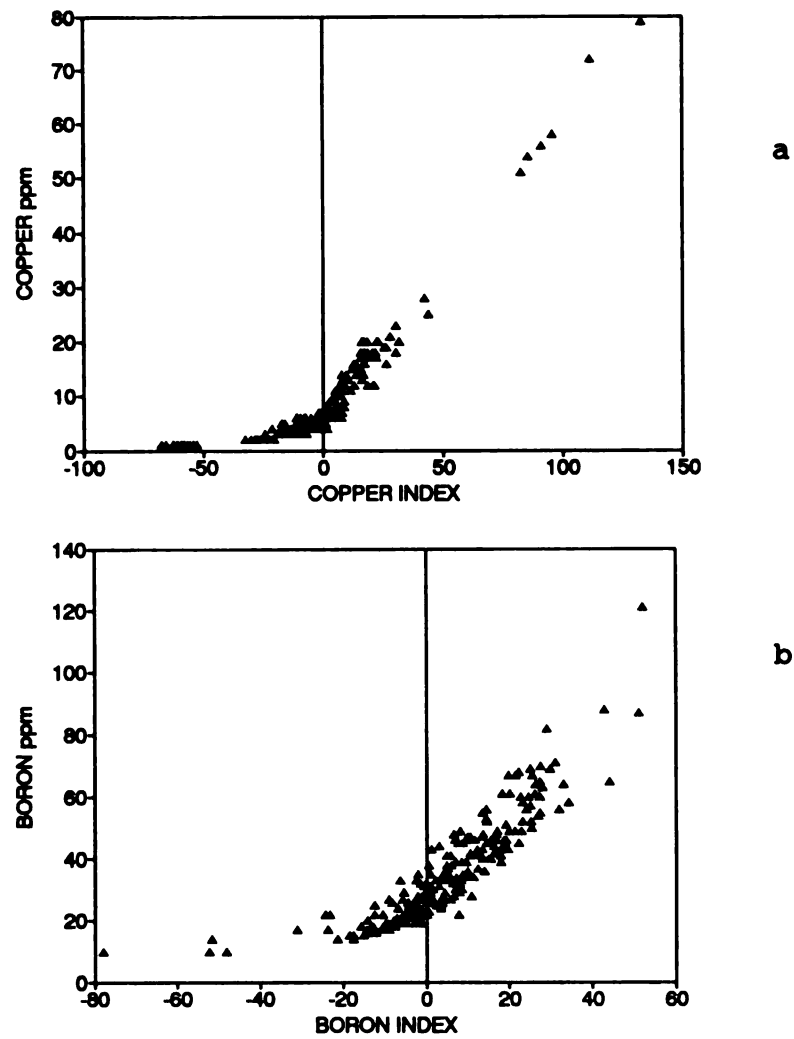


Figure 22. Relationship between DRIS Index and leaf nutrient concentration. a) Cu; b) B.

selection and consequently masked some deficiencies. Of course there is no way to prove this until DRIS norms can be calibrated in field trials. However, since correlations were calculated for a different number of observations, it must be pointed out that higher correlations are required for significances when fewer number are included.

SUMMARY AND CONCLUSIONS

A data base of 1074 observations of highbush blueberry ranging from 3 to 15 years old containing yield and foliar nutrient concentrations was used for developing the Diagnostic and Recommendation Integrated System (DRIS) norms. The criterion for dividing the population in two subpopulations was a yield value equal of or greater than 5 kg berries/bush. A total of 110 nutrient ratios were calculated among all possible combination of nutrient (N, P, K, Ca, Mg, Mn, Fe, Al, Zn, Cu and B) elements. The largest ratio of variance between the low over the high yielding population of all possible ratios was used as a selection criteria for discrimination among ratios. The resulting selected ratios of the high yielding population were used as the first tentative set of DRIS Norms for highbush blueberries. Analysis of the whole population in the data set and of specific subpopulations were made utilizing the tentative set of DRIS Norms. These analysis show that:

1. The number of nutrient analysis available per sample, nutrient concentration variations and the age of plants have been identified as possible factors that can influence DRIS diagnosis;

2. DRIS diagnosis has identified relative deficiencies of N, P, Ca and Zn and relative excesses of K and Mn for the blueberries;

3. DRIS diagnosis has identified N, Ca and Zn as the most limiting (deficient) nutrients for the low yielding population, and Mn, Fe and Cu for the high yielding population;

4. DRIS diagnosis has identified K, Mn and B as the least limiting nutrient for the low yielding population, and Mn, Fe and Ca for the high yielding population;

5. DRIS and the Sufficiency Range Value (SRV) were in agreement for the detection of K and Mn excesses. DRIS appears to indicate excess for the other nutrients where the SRV considers them to be in the sufficient range;

6. DRIS and the Michigan Critical Value (M-CV) had total agreement for K diagnosis. DRIS detected deficiencies for N, Ca, Mg and Cu where the CV placed samples in the normal nutrient range;

7. DRIS appeared to be less sensitive than CV in detecting Mn, Fe, Zn and B deficiencies;

8. The comparison among the diagnostic criteria (DRIS Norms; DRIS Optimum; and CV estimated and reported from the literature) show some divergences, but a total agreement was found for the P values. The lack of uniformity among data and methodologies used have probably affected the results;

10. The correlations found between DRIS indices and leaf

nutrient concentrations were medium ($r \geq 0.6$) to high ($r \geq 0.8$) with the exception for those of N and Mg;

11. Correlation coefficients similar to those relating DRIS indices and leaf nutrient concentration were also found for DRIS indices and each CV estimated and reported from the literature;

12. DRIS indices for Cu above 10 mg/kg, B above 20 mg/kg, Al above 50 mg/kg and Zn in all the ranges studied seemed to be so dependent on their nutrient concentration, that there may be little advantage of a ratio based diagnosis over the CV approach;

13. DRIS norms developed in this work are biased for the high proportion of samples that belong to the Great Lakes area and conclusions and the DRIS norms developed from this work have to be taken as preliminary and tentative and should be tested in future field trials.

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APPENDIX

Table 1. Blueberry DRIS Data Base

YIELD	%N	%P	%K	%Ca	%Mg	Mn	Fe	Zn	Al	Cu	B	Reference
Kg/bush	%					mg/kg						
4.32	2.16	0.19	0.47	0.64	0.29	176	13	18		10		71 Ballinger, 1957
5.54	2.41	0.16	0.55	0.55	0.20	323	17	17		20		46 Ballinger, 1957
9.52	2.20	0.20	0.47	0.76	0.37	283	15	32		14		67 Ballinger, 1957
1.92	2.16	0.15	0.55	0.61	0.20	325	14	16		20		47 Ballinger, 1957
5.66	2.35	0.20	0.63	0.66	0.28	289	14	29		14		67 Ballinger, 1957
2.01	1.99	0.14	0.50	0.52	0.19	317	12	18		18		35 Ballinger, 1957
7.27	2.23	0.14	0.57	0.57	0.25	118	51	22		7		48 Ballinger, 1957
2.16	2.26	0.14	0.59	0.59	0.23	140	33	23		18		33 Ballinger, 1957
8.34	1.92	0.13	0.42	0.60	0.30	84	29	31		7		33 Ballinger, 1957
3.75	1.83	0.14	0.45	0.57	0.24	74	29	21		18		27 Ballinger, 1957
7.06	2.23	0.18	0.46	0.55	0.42	129	12	23		13		60 Ballinger, 1957
3.37	2.02	0.15	0.50	0.63	0.29	242	15	22		16		61 Ballinger, 1957
2.13	1.72	0.21	0.47	0.62	0.34	94	17	21		10		67 Ballinger, 1957
2.04	1.68	0.15	0.37	0.60	0.29	162	10	20		14		52 Ballinger, 1957
8.93	2.11	0.17	0.56	0.77	0.33	186	19	27		20		121 Ballinger, 1957
5.73	1.85	0.10	0.54	0.59	0.17	172	13	17		18		64 Ballinger, 1957
11.09	2.20	0.15	0.52	0.69	0.30	88	18	22		10		46 Ballinger, 1957
10.36	1.97	0.13	0.44	0.57	0.23	143	14	15		18		31 Ballinger, 1957
8.53	1.98	0.19	0.64	0.59	0.39	139	14	29		11		69 Ballinger, 1957
7.55	1.81	0.14	0.59	0.57	0.26	120	13	12		18		42 Ballinger, 1957
11.05	1.94	0.20	0.56	0.78	0.46	176	20	21		8		44 Ballinger, 1957
4.50	1.68	0.14	0.55	0.50	0.25	180	12	14		16		27 Ballinger, 1957
1.50	2.06	0.19	0.66	0.72	0.29	206	20	17		12		22 Ballinger, 1957
0.45	2.19	0.12	0.64	0.60	0.16	257	14	25		17		14 Ballinger, 1957
2.72	1.97	0.13	0.62	0.71	0.23	109	17	20		9		88 Ballinger, 1957
1.14	1.94	0.11	0.69	0.48	0.15	106	10	13		17		20 Ballinger, 1957
3.60	1.80	0.16	0.45	0.72	0.32	161	15	21		10		25 Ballinger, 1957
2.06	1.60	0.15	0.52	0.53	0.26	210	15	11		19		17 Ballinger, 1957
6.96	1.99	0.18	0.47	0.85	0.34	161	16	21		11		35 Ballinger, 1957
5.43	1.71	0.16	0.48	0.57	0.28	244	15	26		17		22 Ballinger, 1957
8.70	2.25	0.19	0.52	0.74	0.28	117	20	22		11		38 Ballinger, 1957
5.75	1.85	0.14	0.56	0.65	0.18	80	9	21		12		22 Ballinger, 1957
8.54	2.04	0.16	0.59	0.55	0.19	112	20	20		8		26 Ballinger, 1957
3.47	1.84	0.15	0.51	0.76	0.18	90	10	19		14		22 Ballinger, 1957
0.54	1.61	0.11	0.44	1.00	0.22	79	14	27		6		45 Ballinger, 1957
0.41	1.56	0.11	0.35	0.91	0.14	42	7	26		12		18 Ballinger, 1957
2.70	1.80	0.15	0.45	0.75	0.29	80	19	32		10		53 Ballinger, 1957
3.21	1.56	0.13	0.46	0.68	0.15	50	10	9		12		20 Ballinger, 1957
4.57	1.63	0.13	0.43	0.73	0.35	76	13	21		11		39 Ballinger, 1957
3.58	1.68	0.15	0.48	0.55	0.27	56	9	29		13		27 Ballinger, 1957
9.37	1.73	0.13	0.42	0.73	0.36	128	14	25		9		48 Ballinger, 1957
3.10	1.73	0.15	0.48	0.76	0.30	190	14	23		15		52 Ballinger, 1957
10.05	2.18	0.15	0.51	0.65	0.27	245	16	22		9		45 Ballinger, 1957
6.91	1.91	0.15	0.55	0.95	0.19	167	11	19		16		32 Ballinger, 1957
5.91	1.96	0.15	0.58	0.65	0.18	158	13	22		8		35 Ballinger, 1957
4.98	1.83	0.13	0.56	1.08	0.14	171	14	15		15		29 Ballinger, 1957
4.79	2.05	0.17	0.50	0.65	0.31	257	13	28		13		70 Ballinger, 1957
5.00	1.74	0.15	0.51	0.79	0.26	290	13	22		12		47 Ballinger, 1957
10.56	2.19	0.16	0.49	0.70	0.30	275	18	20		11		68 Ballinger, 1957
8.39	1.81	0.13	0.50	1.29	0.25	305	15	28		20		43 Ballinger, 1957
3.04	1.68	0.12	0.37	0.91	0.32	224	10	28		15		87 Ballinger, 1957
3.27	1.49	0.10	0.38	0.98	0.12	45	20	25		25		33 Ballinger, 1957
3.04	1.68	0.15	0.35	0.78	0.32	130	35	24		18		10 Ballinger, 1957
2.43	1.36	0.11	0.30	0.68	0.18	71	12	11		20		65 Ballinger, 1957
6.79	1.91	0.15	0.51	0.75	0.26	106	32	20		16		82 Ballinger, 1957
4.29	1.49	0.12	0.46	0.58	0.15	56	22	18		19		35 Ballinger, 1957
6.16	1.65	0.17	0.44	0.69	0.29	152	22	23		17		55 Ballinger, 1957
2.31	1.56	0.14	0.43	0.75	0.26	120	35	22		18		49 Ballinger, 1957
7.20	2.16	0.15	0.47	0.55	0.27	133	15	20		13		46 Ballinger, 1957
7.08	1.92	0.17	0.50	0.94	0.27	116	16	8		28		45 Ballinger, 1957
3.69	2.04	0.16	0.55	0.51	0.24	141	18	20		15		41 Ballinger, 1957
2.83	1.74	0.12	0.55	1.00	0.18	143	10	19		21		32 Ballinger, 1957
9.09	2.16	0.20	0.53	0.57	0.33	206	18	15		12		61 Ballinger, 1957
5.88	1.74	0.13	0.46	1.13	0.25	169	13	20		23		41 Ballinger, 1957
5.81	1.87	0.17	0.56	0.65	0.37	113	19	21		12		56 Ballinger, 1957

Table 1. Cont'd.

YIELD Kg/bush	%N	%P	%K	%Ca	%Mg	Mn	Fe	Zn	Al	Cu	B	Reference
			%						mg/kg			
7.00	1.80	0.17	0.44	0.45	0.34	154	10	22		20	46	Ballinger, 1957
1.15	1.43	0.09	0.41	0.31	0.11							Bailey, 1966
1.10	1.47	0.09	0.43	0.33	0.12							Bailey, 1966
0.97	1.48	0.09	0.43	0.31	0.11							Bailey, 1966
0.90	1.59	0.10	0.45	0.31	0.12							Bailey, 1966
0.90	1.68	0.11	0.45	0.31	0.11							Bailey, 1966
1.05	1.77	0.11	0.44	0.32	0.11							Bailey, 1966
1.26	1.82	0.09	0.41	0.26	0.15							Bailey, 1966
0.97	1.95	0.09	0.42	0.27	0.15							Bailey, 1966
0.96	2.00	0.10	0.42	0.24	0.16							Bailey, 1966
0.85	1.67	0.08	0.44	0.22	0.14							Bailey, 1966
0.79	1.81	0.09	0.44	0.22	0.15							Bailey, 1966
0.59	1.76	0.09	0.42	0.20	0.14							Bailey, 1966
1.30	1.65	0.08	0.47	0.24	0.11							Bailey, 1966
1.39	1.71	0.09	0.48	0.24	0.11							Bailey, 1966
0.91	1.72	0.08	0.50	0.20	0.10							Bailey, 1966
1.07	1.48	0.09	0.42	0.31	0.11							Bailey, 1966
1.17	1.44	0.09	0.42	0.31	0.11							Bailey, 1966
0.99	1.45	0.09	0.43	0.32	0.12							Bailey, 1966
0.88	1.67	0.11	0.42	0.31	0.10							Bailey, 1966
1.01	1.69	0.11	0.45	0.33	0.12							Bailey, 1966
0.96	1.67	0.11	0.47	0.30	0.12							Bailey, 1966
1.05	1.88	0.09	0.35	0.25	0.14							Bailey, 1966
1.11	1.96	0.09	0.44	0.26	0.16							Bailey, 1966
1.05	1.92	0.09	0.47	0.25	0.16							Bailey, 1966
0.74	1.71	0.08	0.36	0.22	0.12							Bailey, 1966
0.76	1.80	0.09	0.48	0.22	0.15							Bailey, 1966
0.75	1.73	0.08	0.48	0.20	0.15							Bailey, 1966
1.37	1.74	0.09	0.37	0.23	0.10							Bailey, 1966
1.27	1.65	0.08	0.50	0.23	0.11							Bailey, 1966
0.97	1.69	0.08	0.58	0.22	0.11							Bailey, 1966
3.70	1.71			0.48	0.20	265						Martin, 1963
3.94	1.94			0.48	0.17	290						Martin, 1963
4.60	1.96			0.47	0.17	336						Martin, 1963
4.40	2.14			0.48	0.17	348						Martin, 1963
3.68	2.01			0.50	0.17	386						Martin, 1963
8.03	1.96			0.57	0.22	253						Martin, 1963
10.59	1.94			0.58	0.21	346						Martin, 1963
10.75	1.96			0.60	0.20	372						Martin, 1963
8.73	1.99			0.61	0.20	469						Martin, 1963
9.96	2.06			0.61	0.18	478						Martin, 1963
3.98				0.69	0.30	584						Martin, 1963
4.71				0.65	0.30	590						Martin, 1963
4.70				0.71	0.30	681						Martin, 1963
3.85				0.61	0.29	603						Martin, 1963
4.34				0.61	0.28	631						Martin, 1963
4.30	1.91	0.11	0.45	0.36	0.11	275	55		84			Lareau, 1969
2.80	2.07	0.12	0.51	0.53	0.13	388	57		112			Lareau, 1969
5.50	1.91	0.10	0.44	0.49	0.12	327	52		78			Lareau, 1969
3.80	1.85	0.10	0.49	0.39	0.13	147	53		75			Lareau, 1969
5.00	1.92	0.10	0.45	0.48	0.13	260	54		79			Lareau, 1969
3.50	1.92	0.12	0.45	0.43	0.12	286	54		92			Lareau, 1969
4.20	1.97	0.10	0.46	0.43	0.12	316	56		96			Lareau, 1969
3.80	1.94	0.10	0.46	0.45	0.13	283	54		86			Lareau, 1969
4.00	1.85	0.11	0.44	0.48	0.12	270	54		87			Lareau, 1969
4.30	1.93	0.16	0.45	0.43	0.12	273	53		84			Lareau, 1969
4.00	2.03	0.11	0.48	0.43	0.13	309	56		91			Lareau, 1969
5.64	1.59	0.05	0.42	0.53	0.19	207	45	11		2	58	Brown, 1968
6.38	1.46	0.06	0.39	0.56	0.19	169	38	11		2	56	Brown, 1968
1.47	1.89	0.12	0.54	0.29	0.26							Eck, 1977
1.40	1.94	0.12	0.53	0.27	0.26							Eck, 1977
1.33	2.06	0.12	0.53	0.27	0.25							Eck, 1977
2.13	1.64	0.11	0.53	0.44	0.30							Eck, 1977
2.26	1.76	0.11	0.51	0.44	0.30							Eck, 1977
2.48	1.83	0.11	0.47	0.43	0.29							Eck, 1977
1.33	1.60	0.16	0.51	0.32	0.19							Eck, 1977
1.80	1.70	0.16	0.50	0.27	0.17							Eck, 1977

Table 1. Cont'd.

YIELD Kg/bush	%N	%P	%K	%Ca	%Mg	Mn	Fe	Zn	Al	Cu	B	Reference
----- mg/kg -----												
1.35	1.85	0.16	0.48	0.26	0.15							Eck, 1977
3.80	1.55	0.07	0.43	0.45	0.27							Eck, 1977
4.05	1.68	0.08	0.44	0.42	0.28							Eck, 1977
4.35	1.67	0.08	0.40	0.42	0.27							Eck, 1977
3.50	1.55	0.14	0.56	0.15	0.30							Eck, 1977
3.20	1.83	0.15	0.57	0.14	0.28							Eck, 1977
2.60	1.88	0.17	0.56	0.13	0.28							Eck, 1977
4.75			0.32		0.32							Eck, 1985
5.95			0.39		0.28							Eck, 1985
6.20			0.44		0.24							Eck, 1985
5.91			0.49		0.24							Eck, 1985
2.06	2.35	0.11	0.40									Rosca, 1985
2.07	1.92	0.10	0.40									Rosca, 1985
2.40	1.98	0.06	0.38									Rosca, 1985
1.78	1.80	0.06	0.40									Rosca, 1985
1.90	2.10	0.11	0.45									Rosca, 1985
1.81	1.61	0.06	0.40									Rosca, 1985
2.76	2.04	0.08	0.43									Rosca, 1985
2.57	1.92	0.10	0.40									Rosca, 1985
2.63	1.98	0.10	0.45									Rosca, 1985
1.91	1.86	0.08	0.51									Rosca, 1985
1.50	2.16	0.06	0.51									Rosca, 1985
1.82	2.38	0.06	0.45									Rosca, 1985
2.13	2.10	0.06	0.45									Rosca, 1985
2.14	2.16	0.10	0.43									Rosca, 1985
1.84	2.37	0.06	0.51									Rosca, 1985
0.31	2.62	0.26	0.49	0.74	0.33							Ballinger, 1969
0.41	2.60	0.29	0.68	0.70	0.40							Ballinger, 1969
0.40	2.86	0.44	0.86	0.64	0.43							Ballinger, 1969
0.30	2.78	0.54	0.85	0.75	0.40							Ballinger, 1969
0.24	2.80	0.75	1.17	0.58	0.57							Ballinger, 1969
0.20	1.83	0.20	0.31	0.44	0.30							Ballinger, 1969
0.38	2.49	0.26	0.35	0.55	0.32							Ballinger, 1969
0.24	2.60	0.38	0.48	0.54	0.33							Ballinger, 1969
0.22	2.88	0.40	0.77	0.66	0.39							Ballinger, 1969
2.77	1.29	0.10	0.48	0.25	0.13							Nauman, 1985
3.67	1.36	0.10	0.49	0.25	0.15							Nauman, 1985
2.58	1.41	0.10	0.50	0.24	0.12							Nauman, 1985
3.30	1.45	0.10	0.50	0.23	0.11							Nauman, 1985
2.83	1.51	0.11	0.50	0.22	0.11							Nauman, 1985
2.58	1.14	0.10	0.48	0.30	0.13							Nauman, 1985
3.43	1.36	0.10	0.47	0.29	0.12							Nauman, 1985
3.33	1.35	0.11	0.50	0.27	0.12							Nauman, 1985
2.83	1.41	0.11	0.49	0.25	0.11							Nauman, 1985
2.00	1.47	0.11	0.50	0.24	0.11							Nauman, 1985
0.13	1.35	0.14	0.18		0.05							Scibiaz, 1990
0.14	1.35	0.10	0.28		0.10							Scibiaz, 1990
0.19	1.32	0.23	0.56		0.14							Scibiaz, 1990
1.13	1.66	0.16	0.55		0.18							Scibiaz, 1990
0.14	1.47	0.13	0.50		0.12							Scibiaz, 1990
0.65	1.40	0.10	0.52		0.33							Scibiaz, 1990
0.16	1.50	0.15	0.58		0.28							Scibiaz, 1990
1.35	1.50	0.13	0.50		0.25							Scibiaz, 1990
0.27	2.12	0.11	0.63	0.37	0.14	395	111					Townsend, 1973
0.18	2.20	0.11	0.66	0.37	0.15	412	114					Townsend, 1973
0.40	2.30	0.11	0.67	0.38	0.15	344	104					Townsend, 1973
0.39	1.81	0.10	0.54	0.47	0.14	225	104					Townsend, 1973
0.84	2.06	0.12	0.56	0.48	0.15	565	66					Townsend, 1973
0.51	2.17	0.13	0.60	0.40	0.15	524	76					Townsend, 1973
0.62	2.17	0.12	0.60	0.42	0.15	486	72					Townsend, 1973
0.99	1.92	0.12	0.52	0.53	0.14	238	64					Townsend, 1973
1.32	2.21	0.12	0.54	0.54	0.18	669	71					Townsend, 1973
1.12	2.29	0.12	0.60	0.48	0.18	606	72					Townsend, 1973
1.08	2.34	0.12	0.61	0.50	0.20	591	80					Townsend, 1973
1.47	2.01	0.12	0.49	0.60	0.17	302	70					Townsend, 1973
1.10	1.97	0.12	0.58	0.49	0.14	494	88					Townsend, 1973
0.96	2.02	0.12	0.63	0.43	0.14	468	103					Townsend, 1973

Table 1. Cont'd.

YIELD Kg/bush	%N	%P	%K	%Ca	%Mg	Mn	Fe	Zn	Al	Cu	B	Reference
----- % ----- mg/kg -----												
0.99	2.15	0.12	0.66	0.41	0.15	410	102					Townsend, 1973
1.31	1.73	0.11	0.54	0.58	0.14	227	78					Townsend, 1973
2.53	1.35		0.34	0.45	0.18		44	16		8		Cumming, 1978
2.53	1.47		0.31	0.42	0.18		47	13		7		Cumming, 1978
2.17	1.55		0.30	0.38	0.17		50	12		5		Cumming, 1978
2.18		0.09			0.17					7		Cumming, 1978
2.58		0.11			0.18					8		Cumming, 1978
2.48		0.12			0.18					8		Cumming, 1978
2.33			0.24	0.43	0.19							Cumming, 1978
2.49			0.34	0.41	0.17							Cumming, 1978
2.41			0.38	0.39	0.16							Cumming, 1978
2.41			0.30							7		Cumming, 1978
2.40			0.33							8		Cumming, 1978
0.12	2.30	0.11	0.60	0.44	0.15	347	118					Townsend, 1973
0.51	2.03	0.11	0.58	0.45	0.16	372	114					Townsend, 1973
0.41	2.14	0.12	0.59	0.44	0.14	423	94					Townsend, 1973
0.81	1.91	0.12	0.56	0.50	0.13	401	93					Townsend, 1973
0.74	2.44	0.13	0.62	0.52	0.18	495	72					Townsend, 1973
1.28	2.12	0.12	0.57	0.60	0.17	437	71					Townsend, 1973
0.40	2.07	0.12	0.60	0.37	0.12	350	90					Townsend, 1973
1.07	1.66	0.12	0.56	0.47	0.13	247	82					Townsend, 1973
0.35	1.50	0.08	0.38	0.65	0.21	583	51			4		Clark, 1993
0.49	1.57	0.07	0.42	0.55	0.13	600	53			4		Clark, 1993
0.27	1.50	0.07	0.40	0.59	0.20	818	66			4		Clark, 1993
0.28	1.85	0.10	0.62	0.38	0.13	911	58			4		Clark, 1993
0.44	2.05	0.07	0.40	0.41	0.14	932	77			5		Clark, 1993
0.37	1.27	0.07	0.32	0.48	0.21	904	57			3		Clark, 1993
0.59	1.53	0.07	0.43	0.69	0.14	448	62			4		Clark, 1993
0.50	1.43	0.08	0.36	0.66	0.19	477	44			3		Clark, 1993
0.48	1.65	0.07	0.39	0.49	0.15	1320	51			4		Clark, 1993
0.31	1.56	0.07	0.36	0.59	0.18	1168	69			4		Clark, 1993
0.18	2.04	0.13	0.48	0.33	0.14	1277	81			5		Clark, 1993
0.71	1.84	0.07	0.33	0.55	0.17	1995	52			6		Clark, 1993
0.44	1.54	0.07	0.39	0.51	0.10	458	52			2		Clark, 1993
0.54	1.79	0.08	0.42	0.47	0.14	574	58			5		Clark, 1993
0.31	2.03	0.09	0.37	0.39	0.10	1392	54			4		Clark, 1993
0.42	1.57	0.08	0.54	0.38	0.11	605	39			4		Clark, 1993
0.15	2.46	0.14	0.84	0.31	0.12	1217	48			5		Clark, 1993
0.70	1.55	0.09	0.40	0.44	0.15	716	46			5		Clark, 1993
0.21	1.76	0.09	0.39	0.47	0.10	890	46			3		Clark, 1993
1.03	1.51	0.09	0.37	0.99	0.24	711	88			5		Clark, 1993
2.07	1.65	0.08	0.47	0.90	0.15	846	80			5		Clark, 1993
0.99	1.58	0.09	0.45	0.74	0.20	697	86			6		Clark, 1993
0.84	1.73	0.10	0.49	0.57	0.15	772	181			6		Clark, 1993
1.14	1.72	0.07	0.36	0.69	0.15	1004	185			6		Clark, 1993
0.72	1.52	0.09	0.44	0.75	0.20	728	126			5		Clark, 1993
1.27	1.54	0.08	0.36	0.95	0.13	414	83			6		Clark, 1993
1.39	1.52	0.09	0.36	0.86	0.24	786	83			7		Clark, 1993
1.06	1.60	0.09	0.53	0.70	0.18	973	95			5		Clark, 1993
0.53	1.52	0.09	0.40	0.90	0.17	672	91			6		Clark, 1993
0.77	1.44	0.11	0.53	0.62	0.17	1225	90			6		Clark, 1993
1.07	1.74	0.08	0.47	0.49	0.15	892	87			5		Clark, 1993
1.14	1.46	0.09	0.39	0.82	0.15	751	97			5		Clark, 1993
0.86	1.52	0.09	0.44	0.79	0.16	485	79			5		Clark, 1993
0.86	1.44	0.08	0.51	0.56	0.15	990	94			6		Clark, 1993
1.59	1.51	0.09	0.47	0.78	0.19	971	97			6		Clark, 1993
0.47	1.76	0.10	0.86	0.34	0.15	971	87			6		Clark, 1993
2.10	1.49	0.09	0.47	0.61	0.17	590	91			5		Clark, 1993
0.65	1.50	0.08	0.44	0.71	0.11	593	81			4		Clark, 1993
2.76	1.64	0.20	0.26	0.40	0.13							Popenoe, 1952
2.50	1.79	0.21	0.29	0.34	0.12							Popenoe, 1952
2.55	1.54	0.20	0.27	0.37	0.14							Popenoe, 1952
3.18	1.69	0.22	0.29	0.36	0.14							Popenoe, 1952
3.36	1.71	0.21	0.27	0.32	0.14							Popenoe, 1952
2.50	1.80	0.20	0.22	0.30	0.14							Popenoe, 1952
2.63	1.46	0.11	0.45	0.71	0.14					56		Popenoe, 1952
2.49	1.56	0.10	0.41	0.66	0.14					51		Popenoe, 1952

Table 1. Cont'd.

YIELD Kg/bush	%N	%P	%K	%Ca	%Mg	Mn	Fe	Zn	Al	Cu	B	Reference
									mg/kg			
2.40	1.58	0.11	0.49	0.86	0.15					79		Popenoe, 1952
3.63	1.71	0.11	0.52	0.78	0.12					72		Popenoe, 1952
3.74	1.74	0.11	0.43	0.78	0.14					54		Popenoe, 1952
2.67	1.68	0.11	0.39	0.72	0.14					58		Popenoe, 1952
8.36	1.47	0.12	0.40	0.63	0.24	145	58	27	149	1		42 Hancock, 1983
7.53	1.82	0.12	0.44	0.52	0.22	138	56	10	145	1		33 Hancock, 1983
8.39	1.61	0.12	0.39	0.56	0.24	123	51	11	126	1		32 Hancock, 1983
6.97	1.89	0.12	0.46	0.57	0.23	133	58	11	139	1		33 Hancock, 1983
7.55	1.47	0.12	0.35	0.69	0.29	179	53	11	151	1		41 Hancock, 1983
7.79	1.75	0.12	0.37	0.54	0.26	115	48	9	135	1		34 Hancock, 1983
7.49	1.82	0.12	0.39	0.56	0.25	134	59	10	145	1		34 Hancock, 1983
6.65	1.47	0.12	0.46	0.46	0.23	114	62	25	151	1		26 Hancock, 1983
7.19	1.75	0.12	0.36	0.56	0.24	116	47	14	217	1		26 Hancock, 1983
6.87	1.82	0.12	0.42	0.54	0.23	124	53	10	204	1		33 Hancock, 1983
7.41	1.40	0.12	0.36	0.62	0.30	118	54	11	152	1		40 Hancock, 1983
6.87	1.75	0.09	0.37	0.53	0.26	39	158	8	104	2		25 Hancock, 1983
6.72	1.68	0.09	0.41	0.51	0.26	48	183	8	118	4		24 Hancock, 1983
5.93	1.54	0.09	0.38	0.60	0.30	44	169	9	120	3		34 Hancock, 1983
6.78	1.68	0.09	0.38	0.58	0.28	51	176	9	117	3		30 Hancock, 1983
8.09	1.68	0.09	0.42	0.45	0.24	44	171	7	113	2		25 Hancock, 1983
6.60	1.68	0.09	0.37	0.53	0.27	40	173	8	107	2		28 Hancock, 1983
3.83	1.82	0.10	0.36	0.48	0.25	51	208	9	113	3		33 Hancock, 1983
5.61	1.68	0.09	0.34	0.50	0.26	35	195	9	105	3		27 Hancock, 1983
6.26	1.61	0.09	0.39	0.46	0.26	38	216	9	118	6		28 Hancock, 1983
4.40	1.62	0.10	0.39	0.46	0.26	55	210	10	121	3		31 Hancock, 1983
6.02	1.54	0.09	0.37	0.50	0.27	47	198	10	110	3		34 Hancock, 1983
3.82	1.68	0.09	0.34	0.51	0.26	45	210	9	115	4		30 Hancock, 1983
7.55	1.82	0.09	0.39	0.49	0.27	113	91	8	150	1		43 Hancock, 1983
6.50	1.68	0.09	0.42	0.54	0.29	125	92	9	157	1		46 Hancock, 1983
5.96	1.82	0.09	0.39	0.54	0.29	116	89	8	158	1		45 Hancock, 1983
6.46	1.33	0.09	0.37	0.57	0.31	101	80	8	160	2		43 Hancock, 1983
5.71	1.68	0.09	0.37	0.53	0.29	100	98	9	163	2		43 Hancock, 1983
6.58	1.68	0.10	0.42	0.53	0.30	108	91	9	164	1		46 Hancock, 1983
5.65	1.33	0.09	0.33	0.57	0.29	113	81	8	159	11		47 Hancock, 1983
6.03	1.68	0.09	0.40	0.61	0.31	146	85	8	169	1		55 Hancock, 1983
5.63	1.54	0.09	0.40	0.57	0.30	114	64	9	165	1		49 Hancock, 1983
4.77	1.47	0.09	0.37	0.67	0.34	118	78	9	164	1		54 Hancock, 1983
5.77	1.47	0.09	0.39	0.53	0.30	118	79	8	147	1		50 Hancock, 1983
5.64	1.68	0.10	0.39	0.60	0.30	114	91	9	165	1		49 Hancock, 1983
8.14	1.82	0.10	0.36	0.45	0.28	48	181	6	98	2		40 Hancock, 1983
8.39	0.98	0.09	0.36	0.41	0.28	37	175	7	96	12		35 Hancock, 1983
8.02	1.40	0.10	0.36	0.41	0.28	37	166	7	102	3		34 Hancock, 1983
9.11	1.61	0.10	0.33	0.43	0.28	31	160	7	82	2		36 Hancock, 1983
8.54	1.54	0.09	0.33	0.41	0.27	34	165	6	91	2		39 Hancock, 1983
8.14	1.61	0.09	0.34	0.42	0.29	37	159	7	97	2		45 Hancock, 1983
8.33	1.82	0.10	0.39	0.38	0.25	44	153	6	108	2		33 Hancock, 1983
8.90	1.75	0.10	0.40	0.38	0.26	37	178	7	101	3		36 Hancock, 1983
7.39	1.68	0.10	0.34	0.42	0.28	40	166	7	97	2		34 Hancock, 1983
9.03	1.82	0.10	0.37	0.42	0.26	40	146	6	118	2		37 Hancock, 1983
8.70	1.68	0.10	0.35	0.45	0.29	41	153	9	111	9		41 Hancock, 1983
8.81	1.82	0.10	0.35	0.43	0.28	43	159	6	102	2		40 Hancock, 1983
13.38	1.82	0.11	0.34	0.61	0.32	80	58	12	110	4		31 Hancock, 1983
14.71	1.98	0.12	0.37	0.51	0.29	61	61	11	105	4		27 Hancock, 1983
13.93	2.03	0.12	0.36	0.54	0.30	78	59	11	107	3		31 Hancock, 1983
13.25	2.17	0.12	0.37	0.49	0.29	61	60	10	107	3		34 Hancock, 1983
13.32	1.89	0.11	0.34	0.61	0.32	81	63	13	119	3		37 Hancock, 1983
13.77	1.89	0.12	0.33	0.53	0.29	68	57	9	103	3		29 Hancock, 1983
14.56	1.82	0.10	0.36	0.58	0.29	99	56	10	105	6		36 Hancock, 1983
15.88	1.98	0.11	0.35	0.60	0.32	88	54	10	115	8		38 Hancock, 1983
14.59	1.98	0.11	0.36	0.59	0.31	92	56	10	114	4		38 Hancock, 1983
14.75	2.03	0.11	0.36	0.59	0.31	110	57	10	117	3		37 Hancock, 1983
13.90	1.82	0.10	0.33	0.54	0.29	67	54	10	112	3		30 Hancock, 1983
14.47	1.98	0.11	0.34	0.63	0.32	83	56	11	109	3		33 Hancock, 1983
4.69	1.68	0.10	0.39	0.42	0.18	76	56	12	123	7		27 Hancock, 1984
5.98	1.61	0.08	0.37	0.47	0.17	78	50	10	127	7		25 Hancock, 1984
5.26	2.03	0.07	0.34	0.40	0.15	80	46	7	128	7		17 Hancock, 1984
6.32	1.47	0.07	0.26	0.45	0.18	57	43	7	115	6		14 Hancock, 1984

Table 1. Cont'd.

YIELD Kg/bush	%N	%P	%K	%Ca	%Mg	Mn	Fe	Zn	Al	Cu	B	Reference
									mg/kg			
5.94	1.47	0.07	0.37	0.44	0.16	80	45	6	143	6		15 Hancock, 1984
4.64	1.68	0.09	0.35	0.51	0.21	92	60	13	127	8		28 Hancock, 1984
4.29	1.69	0.10	0.36	0.43	0.19	73	57	13	126	7		10 Hancock, 1984
4.54	1.82	0.10	0.37	0.46	0.19	84	58	13	128	6		30 Hancock, 1984
4.42	1.82	0.09	0.46	0.35	0.16	64	53	10	129	5		24 Hancock, 1984
4.91	1.68	0.10	0.35	0.44	0.20	63	56	17	108	7		25 Hancock, 1984
5.24	1.47	0.09	0.42	0.41	0.18	56	61	11	123	6		23 Hancock, 1984
4.15	1.75	0.10	0.40	0.48	0.22	73	60	15	125	7		39 Hancock, 1984
8.95	2.17	0.10	0.32	0.48	0.23	36	83	8	85	4		22 Hancock, 1984
8.19	2.03	0.11	0.31	0.43	0.25	32	90	10	74	4		22 Hancock, 1984
7.31	2.03	0.10	0.35	0.34	0.20	36	84	9	82	4		19 Hancock, 1984
7.81	1.68	0.10	0.28	0.43	0.25	31	84	9	77	4		21 Hancock, 1984
8.99	2.03	0.11	0.34	0.38	0.22	46	92	9	92	5		21 Hancock, 1984
7.79	2.03	0.09	0.31	0.46	0.23	34	81	9	86	4		22 Hancock, 1984
6.75	1.96	0.09	0.29	0.47	0.23	40	75	8	90	5		20 Hancock, 1984
7.18	1.54	0.10	0.30	0.47	0.25	43	92	9	96	4		22 Hancock, 1984
8.07	1.68	0.10	0.38	0.40	0.28	43	90	8	111	4		18 Hancock, 1984
6.73	1.68	0.09	0.29	0.43	0.25	28	78	8	90	3		19 Hancock, 1984
7.18	1.82	0.09	0.37	0.37	0.20	78	38	7	95	4		19 Hancock, 1984
6.16	1.48	0.09	0.27	0.44	0.23	36	78	11	84	4		20 Hancock, 1984
3.78	1.61	0.09	0.43	0.51	0.22	81	61	8	143	4		56 Hancock, 1984
3.14	1.69	0.09	0.44	0.51	0.22	99	64	9	152	4		58 Hancock, 1984
2.69	2.03	0.10	0.47	0.46	0.21	99	71	9	155	3		61 Hancock, 1984
3.83	1.75	0.09	0.46	0.47	0.22	92	60	9	137	4		49 Hancock, 1984
2.67	1.40	0.10	0.45	0.46	0.21	89	63	9	140	4		57 Hancock, 1984
3.68	1.61	0.09	0.40	0.54	0.23	84	56	8	147	4		60 Hancock, 1984
4.15	1.68	0.10	0.36	0.55	0.25	100	67	11	137	5		65 Hancock, 1984
4.79	1.82	0.09	0.39	0.55	0.23	111	66	10	146	3		63 Hancock, 1984
4.01	1.68	0.09	0.40	0.65	0.25	109	60	11	158	4		69 Hancock, 1984
3.72	1.61	0.10	0.40	0.60	0.26	97	58	10	141	3		10 Hancock, 1984
4.25	2.10	0.09	0.39	0.56	0.24	104	55	9	142	4		60 Hancock, 1984
4.42	1.54	0.09	0.36	0.63	0.26	98	56	12	145	6		64 Hancock, 1984
4.49	2.03	0.11	0.43	0.30	0.17	30	55	8	77	4		28 Hancock, 1984
5.57	2.03	0.11	0.42	0.33	0.17	29	52	7	87	4		26 Hancock, 1984
4.95	2.17	0.11	0.50	0.26	0.15	35	54	8	94	3		26 Hancock, 1984
4.92	1.82	0.11	0.41	0.33	0.19	23	49	9	78	4		25 Hancock, 1984
5.01	2.10	0.12	0.51	0.31	0.17	32	56	9	79	4		30 Hancock, 1984
4.43	1.82	0.11	0.44	0.34	0.17	32	48	8	88	4		30 Hancock, 1984
4.58	1.82	0.10	0.40	0.36	0.18	29	58	8	100	5		34 Hancock, 1984
6.18	2.03	0.10	0.38	0.36	0.19	32	52	9	93	2		30 Hancock, 1984
4.61	1.69	0.10	0.47	0.30	0.16	34	49	8	98	2		27 Hancock, 1984
5.41	1.75	0.10	0.40	0.33	0.19	22	61	10	98	3		29 Hancock, 1984
5.58	1.61	0.10	0.49	0.31	0.18	33	54	9	98	2		29 Hancock, 1984
5.16	1.75	0.10	0.42	0.35	0.19	37	50	9	105	3		41 Hancock, 1984
6.53	1.75	0.13	0.44	0.46	0.19	58	45	14	107	7		29 Hancock, 1984
5.56	1.61	0.11	0.39	0.35	0.17	48	44	12	92	8		27 Hancock, 1984
6.81	1.68	0.11	0.36	0.39	0.17	47	41	12	93	6		26 Hancock, 1984
6.55	1.82	0.11	0.35	0.44	0.20	55	41	11	88	16		25 Hancock, 1984
6.86	1.69	0.12	0.44	0.40	0.18	48	48	12	86	5		23 Hancock, 1984
5.91	1.68	0.10	0.42	0.36	0.15	56	40	10	97	6		29 Hancock, 1984
7.23	2.03	0.10	0.33	0.41	0.16	55	36	10	80	6		28 Hancock, 1984
6.86	1.82	0.10	0.36	0.39	0.16	48	42	9	90	6		32 Hancock, 1984
6.84	1.96	0.12	0.45	0.37	0.16	48	41	10	100	5		26 Hancock, 1984
5.86	1.89	0.10	0.38	0.39	0.16	47	41	10	105	7		27 Hancock, 1984
5.02	1.68	0.09	0.31	0.42	0.17	45	35	10	88	6		27 Hancock, 1984
6.56	1.69	0.10	0.36	0.44	0.19	49	37	11	99	7		35 Hancock, 1984
2.25	1.75	0.10	0.50	0.34	0.19	71	61	11	101	5		24 Hancock, 1985
2.84	2.03	0.10	0.47	0.39	0.20	81	57	10	100	4		28 Hancock, 1985
2.96	1.82	0.10	0.55	0.38	0.19	93	58	10	111	6		28 Hancock, 1985
2.42	1.82	0.09	0.40	0.40	0.23	55	52	9	87	3		19 Hancock, 1985
2.46	1.68	0.10	0.57	0.34	0.20	60	56	9	86	3		19 Hancock, 1985
1.27	1.75	0.09	0.43	0.45	0.23	93	52	9	104	4		31 Hancock, 1985
0.85	1.82	0.10	0.42	0.35	0.18	47	48	10	79	4		22 Hancock, 1985
0.90	1.82	0.10	0.41	0.37	0.20	69	50	10	84	4		23 Hancock, 1985
1.74	1.82	0.10	0.58	0.30	0.19	64	54	10	92	5		18 Hancock, 1985
1.32	1.75	0.09	0.39	0.42	0.23	51	47	10	80	4		20 Hancock, 1985
2.29	1.75	0.10	0.55	0.36	0.22	46	54	10	86	4		17 Hancock, 1985

Table 1. Cont'd.

YIELD Kg/bush	%N	%P	%K	%Ca	%Mg	Mn	Fe	Zn	Al	Cu	B	Reference
----- mg/kg -----												
1.19	1.82	0.09	0.45	0.48	0.25	69	47	11	89	5		29 Hancock, 1985
1.67	1.68	0.09	0.31	0.42	0.25	28	96	7	61	3		19 Hancock, 1985
2.09	1.82	0.09	0.30	0.43	0.25	37	110	7	73	3		23 Hancock, 1985
2.82	1.68	0.09	0.46	0.34	0.21	26	95	7	79	3		17 Hancock, 1985
2.14	1.40	0.09	0.32	0.44	0.27	21	91	8	64	4		17 Hancock, 1985
2.18	1.68	0.09	0.44	0.35	0.21	30	92	7	77	3		15 Hancock, 1985
2.24	1.68	0.09	0.33	0.43	0.24	26	92	8	67	3		23 Hancock, 1985
2.65	1.47	0.09	0.31	0.46	0.26	32	103	8	79	4		22 Hancock, 1985
2.18	1.68	0.09	0.31	0.41	0.24	24	91	8	63	6		16 Hancock, 1985
2.73	1.61	0.09	0.37	0.38	0.22	34	114	7	88	3		20 Hancock, 1985
2.29	1.54	0.09	0.30	0.47	0.30	24	104	8	67	3		21 Hancock, 1985
3.17	1.68	0.09	0.38	0.36	0.23	30	105	7	76	3		18 Hancock, 1985
2.54	1.47	0.09	0.28	0.45	0.26	28	113	8	68	4		25 Hancock, 1985
1.63	1.75	0.10	0.42	0.50	0.26	85	82	8	161	2		47 Hancock, 1985
1.59	1.75	0.09	0.40	0.49	0.24	103	81	7	160	2		46 Hancock, 1985
1.35	1.54	0.10	0.50	0.43	0.23	87	84	4	164	2		43 Hancock, 1985
1.41	1.89	0.10	0.42	0.45	0.24	76	81	8	135	3		39 Hancock, 1985
1.60	1.61	0.10	0.47	0.42	0.22	80	107	7	151	3		39 Hancock, 1985
1.40	1.68	0.10	0.43	0.47	0.23	87	96	7	156	3		48 Hancock, 1985
1.64	1.47	0.09	0.41	0.47	0.23	64	62	8	123	2		42 Hancock, 1985
1.67	1.33	0.09	0.38	0.50	0.23	78	72	8	145	3		49 Hancock, 1985
1.67	1.68	0.09	0.36	0.52	0.24	82	68	6	146	2		52 Hancock, 1985
1.70	1.47	0.09	0.36	0.47	0.23	59	61	6	122	2		43 Hancock, 1985
1.35	1.54	0.09	0.43	0.45	0.22	70	70	7	137	3		44 Hancock, 1985
1.78	1.47	0.09	0.42	0.56	0.27	85	68	8	151	3		51 Hancock, 1985
3.56	2.03	0.09	0.33	0.28	0.18	21	128	6	60	3		19 Hancock, 1985
4.35	2.03	0.10	0.42	0.37	0.22	30	139	6	78	4		24 Hancock, 1985
4.36	2.03	0.10	0.43	0.28	0.18	26	146	7	66	4		16 Hancock, 1985
4.30	2.03	0.10	0.40	0.37	0.25	16	137	7	46	4		19 Hancock, 1985
4.58	2.03	0.09	0.43	0.30	0.21	24	131	6	52	4		21 Hancock, 1985
4.29	1.82	0.10	0.36	0.29	0.20	21	13	6	51	4		22 Hancock, 1985
3.04	2.03	0.08	0.40	0.34	0.19	21	129	7	61	4		22 Hancock, 1985
2.84	1.96	0.08	0.36	0.30	0.17	19	119	5	56	3		19 Hancock, 1985
3.85	2.03	0.08	0.41	0.27	0.16	25	123	6	63	3		20 Hancock, 1985
3.42	2.03	0.10	0.44	0.38	0.26	19	141	8	42	3		24 Hancock, 1985
4.27	2.17	0.09	0.47	0.36	0.24	27	141	7	38	3		22 Hancock, 1985
3.59	1.82	0.09	0.39	0.33	0.20	21	128	6	49	4		26 Hancock, 1985
7.71	1.75	0.11	0.36	0.39	0.22	43	56	9	93	3		19 Hancock, 1985
7.67	1.96	0.11	0.33	0.40	0.21	39	58	10	95	3		15 Hancock, 1985
7.78	1.89	0.11	0.40	0.40	0.22	49	58	9	100	3		19 Hancock, 1985
7.84	1.68	0.11	0.34	0.42	0.24	45	56	10	87	3		18 Hancock, 1985
7.68	1.96	0.11	0.40	0.39	0.24	40	55	9	88	3		14 Hancock, 1985
7.83	1.54	0.10	0.33	0.47	0.27	52	52	9	103	3		21 Hancock, 1985
8.12	1.68	0.10	0.31	0.39	0.23	41	50	8	76	3		18 Hancock, 1985
9.39	1.68	0.10	0.30	0.42	0.23	43	54	9	87	3		20 Hancock, 1985
8.70	1.89	0.10	0.37	0.42	0.22	44	54	9	98	3		17 Hancock, 1985
8.13	1.68	0.09	0.28	0.41	0.25	37	53	10	304	4		17 Hancock, 1985
7.76	1.82	0.10	0.36	0.41	0.23	48	58	9	96	4		19 Hancock, 1985
8.85	1.61	0.10	0.31	0.45	0.28	45	51	8	87	3		23 Hancock, 1985
2.90	1.60		0.76	0.53	0.16							Dale, 1982
1.71	2.22		1.12	0.42	0.17							Dale, 1982
3.99	1.91		0.75	0.56	0.19							Dale, 1982
0.09	1.73		0.87	0.32	0.13							Dale, 1982
0.45	2.35		1.09	0.39	0.17							Dale, 1982
3.76	1.97		0.73	0.68	0.21							Dale, 1982
3.29	1.58		0.62	0.49	0.16							Dale, 1982
0.87	1.92		0.95	0.38	0.17							Dale, 1982
1.01	1.95		1.05	0.60	0.17							Dale, 1982
4.27	1.93		0.60	0.59	0.18							Dale, 1982
3.73	2.15		0.75	0.66	0.23							Dale, 1982
0.84			0.95	0.57	0.20							Dale, 1982
2.70	1.89		0.63	0.62	0.22							Dale, 1982
1.66	1.95		0.84	0.61	0.21							Dale, 1982
0.05	2.03		0.93	0.44	0.17							Dale, 1982
3.14	1.85		0.71	0.61	0.24							Dale, 1982
0.88	1.62		0.80	0.47	0.15							Dale, 1982
1.14	1.60		0.35	0.83	0.30							Dale, 1982

Table 1. Cont'd.

YIELD Kg/bush	%N	%P	%K	%Ca	%Mg	Mn	Fe	Zn	Al	Cu	B	Reference
			%						mg/kg			
0.04	1.50		0.90	0.33	0.17							Date, 1982
0.49	1.39		0.64	0.46	0.18							Date, 1982
1.07	1.73		0.80	0.46	0.19							Date, 1982
0.03	1.64		0.71	0.64	0.17							Date, 1982
0.64	1.73		0.57	0.73	0.20							Date, 1982
0.23	1.61		0.75	0.27	0.15							Date, 1982
0.41	1.41		0.64	0.34	0.14							Date, 1982
1.70	1.61		0.63	0.49	0.17							Date, 1982
0.72	1.48		0.59	0.36	0.14							Date, 1982
1.27	2.14		0.93	0.40	0.16							Date, 1982
0.55	1.91		0.87	0.44	0.18							Date, 1982
1.52	1.81		0.90	0.44	0.19							Date, 1982
0.36	1.57		0.67	0.44	0.16							Date, 1982
0.30	1.87		0.89	0.39	0.19							Date, 1982
0.61	2.11		1.03	0.37	0.17							Date, 1982
2.94	1.79		0.67	0.40	0.16							Date, 1982
3.06	1.80		0.61	0.51	0.17							Date, 1982
0.41	2.30		1.39	0.57	0.14							Date, 1982
1.26	2.13		0.78	0.63	0.16							Date, 1982
0.60	2.28		0.89	0.37	0.16							Date, 1982
0.67	2.00		1.03	0.37	0.17							Date, 1982
1.04	1.83		0.78	0.46	0.16							Date, 1982
1.19	1.85		0.70	0.78	0.21							Date, 1982
2.00	1.81		0.75	0.48	0.16							Date, 1982
5.05	1.64		0.56	0.61	0.20							Date, 1982
0.69	1.58		0.94	0.49	0.17							Date, 1982
0.62	2.17		1.03	0.36	0.17							Date, 1982
1.93	2.04		0.75	0.52	0.17							Date, 1982
2.56	1.73		0.65	0.59	0.20							Date, 1982
3.91	1.93		0.56	0.62	0.21							Date, 1982
1.70	1.97		0.70	0.59	0.18							Date, 1982
2.62	1.84		0.65	0.59	0.20							Date, 1982
1.86	1.85		0.67	0.56	0.21							Date, 1982
3.96	1.99		0.73	0.63	0.19							Date, 1982
2.62	1.91		0.73	0.55	0.18							Date, 1982
2.20	1.76		0.73	0.52	0.19							Date, 1982
0.16	1.97		1.03	0.38	0.15							Date, 1982
1.19	2.00		0.84	0.38	0.14							Date, 1982
0.39	1.91		0.88	0.37	0.13							Date, 1982
2.30	2.17		0.81	0.54	0.16							Date, 1982
3.11	1.93		0.58	0.60	0.18							Date, 1982
1.82	1.80		0.74	0.41	0.15							Date, 1982
1.00	1.97		0.69	0.39	0.16							Date, 1982
1.86	1.78		0.74	0.52	0.18							Date, 1982
2.57	1.68		0.54	0.44	0.16							Date, 1982
1.94	1.51		0.54	0.53	0.17							Date, 1982
0.56	1.43		0.59	0.43	0.16							Date, 1982
1.80	1.62		0.61	0.50	0.18							Date, 1982
0.04	1.46		0.66	0.42	0.17							Date, 1982
0.33	1.41		0.61	0.41	0.16							Date, 1982
1.35	1.90		0.81	0.47	0.17							Date, 1982
0.55	1.30		0.65	0.39	0.18							Date, 1982
1.65	2.77		0.95	0.34	0.14							Date, 1983
2.58	2.46		0.77	0.44	0.13							Date, 1983
1.86	2.96		0.79	0.44	0.19							Date, 1983
1.68	2.76		0.85	0.50	0.17							Date, 1983
2.11	2.30		0.69	0.52	0.15							Date, 1983
1.96	2.37		0.79	0.50	0.14							Date, 1983
1.64	2.63		0.84	0.62	0.14							Date, 1983
0.50	3.17		1.08	0.50	0.18							Date, 1983
0.33	2.46		0.90	0.62	0.24							Date, 1983
2.75	2.91		0.80	0.60	0.19							Date, 1983
1.78	2.43		0.68	0.58	0.17							Date, 1983
2.52	2.45		0.86	0.50	0.19							Date, 1983
3.13	2.37		0.67	0.60	0.17							Date, 1983
3.79	2.62		0.69	0.58	0.17							Date, 1983
2.63	2.93		0.80	0.46	0.14							Date, 1983

Table 1. Cont'd.

YIELD Kg/bush	%N	%P	%K	%Ca	%Mg	Mn	Fe	Zn	Al	Cu	B	Reference
0.58	3.01		0.82	0.42	0.20							Dale, 1983
1.95	2.09		0.82	0.78	0.16							Dale, 1983
0.68	1.98		0.80	0.66	0.19							Dale, 1983
3.36	2.39		0.66	0.62	0.17							Dale, 1983
2.58	2.16		0.68	0.60	0.13							Dale, 1983
1.62	2.60		0.78	0.54	0.15							Dale, 1983
2.14	2.80		0.84	0.44	0.14							Dale, 1983
0.14	2.88		1.07	0.66	0.21							Dale, 1983
0.70			0.63	0.86	0.17							Dale, 1983
1.15	2.50		0.76	0.60	0.18							Dale, 1983
1.78	2.52		0.63	0.68	0.20							Dale, 1983
1.19	2.36		0.82	0.72	0.17							Dale, 1983
1.32	2.72		0.70	0.70	0.17							Dale, 1983
1.05	2.50		0.70	0.60	0.15							Dale, 1983
1.56	2.62		0.92	0.78	0.25							Dale, 1983
1.74	2.71		0.83	0.58	0.15							Dale, 1983
1.92	2.67		0.73	0.68	0.17							Dale, 1983
2.17	2.40		0.68	0.62	0.22							Dale, 1983
3.53	2.38		0.60	0.66	0.19							Dale, 1983
1.03	2.22		0.67	0.68	0.23							Dale, 1983
1.35	1.84		0.47	0.88	0.22							Dale, 1983
2.24	2.28		0.50	0.72	0.20							Dale, 1983
0.56	2.06		0.56	0.58	0.21							Dale, 1983
1.77	2.67		0.82	0.58	0.16							Dale, 1983
1.62	2.78		0.84	0.58	0.14							Dale, 1983
0.78			0.63	0.52	0.21							Dale, 1983
1.20	2.34		0.71	0.58	0.21							Dale, 1983
1.62	2.29		0.61	0.62	0.15							Dale, 1983
0.43	2.59		1.00	0.60	0.19							Dale, 1983
0.21	2.75		0.65	1.08	0.24							Dale, 1983
0.89	2.39		0.58	1.14	0.20							Dale, 1983
1.29	3.00		0.76	1.02	0.28							Dale, 1983
0.39	1.94		1.14	0.54	0.22							Dale, 1983
1.01	2.22		0.68	0.48	0.17							Dale, 1983
2.56	2.05		0.78	0.46	0.18							Dale, 1983
1.92	2.19		0.56	0.44	0.18							Dale, 1983
2.66	1.34		0.58	0.52	0.13							Dale, 1983
2.05	2.23		0.65	0.56	0.20							Dale, 1983
1.99	2.34		0.77	0.46	0.18							Dale, 1983
2.90	2.32		0.89	0.58	0.17							Dale, 1983
1.18	2.57		0.77	0.44	0.16							Dale, 1983
2.70	2.29		0.69	0.52	0.22							Dale, 1983
0.70	2.37		0.70	0.52	0.18							Dale, 1983
0.80	2.29		0.80	0.54	0.16							Dale, 1983
1.95	2.57		0.81	0.44	0.18							Dale, 1983
1.97	2.21		0.78	0.50	0.14							Dale, 1983
0.77	2.34		0.96	0.48	0.22							Dale, 1983
1.35	2.72		0.78	0.40	0.16							Dale, 1983
1.07	2.43		0.90	0.52	0.22							Dale, 1983
2.84	2.26		0.65	0.50	0.13							Dale, 1983
1.00	2.79		0.67	0.56	0.23							Dale, 1983
2.09	2.50		0.73	0.60	0.16							Dale, 1983
2.86	2.36		0.66	0.42	0.14							Dale, 1983
3.65	2.71		0.85	0.60	0.21							Dale, 1983
3.17	2.36		0.69	0.56	0.17							Dale, 1983
2.74	2.44		0.66	0.60	0.16							Dale, 1983
0.36	1.82		1.08	0.90	0.17							Dale, 1983
0.44	2.92		0.97	0.90	0.17							Dale, 1983
1.22	2.23		1.07	0.84	0.15							Dale, 1983
1.17	2.64		0.83	0.60	0.16							Dale, 1983
0.82	2.33		0.90	0.42	0.19							Dale, 1983
0.72	0.42		0.41	0.24	0.10							Dale, 1983
0.76	2.46		0.81	0.50	0.17							Dale, 1983
0.87	2.52		0.74	0.48	0.18							Dale, 1983
1.37	2.64		0.97	0.60	0.17							Dale, 1983
0.81	2.79		0.96	0.74	0.15							Dale, 1983
2.40	2.42		0.61	0.58	0.15							Dale, 1983

Table 1. Cont'd.

YIELD Kg/bush	%N	%P	%K	%Ca	%Mg	Mn	Fe	Zn	Al	Cu	B	Reference
----- % -----						----- mg/kg -----						
2.41	2.32		0.62	0.54	0.16							Dale, 1963
2.19	2.20		0.53	0.48	0.19							Dale, 1963
4.23	2.01		0.56	0.62	0.15							Dale, 1963
0.23	2.35		0.84	0.52	0.13							Dale, 1963
1.35	2.68		0.81	0.64	0.19							Dale, 1963
3.00	2.52		0.70	0.48	0.16							Dale, 1963
0.95	2.51		0.82	0.48	0.17							Dale, 1963
2.79	2.63		0.77	0.64	0.23							Dale, 1963
4.06	2.34		0.67	0.72	0.21							Dale, 1963
3.33	2.40		0.63	0.68	0.20							Dale, 1963
3.91	2.24		0.63	0.68	0.22							Dale, 1963
4.06	2.57		0.72	0.50	0.19							Dale, 1963
0.96	2.50		0.75	0.58	0.14							Dale, 1963
2.22	2.53		0.80	0.56	0.17							Dale, 1963
2.03	2.03		0.53	0.44	0.14							Dale, 1963
1.30	2.58		0.85	0.64	0.18							Dale, 1963
1.63	3.48		0.81	0.46	0.16							Dale, 1963
0.90	2.33		0.79	0.44	0.17							Dale, 1963
0.03	2.30		0.73	0.48	0.13							Dale, 1963
2.58	2.06		0.77	0.48	0.17							Dale, 1963
2.71	2.45		0.64	0.56	0.19							Dale, 1963
2.30	2.28		0.66	0.52	0.16							Dale, 1963
3.26	2.26		0.69	0.44	0.14							Dale, 1963
2.30	2.41		0.62	0.48	0.15							Dale, 1963
2.59	2.30		0.63	0.76	0.26							Dale, 1963
0.87	2.37		0.70	0.44	0.21							Dale, 1963
1.21	2.24		0.65	0.60	0.17							Dale, 1963
1.91	2.86		0.96	0.38	0.19							Dale, 1963
0.90	2.20		0.66	0.36	0.15							Dale, 1963
1.78	2.60		0.84	0.38	0.15							Dale, 1963
1.60	2.04		0.68	0.38	0.16							Dale, 1963
1.91	2.91		0.89	0.58	0.18							Dale, 1963
2.29	2.72		0.83	0.60	0.16							Dale, 1963
4.13	2.33		0.78	0.54	0.18							Dale, 1963
4.13	2.68		0.87	0.54	0.17							Dale, 1963
1.94	2.35		0.86	0.42	0.20							Dale, 1963
2.35	2.86		0.95	0.42	0.17							Dale, 1963
1.65	2.37		0.82	0.36	0.13							Dale, 1963
1.74	2.43		0.82	0.38	0.18							Dale, 1963
2.19	2.45		0.86	0.68	0.18							Dale, 1963
2.37	2.91		0.81	0.46	0.13							Dale, 1963
3.87	2.50		0.59	0.50	0.17							Dale, 1963
1.93	2.72		0.72	0.48	0.15							Dale, 1963
3.16	2.37		0.73	0.72	0.20							Dale, 1963
1.42	2.09		0.57	0.66	0.16							Dale, 1963
3.21	2.43		0.53	0.70	0.21							Dale, 1963
2.11	2.04		0.52	0.58	0.20							Dale, 1963
4.06	2.07		0.54	0.64	0.22							Dale, 1963
2.61	2.29		0.57	0.60	0.21							Dale, 1963
1.96	2.00		0.63	0.70	0.23							Dale, 1963
2.53	1.80		0.63	0.68	0.24							Dale, 1963
3.37	2.42		0.62	0.60	0.18							Dale, 1963
2.63	2.61		0.64	0.62	0.19							Dale, 1963
2.89	2.52		0.85	0.54	0.19							Dale, 1963
0.96	2.34		0.71	0.64	0.23							Dale, 1963
1.80	2.13		0.69	0.70	0.23							Dale, 1963
0.96	2.44		0.72	0.52	0.21							Dale, 1963
1.99	2.27		0.66	0.46	0.18							Dale, 1963
1.03	2.18		0.72	0.60	0.24							Dale, 1963
1.39	2.52		0.64	0.42	0.16	830	112					Dale, 1964
1.76	2.52		0.64	0.46	0.18	504	84					Dale, 1964
1.44	2.57		0.77	0.46	0.15	666	92					Dale, 1964
1.37	2.97		0.79	0.54	0.19	962	124					Dale, 1964
2.84	2.23		0.55	0.56	0.17	398	56					Dale, 1964
2.57	1.81		0.50	0.58	0.16	502	112					Dale, 1964
1.17	2.46		0.71	0.54	0.16	686	88					Dale, 1964
0.57	2.42		0.54	0.62	0.13	762	52					Dale, 1964

Table 1. Cont'd.

YIELD Kg/bush	%N	%P	%K	%Ca	%Mg	Mn	Fe	Zn	Al	Cu	B	Reference
			%						mg/kg			
0.29	2.57		0.76	0.52	0.16	770	88					Dale, 1984
2.72	2.87		0.84	0.54	0.16	898	112					Dale, 1984
3.11	2.51		0.90	0.48	0.16	786	104					Dale, 1984
3.31	2.14		0.63	0.46	0.22	254	96					Dale, 1984
3.26	2.48		0.65	0.74	0.22	780	92					Dale, 1984
4.38	2.36		0.63	0.54	0.16	896	92					Dale, 1984
2.76	2.23		0.46	0.52	0.15	560	84					Dale, 1984
0.36	2.38		0.53	0.58	0.16	496	100					Dale, 1984
2.26	2.32		0.62	0.60	0.15	626	88					Dale, 1984
1.11	2.51		0.64	0.56	0.13	590	60					Dale, 1984
3.30	2.36		0.66	0.56	0.14	700	80					Dale, 1984
5.10	2.52		0.62	0.66	0.24	762	76					Dale, 1984
2.01	2.23		0.62	0.46	0.12	316	88					Dale, 1984
1.74	2.77		0.81	0.48	0.13	662	76					Dale, 1984
0.04	2.14		0.55	0.64	0.15	184	68					Dale, 1984
0.36	2.68		0.79	0.52	0.16	318	88					Dale, 1984
1.85	2.11		0.64	0.52	0.18	544	80					Dale, 1984
1.99	1.60		0.53	0.42	0.18	136	68					Dale, 1984
1.73	2.52		0.58	0.60	0.25	408	124					Dale, 1984
1.22	2.41		0.70	0.52	0.14	450	104					Dale, 1984
0.78	2.37		0.48	0.76	0.36	250	108					Dale, 1984
1.70	2.08		0.56	0.40	0.14	226	64					Dale, 1984
1.64	2.41		0.42	0.62	0.18	684	84					Dale, 1984
2.69	2.17		0.55	0.74	0.25	452	96					Dale, 1984
3.68	2.25		0.56	0.54	0.19	510	88					Dale, 1984
1.12	2.03		0.47	0.54	0.35	272	96					Dale, 1984
0.87	1.81		0.44	0.58	0.13	144	68					Dale, 1984
1.53	2.23		0.53	0.60	0.19	396	100					Dale, 1984
0.21	2.40		0.72	0.48	0.15	396	84					Dale, 1984
1.60	2.23		0.50	0.54	0.17	322	92					Dale, 1984
0.46	2.69		0.82	0.44	0.14	652	100					Dale, 1984
0.06	3.14		0.90	0.62	0.17	622	124					Dale, 1984
1.06	2.49		0.77	0.46	0.13	360	104					Dale, 1984
1.34	2.44		0.73	0.40	0.12	442	60					Dale, 1984
0.44	2.33		0.77	0.54	0.14	758	88					Dale, 1984
0.06	1.05		0.65	0.64	0.18	486	120					Dale, 1984
0.97	2.14		0.59	0.46	0.13	460	84					Dale, 1984
0.44	2.26		0.52	0.62	0.31	420	92					Dale, 1984
1.04	3.07		0.93	0.48	0.16	1106	116					Dale, 1984
2.92	2.69		0.60	0.56	0.17	610	80					Dale, 1984
1.72	2.62		0.75	0.44	0.16	886	108					Dale, 1984
3.41	2.57		0.59	0.44	0.17	744	80					Dale, 1984
2.26	2.28		0.56	0.52	0.33	516	104					Dale, 1984
2.27	2.14		0.60	0.44	0.36	354	100					Dale, 1984
2.90	2.31		0.53	0.52	0.17	572	80					Dale, 1984
1.37	2.71		0.85	0.52	0.19	1840	92					Dale, 1984
2.51	2.19		0.52	0.54	0.27	474	80					Dale, 1984
0.86	2.17		0.69	0.60	0.17	622	112					Dale, 1984
1.16	2.92		0.88	0.62	0.19	3000	100					Dale, 1984
2.53	3.15		0.83	0.62	0.18	730	72					Dale, 1984
2.43	2.53		0.63	0.42	0.11	518	68					Dale, 1984
1.04	2.54		0.63	0.46	0.12	476	68					Dale, 1984
1.17	2.71		0.71	0.36	0.12	722	72					Dale, 1984
1.01	3.00		0.83	0.42	0.17	494	76					Dale, 1984
3.18	2.76		0.68	0.48	0.16	950	84					Dale, 1984
0.78	2.69		0.74	0.44	0.12	480	80					Dale, 1984
1.93	2.98		0.93	0.54	0.17	1102	84					Dale, 1984
5.10	2.11		0.53	0.56	0.18	1014	92					Dale, 1984
4.19	2.28		0.57	0.56	0.21	542	88					Dale, 1984
3.66	2.45		0.53	0.54	0.25	564	100					Dale, 1984
3.47	2.58		0.58	0.34	0.12	202	84					Dale, 1984
0.13	2.92		0.75	0.62	0.29	510	88					Dale, 1984
0.53	2.58		0.86	0.46	0.12	470	104					Dale, 1984
1.17	3.03		0.94	0.40	0.27	576	10					Dale, 1984
1.40	2.32		0.72	0.54	0.15	494	68					Dale, 1984
0.41	3.13		0.96	0.40	0.17	542	92					Dale, 1984
0.37	2.63		0.87	0.58	0.22	1330	104					Dale, 1984

Table 1. Cont'd.

YIELD Kg/bush	%N	%P	%K	%Ca	%Mg	Mn	Fe	Zn	Al	Cu	B	Reference
			%						mg/kg			
0.45	2.48		0.65	0.56	0.16	494	88					Dale, 1984
0.36	3.35		1.17	0.64	0.23	1500	96					Dale, 1984
0.34	2.51		0.71	0.50	0.23	354	144					Dale, 1984
0.50	3.29		1.18	0.44	0.15	1042	84					Dale, 1984
0.67	3.75		1.35	1.02	0.17	1078	120					Dale, 1984
1.57	2.68		0.66	0.46	0.13	598	76					Dale, 1984
2.56	2.28		0.64	0.70	0.18	496	52					Dale, 1984
1.82	1.81		0.51	0.48	0.16	414	60					Dale, 1984
5.55	2.37		0.53	0.80	0.18	822	88					Dale, 1984
0.47	2.84		0.82	0.62	0.21	1068	120					Dale, 1984
0.90	2.68		0.80	0.66	0.18	492	124					Dale, 1984
2.73	2.52		0.75	0.50	0.17	644	96					Dale, 1984
1.34	2.31		0.63	0.60	0.23	620	88					Dale, 1984
1.90	1.98		0.56	0.84	0.12	318	116					Dale, 1984
3.06	2.28		0.58	0.54	0.17	428	80					Dale, 1984
2.37	2.30		0.66	0.66	0.17	482	128					Dale, 1984
3.61	2.19		0.46	0.52	0.16	396	68					Dale, 1984
5.13	2.56		0.75	0.48	0.12	306	64					Dale, 1984
2.30	2.30		0.53	0.76	0.17	654	64					Dale, 1984
2.08	2.14		0.33	0.32	0.06	214	40					Dale, 1984
2.06	2.62		0.85	0.60	0.18	702	92					Dale, 1984
2.48	2.70		0.78	0.60	0.15	810	96					Dale, 1984
1.83	2.57		0.63	0.32	0.13	418	64					Dale, 1984
1.28	2.42		0.71	0.50	0.19	412	84					Dale, 1984
0.06	3.20		1.77	0.80	0.33	3500	124					Dale, 1984
2.76	2.40		0.64	0.62	0.19	552	72					Dale, 1984
4.19	1.99		0.67	0.60	0.23	432	64					Dale, 1984
2.99	2.54		0.83	0.48	0.15	444	112					Dale, 1984
3.85	2.52		0.75	0.54	0.16	668	88					Dale, 1984
0.45	2.50		0.63	0.56	0.25	544	96					Dale, 1984
2.36	2.48		0.69	0.46	0.14	430	84					Dale, 1984
0.49	3.45		1.32	1.02	0.16	416	128					Dale, 1984
1.28	2.79		0.83	0.54	0.18	758	100					Dale, 1984
1.84	2.47		0.82	0.36	0.21	272	68					Dale, 1984
1.19	2.62		0.74	0.40	0.14	858	84					Dale, 1984
1.91	2.72		0.90	0.38	0.14	838	68					Dale, 1984
1.77	2.53		0.75	0.44	0.20	470	140					Dale, 1984
2.04	2.48		0.69	0.50	0.15	720	76					Dale, 1984
2.93	2.77		0.78	0.62	0.19	1264	64					Dale, 1984
3.34	2.64		0.67	0.74	0.18	2214	92					Dale, 1984
3.75	2.61		0.65	0.42	0.14	680	64					Dale, 1984
2.22	2.88		0.82	0.66	0.15	688	92					Dale, 1984
1.49	2.67		0.76	0.64	0.17	426	104					Dale, 1984
1.83	2.69		0.90	0.50	0.11	380	84					Dale, 1984
1.59	2.49		0.65	0.52	0.11	184	448					Dale, 1984
1.84	2.41		0.65	0.70	0.19	888	172					Dale, 1984
2.83	2.30		0.71	0.80	0.20	338	124					Dale, 1984
2.87	2.53		0.57	0.76	0.17	408	92					Dale, 1984
2.10	2.39		0.50	0.70	0.32	418	120					Dale, 1984
3.25	2.31		0.65	0.48	0.15	498	84					Dale, 1984
3.69	2.32		0.48	0.54	0.18	640	64					Dale, 1984
2.15	2.78		0.82	0.64	0.40	558	100					Dale, 1984
3.22	2.46		0.68	0.52	0.16	578	76					Dale, 1984
0.85	2.97		0.70	0.60	0.17	380	124					Dale, 1984
1.51	2.57		0.68	0.56	0.17	414	104					Dale, 1984
0.41	2.53		0.61	0.84	0.17	292	84					Dale, 1984
2.54	2.25		0.70	0.68	0.21	974	88					Dale, 1984
0.23	2.67		0.64	0.84	0.16	459	144					Dale, 1984
1.89	2.66		0.64	0.54	0.16	876	76					Dale, 1984
0.81	2.54		0.68	0.60	0.27	728	104					Dale, 1984
0.06	2.86		0.85	0.48	0.19	718	84					Dale, 1984
0.07	2.27		0.74	0.37	0.10	142	76					Dale, 1984
1.36	2.68		0.77	0.36	0.17	1034	80					Dale, 1984
0.76	2.75		0.80	0.50	0.12	422	84					Dale, 1984
2.91	2.29		0.66	0.30	0.13	502	100					Dale, 1985
4.31	2.36		0.69	0.49	0.12	250	88					Dale, 1985
3.54	2.31		0.78	0.31	0.14	450	84					Dale, 1985

Table 1. Cont'd.

YIELD Kg/bush	%N	%P	%K	%Ca	%Mg	Mn	Fe	Zn	Al	Cu	B	Reference
									mg/kg			
1.66	2.15		0.76	0.41	0.09	234	84					Dale, 1965
1.86	2.11		0.69	0.40	0.15	288	100					Dale, 1965
4.06	2.26		0.78	0.30	0.18	410	124					Dale, 1965
3.69	2.30		0.65	0.33	0.16	382	68					Dale, 1965
0.56	2.49		0.55	0.42	0.15	322	92					Dale, 1965
0.67	2.45		0.75	0.45	0.13	286	76					Dale, 1965
5.03	1.94		0.67	0.43	0.13	620	60					Dale, 1965
8.64	2.49		0.66	0.48	0.15	808	100					Dale, 1965
3.31	2.15		0.65	0.37	0.10	332	88					Dale, 1965
5.96	2.28		0.63	0.41	0.19	508	112					Dale, 1965
9.02	2.35		0.50	0.43	0.17	620	100					Dale, 1965
6.27	2.26		0.53	0.39	0.16	832	88					Dale, 1965
1.26	2.50		0.53	0.41	0.25	528	120					Dale, 1965
5.18	2.34		0.61	0.31	0.22	614	116					Dale, 1965
2.46			0.68	0.42	0.19	548	100					Dale, 1965
8.21	2.31		0.52	0.40	0.21	576	82					Dale, 1965
4.50	0.62		0.43	0.67	0.11	224	80					Dale, 1965
1.74	2.15		0.68	0.49	0.09	376	364					Dale, 1965
3.97	2.29		0.64	0.31	0.12	462	36					Dale, 1965
0.01	2.33		0.78	0.38	0.14	608	44					Dale, 1965
0.45	2.40		0.69	0.50	0.15	430	120					Dale, 1965
1.39	2.24		0.56	0.31	0.17	472	118					Dale, 1965
0.96	2.24		0.87	0.44	0.08	156	80					Dale, 1965
1.45	2.30		0.64	0.32	0.18	448	108					Dale, 1965
4.77	2.07		0.48	0.41	0.18	884	72					Dale, 1965
1.43	2.48		0.55	0.38	0.19	572	124					Dale, 1965
0.99	2.68		0.76	0.26	0.15	544	96					Dale, 1965
2.32	2.51		0.75	0.36	0.16	780	92					Dale, 1965
5.06	2.38		0.50	0.41	0.25	682	96					Dale, 1965
4.09	2.20		0.46	0.21	0.18	400	84					Dale, 1965
7.48	2.29		0.45	0.52	0.29	680	112					Dale, 1965
1.47	2.29		0.47	0.20	0.27	644	140					Dale, 1965
1.19	2.47		0.62	0.26	0.16	314	140					Dale, 1965
4.35	2.34		0.40	0.48	0.21	68	100					Dale, 1965
0.80				0.32	0.27	1000	104					Dale, 1965
2.98	2.45		0.57	0.40	0.10	475	68					Dale, 1965
0.81	2.53		0.52	0.45	0.14	384	104					Dale, 1965
1.48	2.60		0.66	0.38	0.16	440	132					Dale, 1965
2.85	2.29		0.48	0.39	0.18	550	62					Dale, 1965
1.24	2.43		0.59	0.42	0.19	872	60					Dale, 1965
1.96	2.42		0.54	0.37	0.17	540	84					Dale, 1965
2.68	2.32		0.47	0.34	0.19	350	362					Dale, 1965
0.01	2.14		0.66	0.48	0.14	264	68					Dale, 1965
2.06	2.05		0.63	0.26	0.17	380	72					Dale, 1965
4.20	2.72		0.63	0.48	0.11	280	72					Dale, 1965
3.36	2.00		0.44	0.25	0.16	416	82					Dale, 1965
4.30	2.11		0.44	0.31	0.17	444	72					Dale, 1965
1.75	2.60		0.62	0.35	0.12	264	64					Dale, 1965
4.68	2.01		0.46	0.18	0.15	478	76					Dale, 1965
7.14	2.05		0.51	0.35	0.17	510	124					Dale, 1965
2.60	2.07		0.49	0.29	0.16	552	124					Dale, 1965
5.04	1.90		0.45	0.32	0.17	324	92					Dale, 1965
1.79	2.18		0.55	0.10	0.20	512	88					Dale, 1965
2.26	2.25		0.47	0.32	0.21	542	88					Dale, 1965
3.17	2.28		0.67	0.42	0.14	380	100					Dale, 1965
6.04	2.10		0.50	0.37	0.15	902	84					Dale, 1965
2.02	1.99		0.60	0.36	0.11	364	180					Dale, 1965
2.77	1.93		0.46	0.26	0.13	456	100					Dale, 1965
1.44	2.54		0.77	0.25	0.10	260	84					Dale, 1965
5.65	2.27		0.48	0.44	0.22	370	108					Dale, 1965
1.34	2.72		0.72	0.92	0.18	540	80					Dale, 1965
7.28	2.09		0.62	0.40	0.14	888	112					Dale, 1965
4.95	2.04		0.47									Dale, 1965
4.65	2.44		0.50	0.26	0.30	700	104					Dale, 1965
6.24	2.06		0.49	0.28	0.13	560	40					Dale, 1965
0.93			0.67	0.47	0.17	532	84					Dale, 1965
1.95			0.67	0.31	0.14	340	72					Dale, 1965

Table 1. Cont'd.

YIELD Kg/bush	%N	%P	%K	%Ca	%Mg	Mn	Fe	Zn	Al	Cu	B	Reference
			%						mg/kg			
1.98	3.86		0.55	0.47	0.16	620	56					Dale, 1985
3.01	2.06		0.58	0.26	0.19	368	56					Dale, 1985
0.68	2.21		0.68	0.23	0.11	364	48					Dale, 1985
0.37	2.29		0.70	0.22	0.10	268	80					Dale, 1985
0.18	1.97		0.73	0.37	0.09	122	84					Dale, 1985
1.26	2.90		0.84	0.66	0.14	172	120					Dale, 1985
0.80	2.26		0.84	0.22	0.14	548	100					Dale, 1985
0.32	2.44		0.64	0.27	0.13	210	120					Dale, 1985
2.11	2.37		0.52	0.41	0.20	586	88					Dale, 1985
3.97	1.97		0.46	0.27	0.18	326	62					Dale, 1985
2.52	1.94		0.66	0.50	0.11	126	54					Dale, 1985
4.26	1.84		0.55	0.17	0.12	218	128					Dale, 1985
0.50	2.26		0.61	0.43	0.18	328	96					Dale, 1985
1.88	1.94		0.49	0.32	0.15	416	82					Dale, 1985
3.98	2.05		0.49	0.38	0.19	352	104					Dale, 1985
3.13	1.39		0.58	0.30	0.20	422	84					Dale, 1985
3.76	2.06		0.48	0.25	0.14	230	80					Dale, 1985
7.66	2.13		0.49	0.59	0.19	276	92					Dale, 1985
4.79	2.17		0.47	0.34	0.15	386	44					Dale, 1985
6.71	2.21		0.65	0.49	0.22	788	140					Dale, 1985
7.66	2.32		0.77	0.31	0.12	202	60					Dale, 1985
1.39	2.45		0.53	0.45	0.20	988	124					Dale, 1985
3.88	2.21		0.62	0.58	0.21	700	104					Dale, 1985
4.39	1.94		0.65	0.35	0.09	154	104					Dale, 1985
1.64	2.25		0.62	0.31	0.10	404	72					Dale, 1985
0.22	1.98		0.83	0.55	0.09	122	60					Dale, 1985
0.10	2.10		0.76	0.37	0.10	316	124					Dale, 1985
4.37	2.24		0.60	0.36	0.13	616	128					Dale, 1985
4.79	1.98		0.57	0.33	0.15	380	100					Dale, 1985
5.04	2.09		0.85	0.31	0.27	656	120					Dale, 1985
8.29	2.18		0.46	0.45	0.15	652	100					Dale, 1985
3.79	2.23		0.63	0.54	0.16	300	88					Dale, 1985
2.18	1.78		0.57	0.29	0.12	260	84					Dale, 1985
1.18	2.11		0.73	0.35	0.15	384	124					Dale, 1985
1.14	2.07		0.71	0.31	0.14	600	120					Dale, 1985
1.79	1.73		0.67	0.49	0.11	206	60					Dale, 1985
0.90			0.61	0.25	0.20	206	60					Dale, 1985
2.70	2.20		0.54	0.38	0.19	364	88					Dale, 1985
4.52	2.32		0.55	0.49	0.21	644	144					Dale, 1985
4.24	2.17		0.56	0.29	0.28	442	122					Dale, 1985
5.84	2.16		0.57	0.26	0.22	384	92					Dale, 1985
6.49	1.98		0.66	0.36	0.19	490	100					Dale, 1985
5.06	2.13		0.48	0.29	0.18	510	128					Dale, 1985
3.20	2.39		0.67	0.39	0.15	334	100					Dale, 1985
2.92	2.29		0.70	0.28	0.22	678	88					Dale, 1985
2.79	2.46		0.62	0.29	0.23	380	100					Dale, 1985
2.94	2.21		0.47	0.27	0.20	404	120					Dale, 1985
6.97	2.15		0.48	0.33	0.19	560	92					Dale, 1985
5.67	2.24		0.50	0.33	0.19	248	108					Dale, 1985
3.89	2.17		0.48	0.44	0.21	728	100					Dale, 1985
4.85	1.92		0.50	0.31	0.23	510	122					Dale, 1985
5.30	2.27		0.49	0.49	0.24	792	88					Dale, 1985
5.62	2.30		0.50	0.35	0.22	342	76					Dale, 1985
4.31	2.15		0.47	0.33	0.26	504	100					Dale, 1985
7.90	2.10		0.43	0.47	0.25	500	124					Dale, 1985
4.19	2.03		0.47	0.38	0.25	228	80					Dale, 1985
3.89	2.15		0.42	0.45	0.25	482	116					Dale, 1985
3.18	2.26		0.52	0.24	0.24	274	84					Dale, 1985
8.57	2.16		0.49	0.27	0.15	366	100					Dale, 1985
3.76	2.12		0.63	0.21	0.20	174	124					Dale, 1985
7.00	2.26		0.47	0.42	0.24	482	88					Dale, 1985
1.67	2.63		0.64	0.26	0.23	556	140					Dale, 1985
1.72	2.29		0.50	0.34	0.26	362	124					Dale, 1985
5.36	2.44		0.50	0.50	0.24	490	144					Dale, 1985
1.64	2.16		0.63	0.34	0.18	270	52	10				Dale, 1986
5.42	2.09		0.47	0.67	0.23	326	52	14				Dale, 1986
3.33	2.26		0.54	0.46	0.19	318	56	16				Dale, 1986

Table 1. Cont'd.

YIELD Kg/bush	%N	%P	%K	%Ca	%Mg	Mn	Fe	Zn	Al	Cu	B	Reference
----- % ----- mg/kg -----												
2.80	2.27		0.57	0.50	0.21	338	48	12				Dale, 1986
3.80			0.58	0.59	0.19	312	72	16				Dale, 1986
4.47			0.56	0.53	0.20	418	56	28				Dale, 1986
3.54	2.27		0.60	0.55	0.18	340	80	14				Dale, 1986
0.68	2.55		0.67	0.61	0.27	358	76	10				Dale, 1986
0.60	2.26		0.67	0.52	0.17	222	64	18				Dale, 1986
4.69	2.27		0.55	0.67	0.16	534	72	18				Dale, 1986
8.82	1.97		0.44	0.67	0.15	524	60	18				Dale, 1986
5.26	2.26		0.51	0.67	0.23	438	64	26				Dale, 1986
6.53	2.14		0.52	0.63	0.21	428	56	24				Dale, 1986
8.06	2.32		0.63	0.64	0.17	500	68	12				Dale, 1986
5.11	2.27		0.53	0.76	0.20	410	68	22				Dale, 1986
1.52	2.25		0.48	0.63	0.26	344	84	14				Dale, 1986
3.34	2.27		0.50	0.71	0.19	376	76	26				Dale, 1986
1.72			0.54	0.62	0.22	456	80	18				Dale, 1986
6.31	2.14		0.53	0.51	0.15	530	60	14				Dale, 1986
5.76	2.04		0.48	0.64	0.18	414	68	18				Dale, 1986
4.12	1.92		0.44	0.61	0.18	352	76	22				Dale, 1986
4.70	2.23		0.56	0.52	0.17	414	60	22				Dale, 1986
0.12	2.30		0.84	0.55	0.22	414	68	16				Dale, 1986
1.22	2.03		0.50	0.55	0.23	276	56	32				Dale, 1986
3.61	2.23		0.45	0.54	0.18	462	84	16				Dale, 1986
2.12	2.89		0.53	0.66	0.28	636	56	18				Dale, 1986
2.00	2.11		0.50	0.46	0.21	378	52	18				Dale, 1986
4.62	2.27		0.44	0.50	0.15	416	84	22				Dale, 1986
1.62	2.25		0.45	0.64	0.22	310	60	22				Dale, 1986
2.03	2.41		0.47	0.66	0.21	712	56	16				Dale, 1986
3.60	2.42		0.43	0.75	0.21	406	92	58				Dale, 1986
3.48	2.12		0.45	0.48	0.20	216	48	19				Dale, 1986
4.16	2.16		0.43	0.68	0.23	350	64	16				Dale, 1986
5.95	2.02		0.34	0.63	0.23	248	36	14				Dale, 1986
1.10	2.16		0.47	0.78	0.28	404	64	14				Dale, 1986
1.80	2.38		0.46	0.93	0.29	540	52	18				Dale, 1986
3.14	2.24		0.41	0.76	0.21	326	64	20				Dale, 1986
1.27	2.31		0.55	0.69	0.23	876	176	26				Dale, 1986
4.89	2.05		0.47	0.59	0.17	276	80	18				Dale, 1986
3.43	2.23		0.46	0.55	0.17	284	52	72				Dale, 1986
0.82	2.11		0.50	0.57	0.17	436	48	12				Dale, 1986
1.91	2.40		0.47	0.70	0.25	604	52	18				Dale, 1986
3.54	2.08		0.43	0.72	0.23	514	60	22				Dale, 1986
2.06			0.55	0.59	0.21	286	48	16				Dale, 1986
0.06	2.56		0.56	0.56	0.23	302	62	28				Dale, 1986
1.60	2.59		0.54	0.69	0.21	290	60	24				Dale, 1986
1.79	2.13		0.48	0.82	0.20	326	64	16				Dale, 1986
1.39	2.22		0.64	0.55	0.22	424	56	12				Dale, 1986
3.39	2.29		0.48	0.56	0.18	346	60	18				Dale, 1986
5.20	2.16		0.42	0.58	0.23	382	44	8				Dale, 1986
4.18	2.02		0.46	0.47	0.19	272	60	24				Dale, 1986
5.39			0.45	0.52	0.20	376	44	12				Dale, 1986
3.23	2.18		0.46	0.64	0.21	302	56	10				Dale, 1986
5.27	2.13		0.47	0.66	0.16	408	96	20				Dale, 1986
7.01	2.34		0.46	0.69	0.19	374	40	12				Dale, 1986
2.67	2.32		0.47	0.54	0.23	350	40	26				Dale, 1986
5.26	1.67		0.60	0.54	0.17	218	68	52				Dale, 1986
1.55	2.22		0.51	0.56	0.25	328	60	12				Dale, 1986
1.52	2.55		0.63	0.56	0.24	280	48	28				Dale, 1986
4.24	2.51		0.44	0.57	0.20	348	48	16				Dale, 1986
5.83	2.04		0.47	0.60	0.17	430	84	20				Dale, 1986
2.33	2.04		0.47	0.55	0.14	500	36	18				Dale, 1986
3.65	2.77		0.44	0.65	0.18	520	60	20				Dale, 1986
1.39	2.14		0.55	0.47	0.18	450	52	28				Dale, 1986
4.48	2.24		0.48	0.56	0.30	180	68	16				Dale, 1986
1.33	2.17		0.64	0.50	0.14	328	56	20				Dale, 1986
4.27	2.16		0.43	0.57	0.23	240	64	30				Dale, 1986
6.26	2.02		0.45	0.53	0.16	528	88	12				Dale, 1986
5.73	2.01		0.44	0.55	0.20	310	48	10				Dale, 1986
6.28	2.02		0.46	0.53	0.16	234	56	38				Dale, 1986

Table 1. Cont'd.

YIELD Kg/bush	%N	%P	%K	%Ca	%Mg	Mn	Fe	Zn	Al	Cu	B	Reference
----- % ----- mg/kg -----												
6.35	2.01		0.43	0.67	0.21	580	60	16				Date, 1986
0.73	2.15		0.66	0.47	0.12	306	40	12				Date, 1986
0.86	2.32		0.60	0.57	0.19	376	76	26				Date, 1986
1.82	2.03		0.48	0.66	0.18	368	60	12				Date, 1986
2.81	2.11		0.54	0.68	0.21	450	52	28				Date, 1986
1.50	2.26		0.60	0.37	0.17	348	60	14				Date, 1986
0.28	2.20		0.65	0.36	0.15	304	64	12				Date, 1986
0.97	2.49		0.77	0.41	0.14	436	60	14				Date, 1986
1.38	2.04		0.56	0.47	0.17	390	52	10				Date, 1986
1.17	1.89		0.53	0.70	0.23	344	64	8				Date, 1986
1.06	2.28		0.66	0.37	0.15	474	16	64				Date, 1986
2.05	2.26		0.58	0.59	0.16	300	64	12				Date, 1986
4.07	2.16		0.48	0.63	0.20	622	60	20				Date, 1986
3.27	2.25		0.56	0.67	0.20	268	64	12				Date, 1986
2.28	2.06		0.51	0.58	0.19	480	64	32				Date, 1986
7.56	2.04		0.45	0.73	0.19	402	64	36				Date, 1986
1.00	2.48		0.62	0.77	0.21	760	80	24				Date, 1986
1.44	2.32		0.47	0.62	0.16	210	72	24				Date, 1986
5.96	2.02		0.44	0.73	0.19	508	64	14				Date, 1986
2.31	1.73		0.46	0.65	0.18	220	72	16				Date, 1986
1.67	1.89		0.60	0.69	0.16	308	60	14				Date, 1986
6.64			0.49	0.71	0.20	584	68	18				Date, 1986
5.17	1.95		0.48	0.70	0.17	312	88	16				Date, 1986
5.46	2.07		0.55	0.45	0.18	360	68	14				Date, 1986
6.74	2.30		0.53	0.56	0.19	470	40	20				Date, 1986
2.10	2.57		0.60	0.52	0.20	422	52	20				Date, 1986
2.42	2.27		0.57	0.50	0.16	200	52	10				Date, 1986
3.24	2.09		0.47	0.57	0.16	254	44	14				Date, 1986
4.48			0.50	0.46	0.17	300	72	22				Date, 1986
3.79	2.04		0.47	0.54	0.19	342	56	12				Date, 1986
0.08	2.09		0.66	0.52	0.18	246	56	22				Date, 1986
4.34	2.10		0.53	0.58	0.17	648	60	18				Date, 1986
5.65	2.29		0.52	0.62	0.19	480	80	32				Date, 1986
4.50	2.18		0.57	0.58	0.15	344	72	18				Date, 1986
5.88	2.12		0.47	0.55	0.15	432	60	10				Date, 1986
3.26	2.22		0.53	0.45	0.17	234	60	26				Date, 1986
2.92	2.11		0.54	0.50	0.13	380	56	18				Date, 1986
2.44	2.48		0.54	0.53	0.22	300	68	8				Date, 1986
2.87	2.11		0.53	0.51	0.15	430	60	12				Date, 1986
2.77	2.61		0.52	0.47	0.26	320	60	18				Date, 1986
1.96	2.15		0.49	0.54	0.28	436	64	32				Date, 1986
2.04	2.63		0.53	0.65	0.21	404	64	12				Date, 1986
2.58	2.42		0.62	0.66	0.29	368	68	20				Date, 1986
2.54	2.33		0.59	0.60	0.22	386	76	20				Date, 1986
3.13	2.25		0.49	0.43	0.18	168	56	28				Date, 1986
5.74	2.24		0.49	0.62	0.18	250	60	12				Date, 1986
5.59			0.47	0.49	0.17	292	68	16				Date, 1986
4.05	2.20		0.46	0.53	0.18	302	80	32				Date, 1986
3.48	2.17		0.42	0.56	0.16	278	88	28				Date, 1986
2.20	2.16		0.45	0.48	0.18	256	52	16				Date, 1986
2.18	2.59		0.48	0.42	0.18	284	48	12				Date, 1986
2.54	2.47		0.46	0.57	0.25	436	60	12				Date, 1986
5.16	2.37		0.45	0.45	0.17	308	60	16				Date, 1986
5.20	2.48		0.68	0.57	0.21	292	64	12				Date, 1986
3.66	2.36		0.46	0.49	0.16	318	52	14				Date, 1986
4.32	2.45		0.43	0.84	0.23	514	28	13				Date, 1986
4.76	2.44		0.44	0.59	0.19	386	40	16				Date, 1986
5.51	2.50		0.47	0.63	0.20	350	68	20				Date, 1986
3.07	2.12		0.43	0.76	0.17	242	64	14				Date, 1986
6.04	2.16		0.39	0.64	0.18	206	48	66				Date, 1986
3.71			0.43	0.70	0.18	260	48	18				Date, 1986
3.10	1.90		0.42	0.53	0.18	228	84	74				Date, 1986
2.78	2.26		0.47	0.78	0.21	242	48	48				Date, 1986
6.84	2.44		0.46	0.70	0.19	550	80	26				Date, 1986
4.39	2.17		0.44	0.62	0.21	326	60	14				Date, 1986
4.78	2.25		0.53	0.75	0.23	300	48	18				Date, 1986
1.50	2.06		0.52	0.70	0.23	348	60	12				Date, 1986

Table 1. Cont'd.

YIELD Kg/bush	%N	%P	%K	%Ca	%Mg	Mn	Fe	Zn	Al	Cu	B	Reference
			%						mg/kg			
2.66	2.44		0.46	0.55	0.19	304	68	16				Dale, 1986
1.00	2.12		0.54	0.71	0.14	280	60	38				Dale, 1986
3.68	2.30		0.43	0.81	0.26	104	64	18				Dale, 1986
1.49	2.73		0.45	0.74	0.16	296	52	10				Dale, 1986

Table 2. Blueberry DRIS.

ID	YIELD kg/bush	N	P	K	Ca	Mg	Mn	Fe	Zn	Al	Cu	B	NII	RELATIVE ORDER OF NUTRIENT REQUIREMENTS
1	15.88	6	-1	-4	1	0	-7	3	-4	-4	6	5	41	Mn>Zn>K>Al>P>Mg>Ca>Fe>B>Cu>N
2	14.75	8	-0	-2	2	1	-2	5	-4	-2	-11	5	41	Cu>Zn>K>Mn>Al>P>Mg>Ca>Fe>B>N
3	14.71	7	4	-0	6	3	-16	8	-0	-3	-5	-3	54	Mn>Cu>Al>B>K>Zn>Mg>P>Ca>N>Fe
1	15.88	6	-1	-4	1	0	-7	3	-4	-4	6	5	41	Mn>Zn>K>Al>P>Mg>Ca>Fe>B>Cu>N
2	14.75	8	-0	-2	2	1	-2	5	-4	-2	-11	5	41	Cu>Zn>K>Mn>Al>P>Mg>Ca>Fe>B>N
3	14.71	7	4	-0	6	3	-16	8	-0	-3	-5	-3	54	Mn>Cu>Al>B>K>Zn>Mg>P>Ca>N>Fe
4	14.59	6	-0	-2	2	1	-6	5	-4	-3	-5	6	39	Mn>Cu>Zn>Al>K>P>Mg>Ca>Fe>B>N
5	14.56	3	-3	-2	3	2	-4	4	-4	-5	1	5	36	Al>Mn>Zn>P>K>Cu>Mg>Ca>N>Fe>B
6	14.47	8	1	-3	3	3	-7	6	0	-4	-10	2	47	Cu>Mn>Al>K>Zn>P>B>Ca>Mg>Fe>N
7	13.93	8	4	-2	4	2	-9	7	-0	-4	-10	1	52	Cu>Mn>Al>K>Zn>B>Mg>P>Ca>Fe>N
8	13.90	6	-1	-3	6	4	-11	6	-1	1	-9	2	50	Mn>Cu>K>Zn>P>Al>B>Mg>Ca>Fe>N
9	13.77	7	6	-4	6	4	-11	7	-5	-3	-9	1	63	Mn>Cu>Zn>K>Al>B>Mg>P>Ca>N>Fe
10	13.38	5	1	-3	3	2	-8	6	2	-3	-4	0	38	Mn>Cu>Al>K>B>P>Zn>Mg>Ca>N>Fe
11	13.32	5	0	-5	2	1	-8	8	4	-1	-11	5	51	Cu>Mn>K>Al>P>Mg>Ca>Zn>B>N>Fe
12	13.25	11	3	-1	6	2	-16	8	-3	-3	-11	5	69	Mn>Cu>Zn>Al>K>Mg>P>B>Ca>Fe>N
13	11.09	5	3	5	-4	-3	-11	-21	11		6	9	79	Fe>Mn>Ca>Mg>P>N>K>Cu>B>Zn
14	11.05	-1	16	9	-12	-13	2	-17	10		2	3	85	Fe>Mg>Ca>N>Cu>Mn>B>K>Zn>P
15	10.75	-3			-4	-1	8						15	B>P>Fe>Zn>K>Al>Ca>N>Mg>Mn
16	10.59	-2			-3	-1	6						13	B>P>Fe>Zn>K>Al>Ca>N>Mg>Mn
17	10.56	1	2	-2	-8	-6	9	-28	4		5	22	87	Fe>Ca>Mg>K>N>P>Zn>Cu>Mn>B
18	10.36	1	-0	-1	5	5	-1	-30	1		21	-1	65	Fe>B>Mn>K>P>N>Zn>Ca>Mg>Cu
19	10.05	2	1	2	-3	-2	8	-28	9		3	8	65	Fe>Ca>Mg>P>N>K>Cu>B>Mn>Zn
20	9.96	-4			-6	-2	12						24	B>P>Fe>Zn>K>Al>Ca>N>Mg>Mn
21	9.52	-1	11	-7	-13	-13	9	-36	21		10	20	140	Fe>Mg>Ca>K>N>Mn>Cu>P>B>Zn
22	9.39	6	3	-4	16	11	-25	9	-2	-2	-8	-5	91	Mn>Cu>B>K>Al>Zn>P>N>Fe>Mg>Ca
23	9.37	-3	1	-1	-3	-3	-2	-28	20		5	14	80	Fe>Ca>Mg>N>Mn>K>P>Cu>B>Zn
24	9.11	4	1	-0	16	8	-54	61	-14	-10	-26	14	208	Mn>Cu>Zn>Al>K>P>N>Mg>B>Ca>Fe
25	9.09	-0	12	1	-4	-9	4	-26	-3		7	18	85	Fe>Mg>Ca>Zn>N>K>Mn>Cu>P>B
26	9.03	6	-2	2	12	6	-40	49	-23	5	-27	12	183	Mn>Cu>Zn>P>K>Al>Mg>N>Ca>B>Fe
27	9.02	-5		-8	0	-4	13	4					35	K>N>Mg>Ca>Fe>Mn
28	8.99	9	1	-4	14	7	-30	20	-6	-4	-1	-7	103	Mn>B>Zn>K>Al>Cu>P>Mg>N>Ca>Fe
29	8.95	17	1	-3	13	10	-37	21	-7	-7	-3	-5	123	Mn>Zn>Al>B>Cu>K>P>Mg>Ca>N>Fe
30	8.93	-8	-1	-2	-17	-15	-2	-35	12		17	52	182	Fe>Ca>Mg>N>K>Mn>P>Zn>Cu>B
31	8.90	-2	-4	4	13	4	-49	57	-18	-3	-16	10	181	Mn>Zn>Cu>P>Al>N>K>Mg>B>Ca>Fe
32	8.85	5	3	-1	14	9	-21	8	-5	-4	-7	-2	80	Mn>Cu>Zn>Al>B>K>P>N>Fe>Mg>Ca
33	8.82	-7		-8	-6	6	21	-1	-5				55	K>N>Ca>Zn>Fe>Mg>Mn
34	8.81	7	-2	-1	11	5	-37	54	-23	-2	-28	16	183	Mn>Cu>Zn>Al>P>K>Mg>N>Ca>B>Fe
35	8.73	-4			-7	-2	12						25	Ca>N>Mg>Mn
36	8.70	3	11	2	-7	-3	-6	-18	10		7	1	67	Fe>Ca>Mn>Mg>B>K>N>Cu>Zn>P
37	8.70	10	1	4	15	10	-26	8	-3	2	-8	-13	99	Mn>B>Cu>Zn>P>Al>K>Fe>N>Mg>Ca
38	8.70	-1	-6	-5	6	1	-43	40	-10	-3	9	11	134	Mn>Zn>P>K>Al>N>Mg>Ca>Cu>B>Fe
39	8.64	-8		-1	-5	-5	17	2					40	N>Ca>Mg>K>Fe>Mn
40	8.57	-11		-10	19	-4	2	4					50	N>K>Mg>Mn>Fe>Ca
41	8.54	-1	5	9	4	6	-6	-18	8		2	-8	68	Fe>B>Mn>N>Cu>Ca>P>Mg>Zn>K
42	8.54	1	-4	-0	16	8	-49	63	-21	-4	-27	18	211	Mn>Cu>Zn>Al>P>K>N>Mg>Ca>B>Fe
43	8.53	-6	9	11	-5	-14	-4	-39	18		6	25	136	Fe>Mg>N>Ca>Mn>Cu>P>K>Zn>B
44	8.39	-26	-7	2	14	5	-50	55	-18	-5	21	9	212	Mn>N>Zn>P>Al>K>Mg>B>Ca>Cu>Fe
45	8.39	-4	-5	3	-25	2	15	-30	21		23	1	129	Fe>Ca>P>N>B>Mg>K>Mn>Zn>Cu
46	8.39	1	8	5	7	7	2	8	3	7	-54	6	108	Cu>N>Mn>Zn>K>B>Ca>Al>Mg>P>Fe
47	8.36	-9	2	0	2	4	2	9	36	8	-67	12	154	Cu>N>K>Ca>Mn>P>Mg>Al>Fe>B>Zn
48	8.34	-1	-1	-3	-0	-2	-12	-7	29		1	-2	59	Mn>Fe>K>B>Mg>P>N>Ca>Cu>Zn
49	8.33	5	-2	4	14	6	-36	50	-23	2	-28	8	179	Mn>Cu>Zn>P>Al>K>N>Mg>B>Ca>Fe
50	8.29	-8		-12	1	-0	15	5					40	K>N>Mg>Ca>Fe>Mn
51	8.21	-4		-5	2	-7	12	1					31	Mg>K>N>Fe>Ca>Mn
52	8.19	15	5	-4	16	10	-45	24	0	-13	-3	-4	140	Mn>Al>B>K>Cu>Zn>P>Mg>N>Ca>Fe
53	8.14	6	-2	-0	9	4	-33	61	-24	-5	-30	15	189	Mn>Cu>Zn>Al>P>K>Mg>N>Ca>B>Fe
54	8.14	2	-6	-1	13	5	-44	57	-15	-4	-28	22	196	Mn>Cu>Zn>P>Al>K>N>Mg>Ca>B>Fe
55	8.13	1	-9	-16	7	4	-35	4	-3	77	-4	-24	183	Mn>B>K>P>Cu>Zn>N>Mg>Fe>Ca>Al
56	8.12	7	4	-1	20	13	-26	8	-4	-6	-7	-8	104	Mn>B>Cu>Al>Zn>K>P>N>Fe>Mg>Ca
57	8.09	2	-7	8	11	7	-36	58	-16	4	-28	-2	179	Mn>Cu>Zn>P>B>N>Al>Mg>K>Ca>Fe
58	8.07	4	-0	5	14	7	-29	22	-8	4	-4	-13	110	Mn>B>Zn>Cu>P>N>Al>K>Mg>Ca>Fe
59	8.06	0		-0	-7	2	24	2	-20				55	Zn>Ca>K>N>Fe>Mg>Mn
60	8.03	0			-2	-0	2						4	Ca>Mg>N>Mn
61	8.02	-6	-2	1	13	6	-45	55	-16	-1	-14	9	168	Mn>Zn>Cu>N>P>Al>K>Mg>B>Ca>Fe
62	7.90	-4		-9	-3	-8	11	12					47	K>Mg>N>Ca>Mn>Fe
63	7.84	5	6	1	15	10	-24	9	1	-4	-8	-10	93	Mn>B>Cu>Al>Zn>K>N>P>Fe>Mg>Ca
64	7.83	2	2	0	12	8	-17	7	-2	2	-8	-6	66	Mn>Cu>B>Zn>K>Al>N>P>Fe>Mg>Ca
65	7.81	8	4	-6	18	12	-43	24	-1	-8	-2	-4	130	Mn>Al>K>B>Cu>Zn>P>N>Mg>Ca>Fe
66	7.79	5	8	3	7	6	1	7	-4	11	-53	9	113	Cu>Zn>Mn>K>N>Mg>Fe>Ca>P>B>Al

Table 2. Cont'd.

ID	YIELD		N	P	K	Ca	Mg	Mn	Fe	Zn	Al	Cu	B	NH		RELATIVE ORDER OF NUTRIENT REQUIREMENTS
	kg/bush															
67	7.79	15	-3	-3	14	11	-39	21	-3	-5	-3	-4	121			Mn>Al>B>K>P>Cu>Zn>Mg>Ca>N>Fe
68	7.78	7	3	5	14	8	-23	9	-4	1	-10	-10	94			Mn>B>Cu>Zn>Al>P>K>N>Mg>Fe>Ca
69	7.76	7	0	2	14	8	-23	9	-4	-0	-3	-9	79			Mn>B>Zn>Cu>Al>P>K>N>Mg>Fe>Ca
70	7.71	6	5	2	17	10	-27	9	-3	-1	-9	-8	96			Mn>Cu>B>Zn>Al>K>P>N>Fe>Mg>Ca
71	7.68	12	6	9	18	11	-30	9	-2	-2	-8	-21	129			Mn>B>Cu>Al>Zn>P>K>Fe>Mg>N>Ca
72	7.67	12	5	-1	17	12	-32	11	1	1	-9	-18	118			Mn>B>Cu>K>Zn>Al>P>Fe>Mg>N>Ca
73	7.66	-11		7	18	0	-7	-8					49			N>Mn>Fe>Mg>K>Ca
74	7.66	-2		-2	-5	0	1	7					16			Ca>K>N>Mg>Mn>Fe
75	7.56	-9		-11	-12	-1	9	1	23				66			Ca>K>N>Mg>Fe>Mn>Zn
76	7.55	6	-6	4	6	4	-1	26	-10	15	-61	18	157			Cu>Zn>P>Mn>Mg>K>N>Ca>Al>B>Fe
77	7.55	-3	8	-0	2	5	10	8	1	12	-55	13	117			Cu>N>K>Zn>Ca>Mg>P>Fe>Mn>Al>B
78	7.55	-4	1	12	3	1	-5	-35	-6		21	11	99			Fe>Zn>Mn>N>P>Mg>Ca>B>K>Cu
79	7.53	4	5	8	6	6	3	9	-3	13	-58	6	122			Cu>Zn>Mn>N>P>Ca>Mg>B>K>Fe>Al
80	7.49	5	6	3	5	5	3	11	-2	12	-57	7	117			Cu>Zn>Mn>K>Ca>N>Mg>P>B>Fe>Al
81	7.48	0		-8	-8	-14	21	10					62			Mg>Ca>K>N>Fe>Mn
82	7.41	-5	8	2	4	5	1	9	3	14	-54	13	118			Cu>N>Mn>K>Zn>Ca>Mg>P>Fe>B>Al
83	7.39	3	-1	-1	13	5	-40	58	-15	-3	-28	9	177			Mn>Cu>Zn>Al>K>P>N>Mg>B>Ca>Fe
84	7.31	12	-1	-0	21	11	-41	20	-4	-5	-4	-8	127			Mn>B>Al>Zn>Cu>P>K>Mg>N>Fe>Ca
85	7.28	-18		-4	2	-4	20	4					52			N>Mg>K>Ca>Fe>Mn
86	7.27	0	-3	5	-4	-4	-7	-0	8		-1	7	39			Mn>Mg>Ca>P>Cu>Fe>N>K>B>Zn
87	7.23	9	-2	-5	15	12	-20	-4	-2	-8	3	4	85			Mn>Al>K>Fe>P>Zn>Cu>B>N>Mg>Ca
88	7.20	2	2	-1	2	-1	-3	-30	7		10	12	72			Fe>Mn>Mg>K>Ca>P>N>Zn>Cu>B
89	7.19	2	5	-2	4	4	-0	4	9	37	-58	-5	129			Cu>B>K>Mn>N>Ca>Fe>Mg>P>Zn>Al
90	7.18	1	1	-5	12	9	-28	23	-3	-1	-4	-5	92			Mn>B>K>Cu>Zn>Al>P>N>Mg>Ca>Fe
91	7.16	6	-4	3	16	10	-8	-2	-12	2	-3	-8	73			Zn>Mn>B>P>Cu>Fe>Al>K>N>Mg>Ca
92	7.14	-12		-7	7	-4	8	8					48			N>K>Mg>Ca>Mn>Fe
93	7.08	-0	11	5	-13	0	-6	-25	-22		42	9	135			Fe>Zn>Ca>Mn>N>Mg>K>B>P>Cu
94	7.06	5	10	-2	0	-12	-4	-43	12		11	23	123			Fe>Mg>Mn>K>Ca>N>P>Cu>Zn>B
95	7.01	5		-2	-6	4	17	-5	-13				53			Zn>Ca>Fe>K>Mg>N>Mn
96	7.00	-5	9	-4	10	-5	-1	-54	12		23	16	138			Fe>N>Mg>K>Mn>P>Ca>Zn>B>Cu
97	7.00	-1		-6	1	-7	10	4					29			Mg>K>N>Ca>Fe>Mn
98	6.97	-8		-9	9	-6	11	3					46			K>N>Mg>Fe>Ca>Mn
99	6.97	5	5	10	4	6	2	10	1	9	-59	6	117			Cu>Zn>Mn>Ca>P>N>B>Mg>Al>K>Fe
100	6.96	2	13	2	-9	-3	2	-22	11		8	-2	73			Fe>Ca>Mg>B>K>Mn>N>Cu>Zn>P
101	6.91	-1	4	9	-8	11	3	-42	8		17	-1	103			Fe>Ca>B>N>Mn>P>Zn>K>Mg>Cu
102	6.88	4	3	6	13	9	-27	2	2	-8	-1	-4	79			Mn>Al>B>Cu>Zn>Fe>P>N>K>Mg>Ca
103	6.87	3	4	4	3	4	1	7	-3	31	-59	5	125			Cu>Zn>Mn>N>Ca>Mg>P>K>B>Fe>Al
104	6.87	6	-5	4	9	7	-39	55	-9	-0	-26	-2	164			Mn>Cu>Zn>P>B>Al>K>N>Mg>Ca>Fe
105	6.86	3	-3	-2	15	12	-26	-1	-6	-3	3	8	82			Mn>Zn>Al>P>K>Fe>Cu>N>B>Mg>Ca
106	6.84	4	2	5	15	10	-28	-2	-4	-0	-1	-0	71			Mn>Zn>Fe>Cu>Al>B>P>N>K>Mg>Ca
107	6.84	-0		-11	-13	-2	18	3	5				53			Ca>K>Mg>N>Fe>Zn>Mn
108	6.81	-0	1	-2	15	11	-27	-1	3	-3	3	1	65			Mn>Al>K>Fe>N>P>B>Zn>Cu>Mg>Ca
109	6.79	-7	-1	-1	-11	-6	-11	-11	5		14	29	96			Fe>Ca>Mn>N>Mg>P>K>Zn>Cu>B
110	6.78	1	-8	2	3	3	-29	52	-8	0	-15	0	121			Mn>Cu>P>Zn>B>Al>N>K>Ca>Mg>Fe
111	6.75	13	-2	-6	13	10	-31	17	-6	-3	1	-7	110			Mn>B>Zn>K>Al>P>Cu>Mg>N>Ca>Fe
112	6.74	-2		-2	-3	0	17	-8	-2				34			Fe>Ca>Zn>K>N>Mg>Mn
113	6.73	10	1	-2	19	13	-47	24	-4	-0	-7	-6	134			Mn>Cu>B>Zn>K>Al>P>N>Mg>Ca>Fe
114	6.72	0	-9	5	5	4	-33	54	-12	2	-8	-7	140			Mn>Zn>P>Cu>B>N>Al>Mg>K>Ca>Fe
115	6.71	-11		1	-9	-12	19	12					65			Mg>N>Ca>K>Fe>Mn
116	6.65	-9	3	8	7	5	-2	11	33	13	-66	-4	164			Cu>N>B>Mn>P>Mg>Ca>K>Fe>Al>Zn
117	6.64			-4	-11	-2	26	1	-11				54			Ca>Zn>K>Mg>Fe>Mn
118	6.60	4	-6	3	8	6	-39	61	-10	-0	-27	1	166			Mn>Cu>Zn>P>Al>B>K>N>Mg>Ca>Fe
119	6.58	1	-3	7	3	2	-3	26	-6	17	-63	19	148			Cu>Zn>Mn>P>N>Mg>Ca>K>Al>B>Fe
120	6.56	5	-4	-2	11	8	-25	-4	-0	-2	5	9	74			Mn>Fe>P>Al>K>Zn>N>Cu>Mg>B>Ca
121	6.55	2	-1	-5	11	7	-24	-1	-2	-10	26	-4	93			Mn>Al>K>B>Zn>Fe>P>N>Mg>Ca>Cu
122	6.53	-4		-2	-7	-2	12	-2	5				35			Ca>N>K>Mg>Fe>Zn>Mn
123	6.53	-2	3	3	7	5	-21	-1	4	-3	3	-0	52			Mn>Al>N>Fe>B>K>P>Cu>Zn>Mg>Ca
124	6.50	2	-7	7	3	3	1	26	-6	15	-62	19	152			Cu>P>Zn>Mn>N>Mg>Ca>K>Al>B>Fe
125	6.49	-14		4	5	-6	7	4					41			N>Mg>K>Fe>Ca>Mn
126	6.46	-8	-6	1	2	2	-3	16	-10	15	-22	14	101			Cu>Zn>N>P>Mn>K>Mg>Ca>B>Al>Fe
127	6.38	-4	-29	5	5	10	7	-2	-1		-23	32	117			P>Cu>N>Fe>Zn>K>Ca>Mn>Mg>B
128	6.35	-3		-6	-8	-1	28	-0	-10				55			Zn>Ca>K>N>Mg>Fe>Mn
129	6.32	2	-10	-8	17	17	-14	2	-8	14	6	-18	117			B>Mn>P>K>Zn>Fe>N>Cu>Al>Mg>Ca
130	6.31	-6		-2	-0	4	23	-2	-16				52			Zn>N>K>Fe>Ca>Mg>Mn
131	6.28	-12		-12	-1	3	-1	-2	25				56			K>N>Fe>Ca>Mn>Mg>Zn
132	6.27	-9		-9	3	-5	20	0					46			N>K>Mg>Fe>Ca>Mn
133	6.26	-6		-7	-1	3	25	6	-21				70			Zn>K>N>Ca>Mg>Fe>Mn
134	6.26	-3	-11	1	7	3	-51	66	-10	1	-1	-2	156			Mn>P>Zn>N>B>Cu>K>Al>Mg>Ca>Fe
135	6.24	-13		-10	26	2	13	-18					81			Fe>N>K>Mg>Mn>Ca

Table 2. Cont'd.

ID	YIELD kg/bush	N	P	K	Ca	Mg	Mn	Fe	Zn	Al	Cu	B	NH	RELATIVE ORDER OF NUTRIENT REQUIREMENTS
136	6.20				1	-1							3	Mg>K
137	6.18	13	-0	4	21	13	-44	9	-3	-1	-21	8	138	Mn>Cu>Zn>Al>P>K>B>Fe>N>Mg>Ca
138	6.16	2	-1	-8	17	12	-34	20	5	-4	-3	-5	110	Mn>K>B>Al>Cu>P>N>Zn>Mg>Ca>Fe
139	6.16	-12	7	-6	-6	-4	-2	-18	11			16	96	Fe>N>Ca>K>Mg>Mn>P>Zn>B>Cu
140	6.04	-13		-11	6	-4	23	-1					58	N>K>Mg>Fe>Ca>Mn
141	6.04	-21		-39	-13	-3	-6	-6	89				178	K>N>Ca>Fe>Mn>Mg>Zn
142	6.03	2	-8	5	1	2	5	23	-12	17	-62	27	184	Cu>Zn>P>Ca>N>Mg>K>Mn>Al>Fe>B
143	6.02	-4	-9	-0	5	3	-36	60	-6	-2	-17	5	147	Mn>Cu>P>Zn>N>Al>K>Mg>B>Ca>Fe
144	5.98	-2	-12	-1	8	8	-11	1	-3	10	4	-3	63	P>Mn>Zn>B>N>K>Fe>Cu>Ca>Mg>Al
145	5.98	-8		1	0	-7	8	6					29	N>Mg>Ca>K>Fe>Mn
146	5.98	6	-6	4	4	3	-0	25	-10	16	-61	19	155	Cu>Zn>P>Mn>Mg>Ca>K>N>Al>B>Fe
147	5.96	-2		-4	-9	2	24	2	-13				56	Zn>Ca>K>N>Fe>Mg>Mn
148	5.95	5		-9	-1	4	8	-5	-2				32	K>Fe>Zn>Ca>Mg>N>Mn
149	5.95			3		-3							5	Mg>K
150	5.94	-3	-15	5	14	14	-7	1	-18	24	4	-18	121	B>Zn>P>Mn>N>Fe>Cu>K>Mg>Ca>Al
151	5.93	-2	-8	3	3	3	-35	52	-7	1	-15	5	132	Mn>Cu>P>Zn>N>Al>K>Ca>Mg>B>Fe
152	5.91	-1	-3	5	16	4	-17	-9	-2	0	2	4	63	Mn>Fe>P>Zn>N>Al>Cu>Mg>B>K>Ca
153	5.91	-5	0	6	1	17	-4	-30	9		1	4	77	Fe>N>Mn>P>Cu>Ca>B>K>Zn>Mg
154	5.91			5		-5							10	Mg>K
155	5.88	-2		-3	0	7	22	0	-24				50	Zn>K>N>Fe>Ca>Mg>Mn
156	5.88	-3	-1	2	-16	4	2	-33	10		31	5	106	Fe>Ca>N>P>Mn>K>Mg>B>Zn>Cu
157	5.86	4	-4	-0	14	11	-28	-2	-4	3	5	2	76	Mn>P>Zn>Fe>K>B>Al>N>Cu>Mg>Ca
158	5.84	-9		-2	15	-10	3	3					43	Mg>N>K>Fe>Mn>Ca
159	5.83	-7		-6	-5	2	13	5	-1				38	N>K>Ca>Zn>Mg>Fe>Mn
160	5.81	-4	7	7	-5	-9	-7	-21	9		9	14	94	Fe>Mg>Mn>Ca>N>P>K>Cu>Zn>B
161	5.77	-3	-5	6	5	4	1	21	-9	13	-58	25	151	Cu>Zn>P>N>Mn>Mg>Ca>K>Al>Fe>B
162	5.76	-4		-3	-6	2	14	2	-3				34	Ca>N>K>Zn>Mg>Fe>Mn
163	5.75	0	5	14	9	18	-13	-51	15		13	-10	148	Fe>Mn>B>N>P>Ca>Cu>K>Zn>Mg
164	5.74	2		0	-3	4	6	1	-10				27	Zn>Ca>K>Fe>N>Mg>Mn
165	5.73	-6	-17	6	2	6	1	-45	2		18	33	136	Fe>P>N>Mn>Ca>Zn>K>Mg>Cu>B
166	5.73	1		-1	1	4	14	-2	-17				38	Zn>Fe>K>N>Ca>Mg>Mn
167	5.71	-1	-9	-1	2	1	-5	21	-8	14	-25	12	100	Cu>P>Zn>Mn>K>N>Mg>Ca>B>Al>Fe
168	5.67	-5		-5	10	-4	-3	8					35	K>N>Mg>Mn>Fe>Ca
169	5.66	-2	6	4	-9	-8	8	-43	13		8	22	124	Fe>Ca>Mg>N>K>P>Cu>Mn>Zn>B
170	5.65	-12	-10	-8	-0	-0	-3	11	-14	11	12	13	94	Zn>N>P>K>Mn>Mg>Ca>Fe>Al>Cu>B
171	5.65	-2		-5	-0	-5	4	8					25	K>Mg>N>Ca>Mn>Fe
172	5.65	-6		-7	-10	-3	12	3	13				54	Ca>K>N>Mg>Fe>Mn>Zn
173	5.64	-0	-45	9	5	9	12	2	-2		-25	34	144	P>Cu>Zn>N>Fe>Ca>Mg>K>Mn>B
174	5.64	2	-2	3	2	2	-1	26	-6	16	-62	21	144	Cu>Zn>P>Mn>N>Ca>Mg>K>Al>B>Fe
175	5.63	-1	-6	6	3	3	0	14	-5	18	-57	23	137	Cu>P>Zn>N>Mn>Mg>Ca>K>Fe>Al>B
176	5.62	-2		-4	7	-6	3	1					23	Mg>K>N>Fe>Mn>Ca
177	5.61	3	-7	-2	8	6	-51	67	-7	-1	-15	-1	168	Mn>Cu>Zn>P>K>Al>B>N>Mg>Ca>Fe
178	5.59			-5	2	1	7	1	-7				23	Zn>K>Fe>Mg>Ca>Mn
179	5.58	-0	-2	17	25	13	-45	9	-5	2	-22	8	148	Mn>Cu>Zn>P>N>Al>B>Fe>Mg>K>Ca
180	5.57	11	3	8	24	15	-53	8	-14	-3	-3	4	146	Mn>Zn>Cu>Al>P>B>Fe>K>N>Mg>Ca
181	5.56	-3	-1	0	17	9	-28	-1	2	-4	7	1	73	Mn>Al>N>Fe>P>K>B>Zn>Cu>Mg>Ca
182	5.55	-1		-3	-23	-3	26	4					60	Ca>K>Mg>N>Fe>Mn
183	5.54	1	-2	0	-1	-0	13	-32	-3		17	7	76	Fe>Zn>P>Ca>Mg>K>N>B>Mn>Cu
184	5.51	3		-6	-7	-1	9	2	0				28	Ca>K>Mg>Zn>Fe>N>Mn
185	5.50	-3	-14	0	9	11	19	-3		-19			79	Al>P>Fe>N>K>Ca>Mg>Mn
186	5.46	-5		1	3	0	11	1	-11				33	Zn>N>Mg>K>Fe>Ca>Mn
187	5.43	-8	6	1	3	-0	12	-27	19		18	-23	118	Fe>B>N>Mg>K>Ca>P>Mn>Cu>Zn
188	5.42	1		0	-6	-0	12	-0	-7				26	Zn>Ca>Fe>Mg>K>N>Mn
189	5.41	7	-0	8	27	15	-73	15	0	2	-9	8	106	Mn>Cu>P>Zn>Al>N>B>K>Fe>Mg>Ca
190	5.39			-2	2	2	18	-5	-16				46	Zn>Fe>K>Ca>Mg>Mn
191	5.38	-0		-6	-7	-10	9	15					47	Mg>Ca>K>N>Mn>Fe
192	5.30	-3		-7	-6	-10	24	3					53	Mg>K>Ca>N>Fe>Mn
193	5.27	-5		-7	-8	3	11	7	-1				43	Ca>K>N>Zn>Mg>Fe>Mn
194	5.26	-29		-3	-5	-0	-3	1	41				82	N>Ca>K>Mn>Mg>Fe>Zn
195	5.26	-2		-4	-11	-5	13	1	8				42	Ca>Mg>K>N>Fe>Zn>Mn
196	5.26	10	-18	-3	14	12	-9	0	-14	16	6	-14	116	P>Zn>B>Mn>K>Fe>Cu>N>Mg>Ca>Al
197	5.24	-7	-8	5	11	8	-21	7	-1	8	2	-5	82	Mn>P>N>B>Zn>Cu>K>Fe>Mg>Al>Ca
198	5.20	2		10	-5	-3	9	2	-15				44	Zn>Ca>Mg>Fe>N>Mn>K
199	5.20	6		-1	-1	2	25	-2	-28				64	Zn>Fe>K>Ca>Mg>N>Mn
200	5.18	-8		-2	6	-13	11	6					47	Mg>N>K>Fe>Ca>Mn
201	5.17	-5		-2	-8	4	8	7	-5				39	Ca>N>Zn>K>Mg>Fe>Mn
202	5.16	1		-7	4	2	7	-1	-5				26	K>Zn>Fe>N>Mg>Ca>Mn
203	5.16	2	-3	6	17	9	-38	5	-6	2	-11	18	117	Mn>Cu>Zn>P>Al>N>Fe>K>Mg>Ca>B
204	5.13	-5		6	1	3	-0	-4					19	N>Fe>Mn>Ca>Mg>K

Table 2. Cont'd.

ID	YIELD											B	NII	RELATIVE ORDER OF NUTRIENT REQUIREMENTS
	kg/bush	N	P	K	Ca	Mg	Mn	Fe	Zn	Al	Cu			
205	5.11	-1		-1	-13	-1	12	2	2				32	Ca > Mg > N > K > Fe > Zn > Mn
206	5.10	-11		-7	-10	-6	31	2					67	N > Ca > K > Mg > Fe > Mn
207	5.10	1		3	-17	-11	23	1					56	Ca > Mg > Fe > N > K > Mn
208	5.06	-2		-7	-1	-12	18	4					44	Mg > K > N > Ca > Fe > Mn
209	5.06	-11		-11	13	-7	8	9					59	K > N > Mg > Mn > Fe > Ca
210	5.05	-13		14	-4	3							34	N > Ca > Mg > K
211	5.04	-11		-8	14	-1	2	4					41	N > K > Mg > Mn > Fe > Ca
212	5.04	-17		15	3	-21	14	7					76	Mg > N > Ca > Fe > Mn > K
213	5.03	-17		3	4	3	13	-6					47	N > Fe > Mg > K > Ca > Mn
214	5.02	3	-4	-5	16	14	-26	-4	-1	-2	4	4	83	Mn > K > P > Fe > Al > Zn > N > B > Cu > Mg > Ca
215	5.01	9	3	15	22	11	-52	8	-7	-10	-5	7	148	Mn > Al > Zn > Cu > P > B > Fe > N > Mg > K > Ca
216	5.00	-2	-12	2	9	9	12	-2		-17			65	Al > P > Fe > N > K > Ca > Mg > Mn
217	5.00	-7	2	4	-6	1	13	-37	10		8	11	100	Fe > N > Ca > Mg > P > K > Cu > Zn > B > Mn
218	4.98	-2	-0	11	-9	17	4	-31	1		16	-5	97	Fe > Ca > B > N > P > Zn > Mn > K > Cu > Mg
219	4.95	10	-1	13	26	13	-47	6	-12	0	-12	3	144	Mn > Cu > Zn > P > Al > B > Fe > N > Mg > K > Ca
220	4.95	-0		0									0	N > K
221	4.92	9	5	10	26	16	-68	8	-3	-7	-2	3	158	Mn > Al > Zn > Cu > B > P > Fe > N > K > Mg > Ca
222	4.91	-2	-5	-5	9	6	-18	4	12	-1	4	-4	68	Mn > P > K > B > N > Al > Cu > Fe > Mg > Ca > Zn
223	4.89	-4		-4	-3	3	5	5	-1				25	N > K > Ca > Zn > Mg > Mn > Fe
224	4.88	-13		-6	9	-9	10	9					57	N > Mg > K > Fe > Ca > Mn
225	4.79	-1	-12	-3	-0	-1	-4	6	-7	7	-14	28	82	Cu > P > Zn > Mn > K > N > Mg > Ca > Fe > Al > B
226	4.79	-5		-7	16	3	6	-11					47	Fe > K > N > Mg > Mn > Ca
227	4.79	-14		-2	12	-2	3	4					37	N > K > Mg > Mn > Fe > Ca
228	4.79	-4	4	-2	-5	-7	8	-44	16		8	28	126	Fe > Mg > Ca > N > K > P > Mn > Cu > Zn > B
229	4.78	3		3	-11	-1	8	-2	-0				27	Ca > Fe > Mg > Zn > N > K > Mn
230	4.77	-2	-5	3	1	3	1	21	-5	16	-58	27	142	Cu > P > Zn > N > Ca > Mn > Mg > K > Al > Fe > B
231	4.77	-10		-10	2	-5	26	-2					55	N > K > Mg > Fe > Ca > Mn
232	4.76	5		-6	-3	2	14	-7	-6				42	Fe > K > Zn > Ca > Mg > N > Mn
233	4.75			0		-0							1	Mg > K
234	4.71			-18		-9	26						52	Ca > Mg > Mn
235	4.70	-5		-2	-2	0	10	-2	1				22	N > Ca > Fe > K > Mg > Zn > Mn
236	4.70			-23		-10	33						67	Ca > Mg > Mn
237	4.69	-3	-6	-1	8	5	-13	3	-0	6	3	-2	49	Mn > P > N > B > K > Zn > Fe > Cu > Mg > Al > Ca
238	4.69	-3		-1	-10	1	20	1	-8				45	Ca > Zn > N > K > Fe > Mg > Mn
239	4.68	-19		-17	43	-10	6	-4					99	N > K > Mg > Fe > Mn > Ca
240	4.65	-3		-9	10	-21	18	5					66	Mg > K > N > Fe > Ca > Mn
241	4.64	-2	-9	-5	4	4	-7	4	2	5	5	-2	49	P > Mn > K > B > N > Zn > Mg > Fe > Ca > Al > Cu
242	4.62	-5		-12	-0	2	10	3	1				34	K > N > Ca > Zn > Mg > Fe > Mn
243	4.61	7	-2	14	27	15	-44	6	-9	4	-22	6	156	Mn > Cu > Zn > P > Al > B > Fe > N > K > Mg > Ca
244	4.60	-7		4		-1	4						16	N > Mg > Mn > Ca
245	4.58	18	-3	17	32	16	-77	50	-20	-27	-4	-2	265	Mn > Al > Zn > Cu > P > B > Mg > K > N > Ca > Fe
246	4.58	6	-2	5	19	12	-54	10	-9	1	1	11	130	Mn > Zn > P > Cu > Al > K > N > Fe > B > Mg > Ca
247	4.57	-2	4	3	-1	0	-12	-28	16		11	8	86	Fe > Mn > N > Ca > Mg > K > P > B > Cu > Zn
248	4.54	-0	-6	-4	5	4	-10	3	2	6	0	0	40	Mn > P > K > N > Cu > B > Zn > Fe > Mg > Ca > Al
249	4.52	-6		-5	-7	-9	14	13					54	Mg > Ca > N > K > Fe > Mn
250	4.50	-6	3	10	9	4	6	-37	-1		18	-6	98	Fe > B > N > Zn > P > Mg > Mn > Ca > K > Cu
251	4.50	-87		14	9	49	3	13					174	N > Mn > Ca > Fe > K > Mg
252	4.50	-5		0	-4	3	8	2	-4				26	N > Zn > Ca > K > Fe > Mg > Mn
253	4.49	10	2	9	26	13	-53	8	-9	-8	-4	6	150	Mn > Zn > Al > Cu > P > B > Fe > K > N > Mg > Ca
254	4.48			-6	2	-1	4	1	0				15	K > Mg > Zn > Fe > Ca > Mn
255	4.48	4		1	-3	-6	-1	4	-0				20	Mg > Ca > Mn > Zn > K > Fe > N
256	4.47			-4	-4	-4	10	-3	5				30	K > Mg > Ca > Fe > Zn > Mn
257	4.43	5	2	9	22	13	-47	5	-9	-3	-4	8	126	Mn > Zn > Cu > Al > P > Fe > N > B > K > Mg > Ca
258	4.42	-7	-11	-5	-1	-1	-6	2	-1	5	-0	26	67	P > N > Mn > K > Zn > Ca > Mg > Cu > Fe > Al > B
259	4.42	-0	-11	6	13	7	-18	2	-5	11	-2	-3	79	Mn > P > Zn > B > Cu > N > Fe > K > Mg > Al > Ca
260	4.40	-4	-7	-1	5	1	-31	60	-7	2	-18	1	136	Mn > Cu > Zn > P > N > K > B > Mg > Al > Ca > Fe
261	4.40	-4			3	-2	4						13	N > Mg > Ca > Mn
262	4.39	-21		1	19	10	-15	6					74	N > Mn > K > Fe > Mg > Ca
263	4.39	4		-2	-12	2	12	2	-7				41	Ca > Zn > K > Mg > Fe > N > Mn
264	4.38	-8		-2	-10	-5	23	1					49	Ca > N > Mg > K > Fe > Mn
265	4.37	-14		-6	7	-3	9	7					46	N > K > Mg > Fe > Ca > Mn
266	4.36	14	-1	13	32	15	-76	52	-16	-14	-6	-14	253	Mn > Zn > Al > B > Cu > P > K > N > Mg > Ca > Fe
267	4.35	13	-1	10	19	10	-59	46	-22	-10	-6	-1	197	Mn > Zn > Al > Cu > P > B > K > Mg > N > Ca > Fe
268	4.35	0	-16	5	11	1							32	P > N > Mg > K > Ca
269	4.35	10		-5	6	4	-32	18					75	Mn > K > Mg > Ca > N > Fe
270	4.34	-7		-3	-6	0	27	-2	-10				55	Zn > N > Ca > K > Fe > Mg > Mn
271	4.34			-15		-11	26						52	Ca > Mg > Mn
272	4.32	1	11	-3	-3	-4	2	-42	3		4	31	104	Fe > Mg > Ca > K > N > Mn > Zn > Cu > P > B
273	4.32	11		-3	-14	2	31	-13	-14				86	Zn > Ca > Fe > K > Mg > N > Mn

Table 2. Cont'd.

ID	YIELD kg/bush	N	P	K	Ca	Mg	Mn	Fe	Zn	Al	Cu	B	NII	RELATIVE ORDER OF NUTRIENT REQUIREMENTS
274	4.31	-5		-7	7	-11	10	6					46	Mg>K>N>Fe>Ca>Mn
275	4.31	-8		4	1	3	-3	2					22	N>Mn>Ca>Fe>Mg>K
276	4.30	-7	6	-4	9	7	10	-4		-17			63	Al>N>Fe>K>P>Mg>Ca>Mn
277	4.30	-6	-11	-2	14	8	12	-4		-11			69	P>Al>N>Fe>K>Mg>Mn>Ca
278	4.30	-7		-11	15	-3	7	-1					44	K>N>Mg>Fe>Mn>Ca
279	4.30	25	7	19	33	20	-116	66	-9	-38	-1	-5	339	Mn>Al>Zn>B>Cu>P>K>Mg>N>Ca>Fe
280	4.29	-13	-4	2	5	15	-29	-17	8		26	5	124	Mn>Fe>N>P>K>Ca>B>Zn>Mg>Cu
281	4.29	18	9	12	52	27	-64	-32	-12	-19	2	8	254	Mn>Fe>Al>Zn>Cu>B>P>K>N>Mg>Ca
282	4.29	7	-1	0	12	9	-11	5	7	14	6	-48	120	B>Mn>P>K>Fe>Cu>Zn>N>Mg>Ca>Al
283	4.27	-8		11	-5	1							26	N>Ca>Mg>K
284	4.27	-3		-10	-4	-3	1	2	18				40	K>Ca>N>Mg>Mn>Fe>Zn
285	4.27	24	-2	25	27	16	-66	55	-11	-56	-11	-0	293	Mn>Al>Cu>Zn>P>B>Mg>N>K>Ca>Fe
286	4.26	-29		-10	52	-10	-10	8					120	N>Mg>K>Mn>Fe>Ca
287	4.25	6	-12	-3	-0	-1	-5	2	-10	5	-7	25	76	P>Zn>Cu>Mn>K>Mg>Ca>Fe>Al>N>B
288	4.24	5		-7	-3	0	10	-3	-2				30	K>Fe>Ca>Zn>Mg>N>Mn
289	4.24	-7		-2	8	-15	7	9					48	Mg>N>K>Mn>Ca>Fe
290	4.23	-8		8	-5	5							26	N>Ca>Mg>K
291	4.20	-2		-2	3	5	-2	-2					14	N>Fe>Mn>K>Ca>Mg
292	4.20	-4	-17	-0	9	7	15	-3		-7			62	P>Al>N>Fe>K>Mg>Ca>Mn
293	4.19	-3		0	-8	-5	12	4					32	Ca>Mg>N>K>Fe>Mn
294	4.19	-7		11	-8	-5	9	-0					40	Ca>N>Mg>Fe>Mn>K
295	4.19	-3		-2	6	-5	-1	4					21	Mg>N>K>Mn>Fe>Ca
296	4.18	-6		-7	2	0	3	-0	8				27	K>N>Fe>Mg>Ca>Mn>Zn
297	4.16	2		-4	-7	-1	12	2	-4				33	Ca>K>Zn>Mg>N>Fe>Mn
298	4.15	-4	-8	-7	-1	-1	-7	6	-5	3	-4	27	71	P>K>Mn>Zn>N>Cu>Mg>Ca>Al>Fe>B
299	4.15	-2	-7	-1	4	2	-14	4	5	1	2	7	50	Mn>P>N>K>Al>Mg>Cu>Ca>Fe>Zn>B
300	4.13	-6		19	-7	-6							38	Ca>N>Mg>K
301	4.13	-2		21	-11	-6							42	Ca>Mg>N>K
302	4.12	-7		-7	-4	2	8	4	5				39	N>K>Ca>Mg>Fe>Zn>Mn
303	4.09	-10		-14	29	-9	4	-0					66	K>N>Mg>Fe>Mn>Ca
304	4.07	-4		-6	-8	-2	26	-1	-4				51	Ca>K>Zn>N>Mg>Fe>Mn
305	4.06	1		8	-8	-1							19	Ca>Mg>N>K
306	4.06	4		18	-18	-4							43	Ca>Mg>N>K
307	4.06	-13		6	9	-10	2	6					47	N>Mg>Mn>K>Fe>Ca
308	4.06	0		12	-5	-7							25	Mg>Ca>N>K
309	4.05	-7		-11	-3	-1	3	3	16				44	K>N>Ca>Mg>Mn>Fe>Zn
310	4.05	-1	-18	10	10	-1							39	P>Mg>N>Ca>K
311	4.01	-4	-13	-2	-3	-2	-4	3	-5	8	-8	30	82	P>Cu>Zn>N>Mn>Ca>K>Mg>Fe>Al>B
312	4.00	-2	-12	1	8	5	14	-3		-12			58	Al>P>Fe>N>K>Mg>Ca>Mn
313	4.00	-5	-9	-1	8	10	12	-3		-12			59	Al>P>N>Fe>K>Ca>Mg>Mn
314	3.99	-15		24	-6	-3							48	N>Ca>Mg>K
315	3.98	-10		23	-11	-2							46	Ca>N>Mg>K
316	3.98			-19	-7	27							53	Ca>Mg>Mn
317	3.97	-10		-0	21	3	7	-21					63	Fe>N>K>Mg>Mn>Ca
318	3.97	-10		-8	22	-3	2	-4					48	N>K>Fe>Mg>Mn>Ca
319	3.96	-7		-5	6	-3	3	7					31	N>K>Mg>Mn>Ca>Fe
320	3.94	-6		4	0	2							13	N>Mg>Mn>Ca
321	3.91	3		15	-14	-4							36	Ca>Mg>N>K
322	3.91	-4		11	-7	-0							21	Ca>N>Mg>K
323	3.89	-7		-8	-2	-7	19	5					48	K>Mg>N>Ca>Fe>Mn
324	3.89	-2		-10	-1	-6	10	11					42	K>Mg>N>Ca>Mn>Fe
325	3.88	-7		2	-12	-8	18	6					53	Ca>Mg>N>K>Fe>Mn
326	3.87	2		3	-1	-3							8	Mg>Ca>N>K
327	3.85			-15	-10	25							50	Ca>Mg>Mn
328	3.85	-6		6	-9	-5	13	1					40	Ca>N>Mg>Fe>K>Mn
329	3.85	16	-11	12	38	20	-76	46	-21	-13	-12	-2	267	Mn>Zn>Al>Cu>P>B>K>N>Mg>Ca>Fe
330	3.83	2	-6	-4	5	2	-34	61	-10	-1	-18	3	147	Mn>Cu>Zn>P>K>Al>N>Mg>B>Ca>Fe
331	3.83	-2	-12	5	3	1	-8	4	-9	7	-7	17	75	P>Zn>Mn>Cu>N>Mg>Ca>Fe>K>Al>B
332	3.82	-0	-10	-5	5	3	-39	64	-9	0	-9	0	145	Mn>P>Cu>Zn>K>N>Al>B>Mg>Ca>Fe
333	3.80	-2	-24	14	10	2							51	P>N>Mg>Ca>K
334	3.80	-3	-11	7	14	10	-1	-2		-14			62	Al>P>N>Fe>Mn>K>Mg>Ca
335	3.80	-2	-14	2	9	8	14	-3		-13			64	P>Al>Fe>N>K>Mg>Ca>Mn
336	3.79	8		9	-11	-5							31	Ca>Mg>N>K
337	3.79	-2		-1	0	3	13	-0	-13				32	Zn>N>K>Fe>Ca>Mg>Mn
338	3.79	-5		4	-3	0	1	4					17	N>Ca>Mg>Mn>K>Fe
339	3.78	-5	-11	3	2	1	-10	5	-13	8	-7	24	90	Zn>P>Mn>Cu>N>Mg>Ca>K>Fe>Al>B
340	3.78	-11		-10	27	-2	-4	0					55	N>K>Mn>Mg>Fe>Ca
341	3.78	-14		0	27	-11	-12	10					74	N>Mn>Mg>K>Fe>Ca
342	3.78	-8		26	-14	-3							52	Ca>N>Mg>K

Table 2. Cont'd.

ID	YIELD		N	P	K	Ca	Mg	Mn	Fe	Zn	Al	Cu	B	NH	RELATIVE ORDER OF NUTRIENT REQUIREMENTS
	kg/bush														
343	3.75	-5			-2	2	-3	14	-6					31	Fe > N > Mg > K > Ca > Mn
344	3.75	-3	1		-1	2	2	-18	-8	12		22	-9	77	Mn > B > Fe > N > K > P > Mg > Ca > Zn > Cu
345	3.74	-23	-27		-20	-22	6					86		183	P > N > Ca > K > Mg > Cu
346	3.73	-4			26	-16	-7							53	Ca > Mg > N > K
347	3.72	3	2		9	10	9	0	8	1	18	-8	-52	121	B > Cu > Mn > Zn > P > N > Fe > K > Mg > Ca > Al
348	3.71				-4	-4	5	6	-2	0				21	K > Ca > Fe > Zn > Mg > Mn
349	3.70	-8				4	1	2						15	N > Mg > Mn > Ca
350	3.69	-3	2		3	2	-1	-3	-25	6		12	6	64	Fe > Mn > N > Mg > Ca > P > K > B > Zn > Cu
351	3.69	-8			1	10	-4	3	-3					30	N > Mg > Fe > K > Mn > Ca
352	3.69	-2			-7	-5	-2	17	-2					34	K > Ca > Fe > Mg > N > Mn
353	3.68	-4	-11		0	1	1	-9	3	-13	9	-6	27	86	Zn > P > Mn > Cu > N > K > Mg > Ca > Fe > Al > B
354	3.68	10			-1	-11	0	-10	6	6				45	Ca > Mn > K > Mg > Zn > Fe > N
355	3.68	-4			-1	-6	-3	10	4					27	Ca > N > Mg > K > Fe > Mn
356	3.68	-6				2	-1	6						15	N > Mg > Ca > Mn
357	3.67	-36	-17		5	42	6							106	N > P > K > Mg > Ca
358	3.66	1			-5	3	4	9	-3	-9				34	Zn > K > Fe > N > Ca > Mg > Mn
359	3.66	1			-2	-8	-10	13	6					42	Mg > Ca > K > N > Fe > Mn
360	3.65	7			-11	-9	-0	19	-1	-3				51	K > Ca > Zn > Fe > Mg > N > Mn
361	3.65	3			25	-17	-12							56	Ca > Mg > N > K
362	3.63	-36	-40		-15	-28	7					112		238	P > N > Ca > K > Mg > Cu
363	3.61	-2			-6	-0	3	6	-0					18	K > N > Ca > Fe > Mg > Mn
364	3.61	-2			-8	-3	0	17	5	-9				43	Zn > K > Ca > N > Mg > Fe > Mn
365	3.60	-8			-25	-21	-7	7	6	48				121	K > Ca > N > Mg > Fe > Mn > Zn
366	3.60				2	-4	-1	8	2	-8				25	Zn > Ca > Mg > K > Fe > Mn
367	3.60	-1	10		2	-1	1	4	-22	13		7	-12	74	Fe > B > Ca > N > Mg > K > Mn > Cu > P > Zn
368	3.59	14	-1		13	32	19	-87	52	-18	-31	-3	11	282	Mn > Al > Zn > Cu > P > B > K > N > Mg > Ca > Fe
369	3.58	-4	8		6	12	7	-25	-50	31		17	-3	163	Fe > Mn > N > B > K > Mg > P > Ca > Cu > Zn
370	3.56	20	-2		2	40	21	-89	54	-19	-14	-11	-3	275	Mn > Zn > Al > Cu > B > P > K > N > Mg > Ca > Fe
371	3.54	-2			3	-4	-0	10	4	-11				35	Zn > Ca > N > Mg > K > Fe > Mn
372	3.54	-13			5	12	-6	4	-1					41	N > Mg > Fe > Mn > K > Ca
373	3.54	-2			-8	-11	-3	20	0	3				47	Ca > K > Mg > N > Fe > Zn > Mn
374	3.53	4			9	-12	-2							27	Ca > Mg > N > K
375	3.50	-38	-4		3	57	-18							121	N > Mg > P > K > Ca
376	3.50	-5	-7		-2	9	7	12	-4		-9			56	Al > P > N > Fe > K > Mg > Ca > Mn
377	3.48	-1			-5	3	1	1	-3	3				17	K > Fe > N > Mn > Mg > Ca > Zn
378	3.48	-6			-14	-3	3	2	5	13				45	K > N > Ca > Mn > Mg > Fe > Zn
379	3.47	0	8		9	3	17	-9	-43	11		17	-12	130	Fe > B > Mn > N > Ca > P > K > Zn > Mg > Cu
380	3.47	-4			-4	14	1	-7	1					31	Mn > K > N > Mg > Fe > Ca
381	3.43	-19			-26	-8	-3	-0	-6	61				123	K > N > Ca > Fe > Mg > Mn > Zn
382	3.43	-37	-17		1	37	16							107	N > P > K > Mg > Ca
383	3.42	22	5		22	29	17	-97	63	-5	-49	-10	4	323	Mn > Al > Cu > Zn > B > P > Mg > N > K > Ca > Fe
384	3.41	-4			-4	-2	-6	17	-1					34	Mg > K > N > Ca > Fe > Mn
385	3.39	-0			-4	-3	1	9	-0	-2				20	K > Ca > Zn > N > Fe > Mg > Mn
386	3.37	2			8	-9	-2							21	Ca > Mg > N > K
387	3.37	-3	-1		-1	-4	-5	7	-35	8		13	20	96	Fe > Mg > Ca > N > P > K > Mn > Zn > Cu > B
388	3.36	0			11	-10	-1							23	Ca > Mg > N > K
389	3.36	-12			-13	24	-4	5	0					60	K > N > Mg > Fe > Mn > Ca
390	3.36	-20	37		-55	27	11							150	K > N > Mg > Ca > P
391	3.34	-2			-5	-12	-1	8	3	8				40	Ca > K > N > Mg > Fe > Zn > Mn
392	3.34	-11			-7	-41	-18	79	-3					158	Ca > Mg > N > K > Fe > Mn
393	3.33	5			12	-14	-3							35	Ca > Mg > N > K
394	3.33	-2			-0	2	-0	8	-2	-6				20	Zn > N > Fe > Mg > K > Ca > Mn
395	3.33	-41	-13		2	40	12							109	N > P > K > Mg > Ca
396	3.31	-5			6	-1	-5	-1	6					24	N > Mg > Mn > Ca > K > Fe
397	3.31	-16			-1	12	4	-0	0					34	N > K > Mn > Fe > Mg > Ca
398	3.30	-40	-23		-0	53	10							126	Zn > N > P > K > Mg > Ca
399	3.30	-7			1	-8	-1	15	-1					33	Ca > N > Mg > Fe > K > Mn
400	3.29	-25			15	5	5							50	N > Ca > Mg > K
401	3.27	-13	-12		-7	-6	28	-42	-20	25		44	2	198	Mn > Fe > N > P > K > Ca > B > Zn > Mg > Cu
402	3.27	2			5	-7	1	8	3	-12				37	Zn > Ca > Mg > N > Fe > K > Mn
403	3.26	-0			5	-23	-9	23	4					65	Ca > Mg > N > Fe > K > Mn
404	3.26	-6			-4	3	0	-0	-1	9				23	N > K > Fe > Mn > Mg > Ca > Zn
405	3.26	-11			8	5	-2							26	N > Mg > Ca > K
406	3.25	-7			2	-2	-1	7	1					21	N > Ca > Mg > Fe > K > Mn
407	3.24	-1			-2	1	7	6	-4	-6				27	Zn > Fe > K > N > Ca > Mn > Mg
408	3.23	4			0	-4	2	13	1	-17				41	Zn > Ca > K > Fe > Mg > N > Mn
409	3.22	-5			3	-6	-3	11	-1					28	Ca > N > Mg > Fe > K > Mn
410	3.21	10			5	-14	-2							30	Ca > Mg > K > N
411	3.21	-1	9		12	12	30	-25	-41	-7		19	-8	163	Fe > Mn > B > Zn > N > P > K > Ca > Cu > Mg

Table 2. Cont'd.

YIELD														RELATIVE ORDER OF NUTRIENT REQUIREMENTS	
ID	kg/bush	N	P	K	Ca	Mg	Mn	Fe	Zn	Al	Cu	B	NH		
412	3.20	-7		2	4	-3		0	4					20	N > Mg > Mn > K > Fe > Ca
413	3.20	-30	-5	-2	57	-21								115	N > Mg > P > K > Ca
414	3.18	-20	37	-49	20	12								138	K > N > Mg > Ca > P
415	3.18	-5		-5	19	-10								42	Mg > N > K > Mn > Fe > Ca
416	3.18	-4		-2	-7	-8	23	-2						46	Mg > Ca > N > K > Fe > Mn
417	3.17	7	-2	9	23	13	-50	35	-11	-7	-10	-8	175	Mn > Zn > Cu > B > Al > P > N > K > Mg > Ca > Fe	
418	3.17	-9		2	3	-1	2	4						22	N > Mg > K > Mn > Ca > Fe
419	3.17	-3		12	-7	-3								24	Ca > N > Mg > K
420	3.16	2		22	-19	-4								47	Ca > Mg > N > K
421	3.14	0	-13	2	0	-1	-7	5	-11	9	-8	23	79	P > Zn > Cu > Mn > Mg > N > Ca > K > Fe > Al > B	
422	3.14	-11		27	-10	-6								53	N > Ca > Mg > K
423	3.14	3		-8	-11	1	9	2	4					37	Ca > K > Mg > Fe > N > Zn > Mn
424	3.13	-4		-7	5	0	-5	-2	13					35	K > Mn > N > Fe > Mg > Ca > Zn
425	3.13	-1		12	-9	-2								23	Ca > Mg > N > K
426	3.13	-30		6	17	-3	7	3						66	N > Mg > Fe > K > Mn > Ca
427	3.11	-6		-4	-5	-5	18	4						42	N > Mg > Ca > K > Fe > Mn
428	3.11	-7		10	-5	2								24	N > Ca > Mg > K
429	3.10	-28		-31	-7	-4	-5	4	70					148	K > N > Ca > Mn > Mg > Fe > Zn
430	3.10	-7	3	1	-6	-2	3	-33	13		14	15	96	Fe > N > Ca > Mg > K > P > Mn > Zn > Cu > B	
431	3.08	-15		12	1	2								30	N > Ca > Mg > K
432	3.07	2		-4	-8	6	5	3	-5					32	Ca > Zn > K > N > Fe > Mn > Mg
433	3.06	-4		1	-4	-1	6	2						18	Ca > N > Mg > K > Fe > Mn
434	3.04	19	-9	13	30	19	-88	51	-12	-18	-3	0	262	Mn > Al > Zn > P > Cu > B > K > N > Mg > Ca > Fe	
435	3.04	-1	15	-6	3	6	3	-2	28		31	-78	172	B > K > Fe > N > Mn > Ca > Mg > P > Zn > Cu	
436	3.04	-8	-7	-12	-11	-2	8	-59	24		16	51	198	Fe > K > Ca > N > P > Mg > Mn > Cu > Zn > B	
437	3.01	-10		-1	20	-6	3	-7						48	N > Fe > Mg > K > Mn > Ca
438	3.00	-3		9	-1	-5								17	Mg > N > Ca > K
439	2.99	-8		9	-5	-4	4	5						35	N > Ca > Mg > Mn > Fe > K
440	2.98	-8		-7	10	5	6	-5						41	N > K > Fe > Mg > Mn > Ca
441	2.98	-2	-8	12	8	3	-9	3	-6	0	-0	-1	53	Mn > P > Zn > N > B > Cu > Al > Mg > Fe > Ca > K	
442	2.94	-8		-11	15	-8	4	8						54	K > Mg > N > Mn > Fe > Ca
443	2.94	-22		13	10	-1								47	N > Mg > Ca > K
444	2.93	-4		6	-21	-13	40	-7						90	Ca > Mg > Fe > N > K > Mn
445	2.92	-11		3	9	-14	14	-0						52	Mg > N > Fe > K > Ca > Mn
446	2.92	1		-1	-9	-4	13	0						28	Ca > Mg > K > Fe > N > Mn
447	2.92	-8		-3	2	7	10	-4	-5					37	N > Zn > Fe > K > Ca > Mg > Mn
448	2.91	-14		-2	14	-5	5	2						41	N > Mg > K > Fe > Mn > Ca
449	2.90	-10		28	-12	-6								55	Ca > N > Mg > K
450	2.90	-30		28	-1	3								62	N > Ca > Mg > K
451	2.90	-4		-4	-4	-2	12	1						27	K > Ca > N > Mg > Fe > Mn
452	2.89	-4		23	-10	-9								46	Ca > Mg > N > K
453	2.89	1		4	0	-1	13	-3	-14					35	Zn > Fe > Mg > Ca > N > K > Mn
454	2.88	-8		5	7	-3								23	N > Mg > K > Ca
455	2.87	-5		-0	1	5	18	-1	-18					48	Zn > N > Fe > K > Ca > Mg > Mn
456	2.87	3		1	-17	-0	6	6						34	Ca > Mg > K > N > Fe > Mn
457	2.85	-3		-7	6	-3	12	-4						35	K > Fe > N > Mg > Ca > Mn
458	2.84	5	-6	7	9	4	-11	4	-5	-3	-6	0	60	Mn > Cu > P > Zn > Al > B > Fe > Mg > N > K > Ca	
459	2.84	21	-5	11	42	26	-96	54	-26	-16	-10	-1	308	Mn > Zn > Al > Cu > P > B > K > N > Mg > Ca > Fe	
460	2.84	-2		1	-3	1	6	-3						17	Fe > Ca > N > K > Mg > Mn
461	2.84	-9		6	2	1								19	N > Mg > Ca > K
462	2.83	-2		12	-23	-4	3	14						57	Ca > Mg > N > Mn > K > Fe
463	2.83	-41	-15	-2	47	12								117	N > P > K > Mg > Ca
464	2.83	-39	-18	-4	54	6								122	N > P > K > Mg > Ca
465	2.83	-4	-4	12	-8	14	-1	-47	9		28	-0	126	Fe > Ca > P > N > Mn > B > Zn > K > Mg > Cu	
466	2.82	-11		18	-6	-1								36	N > Ca > Mg > K
467	2.81	-6		-2	-10	-3	13	-3	10					47	Ca > N > Fe > Mg > K > Zn > Mn
468	2.80	-4	-11	1	2	3	18	-3		-6				48	P > Al > N > Fe > K > Ca > Mg > Mn
469	2.79	7		22	-18	-11								58	Ca > Mg > N > K
470	2.79	-4		0	9	-12	3	4						31	Mg > N > K > Mn > Fe > Ca
471	2.78	-6		-12	-16	-3	0	-3	39					79	Ca > K > N > Fe > Mg > Mn > Zn
472	2.77	-18		-14	25	-2	6	3						67	N > K > Mg > Fe > Mn > Ca
473	2.77	-43	-17	3	46	11								120	N > P > K > Mg > Ca
474	2.77	5		-2	-1	-7	8	-0	-2					25	Mg > Zn > K > Ca > Fe > N > Mn
475	2.76	-2		4	-11	-4	12	0						33	Ca > Mg > N > Fe > K > Mn
476	2.76	-5		-9	-2	2	12	2						32	K > N > Ca > Mg > Fe > Mn
477	2.76	17	-30	13										60	P > K > N
478	2.76	-20	35	-54	19	19								147	K > N > Ca > Mg > P
479	2.75	7		18	-16	-9								50	Ca > Mg > N > K
480	2.74	-0		10	-8	-1								19	Ca > Mn > N > K

Table 2. Cont'd.

ID	YIELD		N	P	K	Ca	Mg	Mn	Fe	Zn	Al	Cu	B	Ni		RELATIVE ORDER OF NUTRIENT REQUIREMENTS
	kg/bush															
481	2.73	-6			5	-7	-6	12	2						40	Ca > Mg > N > Fe > K > Mn
482	2.73	3	-3		6	20	12	-44	36	-12	-2	-11	-6	154		Mn > Zn > Cu > B > P > Al > N > K > Mg > Ca > Fe
483	2.72	-5			6	-15	-9	19	4					58		Ca > Mg > N > Fe > K > Mn
484	2.72	-5	-7		10	-7	-2	-9	-32	6		3	43	124		Fe > Mn > P > Ca > N > Mg > Cu > Zn > K > B
485	2.71	2			9	-7	-4							22		Ca > Mg > N > K
486	2.70	-7			18	-8	-2							36		Ca > N > Mg > K
487	2.70	-2			15	-6	-8							31		Mg > Ca > N > K
488	2.70	-5			-2	5	-4	3	3					23		N > Mg > K > Fe > Mn > Ca
489	2.70	-6	3		-3	-6	-2	-15	-21	28		6	14	103		Fe > Mn > Ca > N > K > Mg > P > Cu > B > Zn
490	2.69	1	-11		3	0	-2	-8	7	-12	10	-15	26	96		Cu > Zn > P > Mn > Mg > Ca > N > K > Fe > Al > B
491	2.69	0			4	-17	-6	10	8					46		Ca > Mg > N > K > Fe > Mn
492	2.68	-14			-20	-0	-13	-4	51					102		K > N > Mg > Mn > Ca > Fe
493	2.67	-12	-7		4	3	1	-9	5	-10	8	-7	25	92		N > Zn > Mn > P > Cu > Mg > Ca > K > Fe > Al > B
494	2.67	-0			-6	-2	-3	8	-7	10				36		Fe > K > Mg > Ca > N > Mn > Zn
495	2.67	-27	-31		-28	-18	8					96		208		P > K > N > Ca > Mg > Cu
496	2.66	-40			15	8	16							79		N > Ca > K > Mg
497	2.66	3			-5	-2	0	7	2	-5				25		K > Zn > Ca > Mg > Fe > N > Mn
498	2.65	2	-1		-0	16	11	-42	32	-5	-8	-3	-3	123		Mn > Al > Zn > B > Cu > P > K > N > Mg > Ca > Fe
499	2.63	6	-14		8									28		P > N > K
500	2.63	-1			9	-1	-7							19		Mg > Ca > N > K
501	2.63	7			9	-12	-4							32		Ca > Mg > N > K
502	2.63	-37	-29		-17	-17	9					91		201		N > P > K > Ca > Mg > Cu
503	2.62	7	-3		20	26	15	-61	32	-11	-5	-10	-10	200		Mn > Zn > B > Cu > Al > P > N > Mg > K > Ca > Fe
504	2.62	-15			21	-5	-2							43		N > Ca > Mg > K
505	2.61	3			7	-8	-3							22		Ca > Mg > N > K
506	2.60	-14			-11	14	-6	9	8					62		N > K > Mg > Fe > Mn > Ca
507	2.60	-32	0		-7	61	-23							123		N > Mg > K > P > Ca
508	2.59	9			19	-21	-6							55		Ca > Mg > N > K
509	2.58	-10			10	4	-4							29		N > Mg > Ca > K
510	2.58		-8				6					2		17		P > Cu > Mg
511	2.58	-11			12	-5	4							31		N > Ca > Mg > K
512	2.58	-48	-12		5	37	18							121		N > P > K > Mg > Ca
513	2.58	-15			19	-1	-4							39		N > Mg > Ca > K
514	2.58	3			7	-12	-10	10	2	-0				45		Ca > Mg > Zn > Fe > N > K > Mn
515	2.58	-39	-21		2	48	10							120		N > P > K > Mg > Ca
516	2.57	-19			6	9	4							38		N > Mg > K > Ca
517	2.57	8	-9		1									18		P > K > N
518	2.57	-13			-3	-6	2	10	10					45		N > Ca > K > Mg > Fe > Mn
519	2.56	-15			20	-0	-5							41		N > Mg > Ca > K
520	2.56	-15			20	-5	0							40		N > Ca > Mg > K
521	2.56	-2			7	-12	-0	12	-4					37		Ca > Fe > N > Mg > K > Mn
522	2.55	-23	36		-49	21	14							144		Zn > K > N > Mg > Ca > P
523	2.54	-8			7	-21	-10	30	2					79		Ca > Mg > N > Fe > K > Mn
524	2.54	7			-3	-4	-4	21	1	-16				56		Zn > Mg > Ca > K > Fe > N > Mn
525	2.54	-1			2	-8	-4	10	3	-2				31		Ca > Mg > Zn > N > K > Fe > Mn
526	2.54	4	0		-4	19	13	-51	39	-5	-14	-3	2	154		Mn > Al > Zn > K > Cu > P > B > N > Mg > Ca > Fe
527	2.53	-10			-13	13	10		-1	1		1		49		K > N > Fe > Cu > Zn > Mg > Ca
528	2.53	4			9	-18	-9	16	-2					59		Ca > Mg > Fe > N > K > Mn
529	2.53	-16			-10	10	10		-2	7		2		57		N > K > Fe > Cu > Zn > Mg > Ca
530	2.53	-7			22	-12	-2							44		Ca > N > Mg > K
531	2.52	-12			8	7	15	-14	-4					61		Mn > N > Fe > Ca > K > Mg
532	2.52	-7			23	-7	-9							46		Mg > Ca > N > K
533	2.51	-0			0	-6	-9	11	4					30		Mg > Ca > N > K > Fe > Mn
534	2.50	-19	32		-52	25	14							142		K > N > Mg > Ca > P
535	2.50	-11	42		-77	34	13							177		K > N > Mg > Ca > P
536	2.49				-20	18	3							41		K > Mg > Ca
537	2.49	-29	-29		-21	-13	9					83		185		N > P > K > Ca > Mg > Cu
538	2.49	-40	-37		-18	-36	-2					133		267		N > P > Ca > K > Mg > Cu
539	2.48	-1	-5		6	5	-5							22		Mg > P > N > Ca > K
540	2.48		-6				5					2		12		P > Cu > Mg
541	2.48	-5			6	-16	-5	18	2					51		Ca > Mg > N > Fe > K > Mn
542	2.48	-1	-3		22	17	8	-18	6	-6	-5	-11	-10	108		Mn > Cu > B > Zn > Al > P > N > Fe > Mg > Ca > K
543	2.46				0	-1	-9	8	2					21		Mg > Ca > K > Fe > Mn
544	2.44	7			5	-1	-1	15	4	-29				62		Zn > Ca > Mg > Fe > K > N > Mn
545	2.43	-12	-3		-15	4	15	-17	-42	-5		32	44	189		Fe > Mn > K > N > Zn > P > Ca > Mg > Cu > B
546	2.43	-7			-3	6	2	7	-5					31		N > Fe > K > Mg > Ca > Mn
547	2.42	7	-4		7	15	9	-18	6	-3	-4	-9	-8	90		Mn > Cu > B > P > Al > Zn > Fe > N > K > Mg > Ca
548	2.42	1			5	3	6	3	-1	-16				35		Zn > Fe > N > Mn > Ca > K > Mg
549	2.41				-8							8		16		K > Cu

Table 2. Cont'd.

YIELD														RELATIVE ORDER OF NUTRIENT REQUIREMENTS	
ID	kg/bush	N	P	K	Ca	Mg	Mn	Fe	Zn	Al	Cu	B	NII		
550	2.41			-18	19	-1								37	K > Mg > Ca
551	2.41	-3		6	-3	-1								13	Ca > N > Mg > K
552	2.40			-9								9		18	K > Cu
553	2.40	31	-49	18										99	P > K > N
554	2.40	-0		5	-5	1								11	Ca > N > Mg > K
555	2.37	-2		9	-0	-7								19	Mg > N > Ca > K
556	2.37	-3		7	-26	-1	9	14						61	Ca > N > Mg > K > Mn > Fe
557	2.36	-6		3	-0	-1	4	1						15	N > Mg > Ca > Fe > K > Mn
558	2.35	-5		20	-3	-13								41	Mg > N > Ca > K
559	2.33	-7		-6	1	9	20	-12	-5					60	Fe > N > K > Zn > Ca > Mg > Mn
560	2.33			-35	22	13								71	K > Mg > Ca
561	2.32	-10		2	3	-9	15	-0						39	N > Mg > Fe > K > Ca > Mn
562	2.31	-8		-1	-3	5	2	5	-1					25	N > Ca > K > Zn > Mn > Fe > Mg
563	2.31	-12	0	-4	-7	-2	-6	-6	11		19	8		77	N > Ca > Mn > Fe > K > Mg > P > B > Zn > Cu
564	2.30	-5		9	-2	-2								18	N > Ca > Mg > K
565	2.30	-13		22	-6	-3								43	N > Ca > Mg > K
566	2.30	-0		-1	-16	0	19	-2						30	Ca > Fe > K > N > Mg > Mn
567	2.30	-3		4	2	-2								10	N > Mg > Ca > K
568	2.29	8	2	2	20	14	-58	40	-3	-15	-7	-3	172	Mn > Al > Cu > B > Zn > K > P > N > Mg > Ca > Fe	
569	2.29	0		19	-14	-5								39	Ca > Mg > N > K
570	2.29	3	-3	22	17	8	-27	6	-2	-6	-4	-14	111	Mn > B > Al > Cu > P > Zn > N > Fe > Mg > Ca > K	
571	2.28	-6		1	-10	-1	13	2						33	Ca > N > Mg > K > Fe > Mn
572	2.28	-10		-7	-6	-2	12	-1	14					54	N > K > Ca > Mg > Fe > Mn > Zn
573	2.27	-1		8	-3	-18	5	8						44	Mg > Ca > N > Mn > K > Fe
574	2.26	-5		-9	9	-8	11	2						44	K > Mg > N > Fe > Ca > Mn
575	2.26	1		3	-8	-17	13	9						52	Mg > Ca > N > K > Fe > Mn
576	2.26	-4	-6	12	4	-6								31	Mg > P > N > Ca > K
577	2.25	-2	-6	10	13	5	-15	5	-2	-1	-2	-4	66	Mn > P > B > Zn > Cu > N > Al > Mg > Fe > K > Ca	
578	2.24	10	0	4	21	14	-55	31	-4	-14	-8	1	162	Mn > Al > Cu > Zn > P > B > K > N > Mg > Ca > Fe	
579	2.24	8		4	-12	1								25	Ca > Mg > K > N
580	2.22	-3		18	-10	-6								37	Ca > Mg > N > K
581	2.22	-1		9	-19	-4	14	2						49	Ca > Mg > N > Fe > K > Mn
582	2.20	-1		-5	3	3	4	-2	-3					21	K > Zn > Fe > N > Mg > Ca > Mn
583	2.20	-19		24	-2	-2								48	N > Ca > Mg > K
584	2.19	-1		2	1	-2								6	Mg > N > Ca > K
585	2.19	-3		28	-20	-6								56	Ca > Mg > N > K
586	2.18		-14			12					2			28	P > Cu > Mg
587	2.18	-21		-2	23	2	-3	1						52	N > Mn > K > Fe > Mg > Ca
588	2.18	5		-4	6	1	8	-4	-13					41	Zn > Fe > K > Mg > N > Ca > Mn
589	2.18	11	1	2	24	16	-62	31	-3	-16	8	-12	187	Mn > Al > B > Zn > P > K > Cu > N > Mg > Ca > Fe	
590	2.18	7	-2	17	25	15	-50	29	-11	-5	-9	-15	185	Mn > B > Zn > Cu > Al > P > N > Mg > K > Ca > Fe	
591	2.17	3		16	-13	-7								39	Ca > Mg > N > K
592	2.17	-8		-15	17	11		0	-1		-5			57	K > N > Cu > Zn > Fe > Mg > Ca
593	2.16	-0	-4	5	-4	-3	-5	-8	9		16	-6	60	Fe > B > Mn > P > Ca > Mg > N > K > Zn > Cu	
594	2.15	10		22	-23	-33	16	8						111	Mg > Ca > Fe > N > Mn > K
595	2.14	5	4	7	25	17	-67	35	-2	-15	0	-9	184	Mn > Al > B > Zn > Cu > P > N > K > Mg > Ca > Fe	
596	2.14	13	-15	2										30	P > K > N
597	2.14	-5		12	0	-8								25	Mg > N > Ca > K
598	2.13	-9	18	-2	-4	-7	-11	-27	10		6	26	118	Fe > Mn > N > Mg > Ca > K > Cu > Zn > P > B	
599	2.13	31	-62	31										124	P > N > K
600	2.13	-8	-6	15	4	-6								39	N > Mg > P > Ca > K
601	2.12	10		-2	-14	-12	29	-2	-9					78	Ca > Mg > Zn > Fe > K > N > Mn
602	2.11	-1		5	-4	0								10	Ca > N > Mg > K
603	2.11	-3		-6	1	-6	12	2						31	Mg > K > N > Ca > Fe > Mn
604	2.11	-7		10	-2	-1								21	N > Ca > Mg > K
605	2.10	1		1	-3	-3	12	-4	-3					27	Fe > Ca > Mg > Zn > N > K > Mn
606	2.10	7		0	-18	-13	9	15						62	Ca > Mg > K > N > Mn > Fe
607	2.10	-14	-26	3	-3	7	29	12			-8			104	P > N > Cu > Ca > K > Mg > Fe > Mn
608	2.09	-1		14	-10	-3								28	Ca > Mg > N > K
609	2.09	11	-1	-3	17	11	-36	34	-11	-11	-10	-1	147	Mn > Al > Zn > Cu > K > P > B > Mg > N > Ca > Fe	
610	2.08	-2		11	-17	-9	15	2						54	Ca > Mg > N > Fe > K > Mn
611	2.08	-15		-30	42	41	-7	-22						166	K > Fe > N > Mn > Mg > Ca
612	2.07	8	-9	1										18	P > K > N
613	2.07	-9	-40	3	-16	11	51	9			-10			149	P > Ca > Cu > N > K > Fe > Mg > Mn
614	2.06	-14		1	19	-6	3	-3						46	N > Mg > Fe > K > Mn > Ca
615	2.06	18	-9	-9										36	P > K > N
616	2.06			3	-2	0	8	-3	-6					22	Zn > Fe > Ca > Mg > K > Mn
617	2.05	-6	8	10	8	4	13	-25	-8		26	-31	140	B > Fe > Zn > N > Mg > Ca > P > K > Mn > Cu	
618	2.05	-2		13	-6	-4								25	Ca > Mg > N > K

Table 2. Cont'd.

YIELD														RELATIVE ORDER OF NUTRIENT REQUIREMENTS	
ID	kg/bush	N	P	K	Ca	Mg	Mn	Fe	Zn	Al	Cu	B	NH		
619	2.05	-1		4	-3	4	9	1	-14					36	Zn>Ca>N>Fe>K>Mg>Mn
620	2.04	-5	7	-8	4	2	2	-50	11		14	23	126	Fe>K>N>Mn>Mg>Ca>P>Zn>Cu>B	
621	2.04	-7		2	-5	-3	15	-2					34	N>Ca>Mg>Fe>K>Mn	
622	2.04	7		1	-8	-2	17	2	-17				54	Zn>Ca>Mg>K>Fe>N>Mn	
623	2.03	2		-6	-10	-3	35	-3	-15				74	Zn>Ca>K>Mg>Fe>N>Mn	
624	2.03	-11		-1	9	3							24	N>K>Mg>Ca	
625	2.02	-22		-5	10	1	-1	17					55	N>K>Mn>Mg>Ca>Fe	
626	2.01	-9		-0	3	4	0	2					19	N>K>Mn>Fe>Ca>Mg	
627	2.01	-3	-3	1	6	7	17	-48	2		17	1	102	Fe>P>N>K>B>Zn>Ca>Mg>Cu>Mn	
628	2.00	-39	-17	-2	48	10							116	N>P>K>Mg>Ca	
629	2.00	-4		-2	2	-2	11	-3	-3				26	N>Fe>Zn>K>Mg>Ca>Mn	
630	2.00	-23		21	2	-0							45	N>Mg>Ca>K	
631	1.99	-13		5	9	5	-10	3					45	N>Mn>Fe>Mg>K>Ca	
632	1.99	-5		9	1	-5							20	N>Mg>Ca>K	
633	1.99	-8		16	-1	-7							32	N>Mg>Ca>K	
634	1.98	-2		19	-14	-3							38	Ca>Mg>N>K	
635	1.98	-10		15	-2	-3							30	N>Mg>Ca>K	
636	1.97	-14		16	-1	-1							32	N>Mg>Ca>K	
637	1.96	-6		-7	-6	-10	11	0	17				57	Mg>K>Ca>N>Fe>Mn>Zn	
638	1.96	15		-10	-4	-5	12	-7					54	K>Fe>Mg>Ca>Mn>N	
639	1.96	-4		-6	5	-5	9	1					30	K>Mg>N>Fe>Ca>Mn	
640	1.95	-5		16	-2	-10							32	Mg>N>Ca>K	
641	1.95			-2	14	-8	-0	-4					28	Mg>Fe>K>Mn>Ca	
642	1.95	5		24	-26	-3							58	Ca>Mg>N>K	
643	1.94	-22		11	4	7							43	N>Ca>Mg>K	
644	1.94	-10		23	-1	-12							45	Mg>N>Ca>K	
645	1.93	-14		19	-3	-2							39	N>Ca>Mg>K	
646	1.93	-1		8	-2	-5							15	Mg>Ca>N>K	
647	1.93	-5		10	-17	-12	27	-3					74	Ca>Mg>N>Fe>K>Mn	
648	1.92	-1	-2	2	-1	2	15	-40	-4		18	10	97	Fe>Zn>P>Ca>N>Mg>K>B>Mn>Cu	
649	1.92	5		15	-17	-3							41	Ca>Mg>N>K	
650	1.92	-4		2	4	-3							13	N>Mg>K>Ca	
651	1.91	4		-4	-12	-6	28	-3	-7				64	Ca>Zn>Mg>K>Fe>N>Mn	
652	1.91	-5		22	-0	-17							43	Mg>N>Ca>K	
653	1.91	3		23	-16	-10							52	Ca>Mg>N>K	
654	1.91	-10		7	1	-8	16	-7					49	N>Mg>Fe>Ca>K>Mn	
655	1.91	6	-35	29									70	P>N>K	
656	1.90	-9		2	-17	10	2	13					52	Ca>N>K>Mn>Mg>Fe	
657	1.90	7	-10	3									19	P>K>N	
658	1.89	-3		-2	-10	-5	22	-2					44	Ca>Mg>N>Fe>K>Mn	
659	1.88	-13		-7	15	-1	5	1					42	N>K>Mg>Fe>Mn>Ca	
660	1.86	-20		23	-2	-1							47	N>Ca>Mg>K	
661	1.86	-12		20	-5	-3							39	N>Ca>Mg>K	
662	1.86	-12		5	5	-2	-1	5					29	N>Mg>Mn>Fe>Ca>K	
663	1.86	4		12	-4	-12							32	Mg>Ca>N>K	
664	1.85	-9		4	-5	-3	11	1					33	N>Ca>Mg>Fe>K>Mn	
665	1.84	-7		0	-26	-10	24	19					86	Ca>Mg>N>K>Fe>Mn	
666	1.84	-5		12	4	-9	-1	-1					32	Mg>N>Fe>Mn>Ca>K	
667	1.84	23	-45	22									89	P>K>N	
668	1.83	-8		10	-3	1	1	-1					23	N>Ca>Fe>Mg>Mn>K	
669	1.83	-6		-3	13	-3	3	-6					34	N>Fe>Mg>K>Mn>Ca	
670	1.82	-1		-0	-5	4	15	1	-14				41	Zn>Ca>N>K>Fe>Mg>Mn	
671	1.82	42	-69	27									138	P>K>N	
672	1.82	-26		18	9	-1							53	N>Mg>Ca>K	
673	1.82	-11		-1	3	4	7	-2					28	N>Fe>K>Ca>Mg>Mn	
674	1.81	14	-43	28									86	P>N>K	
675	1.80	-24	5	-4	26	-3							62	N>K>Mg>P>Ca	
676	1.80	-1		23	-16	-5							45	Ca>Mg>N>K	
677	1.80	-20		15	3	3							41	N>Mg>Ca>K	
678	1.80	8		-2	-23	-6	26	-1	-4				70	Ca>Mg>Zn>K>Fe>N>Mn	
679	1.79	-28		-19	76	-27	5	-7					162	N>Mg>K>Fe>Mn>Ca	
680	1.79	1		0	-13	2	10	3	-4				33	Ca>Zn>K>N>Mg>Fe>Mn	
681	1.79	-20		8	6	13	-5	-3					55	N>Mn>Fe>Ca>K>Mg	
682	1.78	-1		11	-8	-3							23	Ca>Mg>N>K	
683	1.78	22	-48	25									95	P>N>K	
684	1.78	-9		13	6	-10							38	Mg>N>Ca>K	
685	1.78	7		11	-15	-4							38	Ca>Mg>N>K	
686	1.78	-6	-9	5	2	1	-8	9	-11	10	-12	19	93	Cu>Zn>P>Mn>N>Mg>Ca>K>Fe>Al>B	
687	1.77	3		16	-13	-6							39	Ca>Mg>N>K	

Table 2. Cont'd.

ID	YIELD kg/bush	N	P	K	Ca	Mg	Mn	Fe	Zn	Al	Cu	B	NII	RELATIVE ORDER OF NUTRIENT REQUIREMENTS		
688	1.77	-6		6	-5	-10	5	10						42	Mg>N	>Ca>Mn>K>Fe
689	1.76	-3		1	-2	-5	8	1						20	Mg>N	>Ca>K>Fe>Mn
690	1.75	-4		-2	13	1	-2	-4						27	Fe>N	>Mn>K>Mg>Ca
691	1.74	0	-6	20	17	6	-19	3	-4	-3	-2	-13	93	Mn>B	>P>Zn>Al>Cu>N>Fe>Mg>Ca>K	
692	1.74	-9		16	4	-11								41	Mg>N	>Ca>K
693	1.74	-6		5	-4	-3	11	-3						32	N>Ca>Fe>Mg>K	>Mn
694	1.74	-1		18	-12	-5								35	Ca>Mg>N	>K
695	1.74	-29		-7	-9	4	-5	48						100	N>Ca>K>Mn>Mg>Fe	
696	1.73	3		2	-13	-10	6	12						45	Ca>Mg>K	>N>Mn>Fe
697	1.72	-3		-5	5	-11	3	11						38	Mg>K>N>Mn>Ca>Fe	
698	1.72	-6		1	-6	-9	18	2						42	Mg>Ca>N>K>Fe>Mn	
699	1.72			-1	-8	-4	17	4	-8					41	Zn>Ca>Mg>K>Fe>Mn	
700	1.71	-24		40	-2	-13								79	N>Mg>Ca>K	
701	1.70	-2	-4	3	10	8	-16	11	-18	8	-20	20	120	Cu>Zn>Mn>P>N>K>Al>Mg>Ca>Fe>B		
702	1.70	-23		16	4	3								46	N>Mg>Ca>K	
703	1.70	-11		19	-7	-1								38	N>Ca>Mg>K	
704	1.70	-8		-0	9	4	-3	-2						25	N>Mn>Fe>K>Mg>Ca	
705	1.68	-1		18	-7	-9								35	Mg>Ca>N>K	
706	1.67	1	-7	-1	5	4	-8	12	-22	13	-23	25	120	Cu>Zn>Mn>P>K>N>Mg>Ca>Fe>Al>B		
707	1.67	-11	-8	1	5	4	-10	11	-11	12	-12	20	104	Cu>Zn>N>Mn>P>K>Mg>Ca>Fe>Al>B		
708	1.67	-7		7	-7	6	9	1	-8					45	Zn>N>Ca>Fe>Mg>K>Mn	
709	1.67	-6		-3	9	-17	8	8						52	Mg>N>K>Mn>Fe>Ca	
710	1.67	11	2	2	22	15	-49	33	-8	-17	-8	-5	173	Mn>Al>Zn>Cu>B>P>K>N>Mg>Ca>Fe		
711	1.66	-18		5	11	8	-6	-0						48	N>Mn>Fe>K>Mg>Ca	
712	1.66	-15		34	-12	-7								68	N>Ca>Mg>K	
713	1.65	-16		12	12	-8								48	N>Mg>K>Ca	
714	1.65	-11		15	10	-14								50	Mg>N>Ca>K	
715	1.64	-4	-6	7	8	6	-14	10	-9	6	-22	16	109	Cu>Mn>Zn>P>N>Mg>Al>K>Ca>Fe>B		
716	1.64	2		-13	-10	-2	19	3						48	K>Ca>Mg>N>Fe>Mn	
717	1.64	1		18	-15	-4								37	Ca>Mg>N>K	
718	1.64	-4		7	12	0	8	-3	-20					56	Zn>N>Fe>Mg>K>Mn>Ca	
719	1.64	-14		-4	19	1	2	-5						47	N>Fe>K>Mg>Mn>Ca	
720	1.63	15		-4	-3	-8								29	Mg>K>Ca>N	
721	1.63	-0	-5	3	3	1	-9	16	-13	14	-25	16	105	Cu>Zn>Mn>P>N>Mg>Ca>K>Al>Fe>B		
722	1.62	-3		14	-7	-4								28	Ca>Mg>N>K	
723	1.62	-2		7	-7	2								18	Ca>N>Mg>K	
724	1.62	-1		17	-12	-4								33	Ca>Mg>N>K	
725	1.62	1		-6	-7	-1	7	1	6					27	Ca>K>Mg>Fe>N>Zn>Mn	
726	1.60	-2		-3	-3	1	2	5						17	K>Ca>N>Mg>Mn>Fe	
727	1.60	4		-1	-11	-2	4	0	6					29	Ca>Mg>K>Fe>N>Mn>Zn	
728	1.60	-16		10	10	-4								40	N>Mg>K>Ca	
729	1.60	-6	-7	7	5	2	-13	22	-19	13	-15	10	118	Zn>Cu>Mn>P>N>Mg>Ca>K>B>Al>Fe		
730	1.59	-18		-9	-17	-0	-26	72						143	Mn>N>Ca>K>Mg>Fe	
731	1.59	-15	-36	1	-15	2	56	13			-7			145	P>N>Ca>Cu>K>Mg>Fe>Mn	
732	1.59	1	-9	2	3	2	-4	15	-18	16	-25	17	112	Cu>Zn>P>Mn>N>K>Mg>Ca>Fe>Al>B		
733	1.57	-4		-1	-1	-1	10	-2						20	N>Fe>K>Mg>Ca>Mn	
734	1.56	12		39	-35	-16								102	Ca>Mg>N>K	
735	1.55	2		2	-3	-3	13	2	-13					37	Zn>Mg>Ca>Fe>K>N>Mn	
736	1.53	-2		-1	-8	-2	6	7						26	Ca>N>Mg>K>Mn>Fe	
737	1.52	1		3	-6	-7	3	-4	10					33	Mg>Ca>Fe>N>Mn>K>Zn	
738	1.52	3		-1	-8	-5	12	7	-9					44	Zn>Ca>Mg>K>N>Fe>Mn	
739	1.52	-27		34	0	-7								69	N>Mg>Ca>K	
740	1.51	-2		4	-9	-3	4	6						28	Ca>Mg>N>K>Mn>Fe	
741	1.50	-0	13	16	-5	-2	8	-16	3		9	-24	96	B>Fe>Ca>Mg>N>Zn>Mn>Cu>P>K		
742	1.50	-4		2	8	-1	10	-2	-12					38	Zn>N>Fe>Mg>K>Ca>Mn	
743	1.50	1		4	-8	-1	15	2	-13					43	Zn>Ca>Mg>N>Fe>K>Mn	
744	1.50	30	-72	42										144	P>N>K	
745	1.49	13		-3	-9	5	12	-0	-18					60	Zn>Ca>K>Fe>Mg>Mn>N	
746	1.49	2		8	-16	-5	5	6						40	Ca>Mg>N>Mn>Fe>K	
747	1.48	-6		-1	2	-6	3	8						27	Mg>N>K>Ca>Mn>Fe	
748	1.47	-3	-10	1	-3	5	7	3						31	P>Ca>N>K>Fe>Mg>Mn	
749	1.47	-9	-8	7	17	-8								49	N>Mg>P>K>Ca	
750	1.47	-10		-16	22	-20	14	11						93	Mg>K>N>Fe>Mn>Ca	
751	1.45	-9		-0	8	-8	5	4						34	N>Mg>K>Fe>Mn>Ca	
752	1.44	-8		4	-4	-5	12	1						34	N>Mg>Ca>Fe>K>Mn	
753	1.44	-13		1	27	-6	-6	-3						56	N>Mg>Mn>Fe>K>Ca	
754	1.44	-1		-7	-5	4	-1	3	8					26	K>Ca>Mn>N>Fe>Mg>Zn	
755	1.43	-5		-6	2	-8	10	8						38	Mg>K>N>Ca>Fe>Mn	
756	1.42	-4		7	-8	4								23	Ca>N>Mg>K	

Table 2. Cont'd.

ID	YIELD													RELATIVE ORDER OF NUTRIENT REQUIREMENTS
	kg/bush	N	P	K	Ca	Mg	Mn	Fe	Zn	Al	Cu	B	NII	
757	1.41	3	-5	3	5	2	-12	14	-12	7	-13	9	85	Cu>Mn>Zn>P>Mg>K>N>Ca>Al>B>Fe
758	1.40	-3	-7	3	3	1	-10	18	-19	13	-14	17	108	Zn>Cu>Mn>P>N>Mg>Ca>K>Al>B>Fe
759	1.40	-7		7	-5	-0		8	-2				29	N>Ca>Fe>Mg>K>Mn
760	1.40	-8	-8	5	20	-9							51	Mg>P>N>K>Ca
761	1.39	-24	-30	-3	48	10							116	P>N>K>Mg>Ca
762	1.39	-9		-4	0	-1	11	-5	8				38	N>Fe>K>Mg>Ca>Zn>Mn
763	1.39	-8		-4	-2	-7	18	4					43	N>Mg>K>Ca>Fe>Mn
764	1.39	-2		8	-4	-3	19	-1	-18				54	Zn>Ca>Mg>N>Fe>K>Mn
765	1.39	-7		-10	-6	-11	27	7					68	Mg>K>N>Ca>Fe>Mn
766	1.39	-10		-5	10	-7	6	6					44	N>Mg>K>Mn>Fe>Ca
767	1.39	-8	-26	-7	-15	0	47	11			-2		115	P>Ca>N>K>Cu>Mg>Fe>Mn
768	1.38	-4		4	4	4	19	-2	-23				60	Zn>N>Fe>Mg>Ca>K>Mn
769	1.37	-2		4	-17	-14	22	6					65	Ca>Mg>N>K>Fe>Mn
770	1.37	-5		30	-17	-8							61	Ca>Mg>N>K
771	1.37	-13		4	-21	-21	55	-4					117	Ca>Mg>N>Fe>K>Mn
772	1.37	-22	-28	-24	58	15							147	P>K>N>Mg>Ca
773	1.36	-9		1	1	-12	24	-4					51	Mg>N>Fe>Ca>K>Mn
774	1.35	-4	-3	16	7	4	-7	19	-49	22	-25	18	175	Zn>Cu>Mn>N>P>Mg>Ca>K>B>Fe>Al
775	1.35	-4	-8	6	7	4	-14	11	-16	10	-12	16	108	Zn>Mn>Cu>P>N>Mg>K>Ca>Al>Fe>B
776	1.35	4		22	-18	-8							50	Ca>Mg>N>K
777	1.35	-4		10	3	-9							26	Mg>N>Ca>K
778	1.35	-20	3	-10	29	-2							64	N>K>Mg>P>Ca
779	1.35	-21		25	0	-3							49	N>Mg>Ca>K
780	1.35	3		9	-17	5							35	Ca>N>Mg>K
781	1.35	-16	5	12		-1							34	N>Mg>P>K
782	1.34	-9		3	7	1	5	-6					31	N>Fe>Mg>K>Mn>Ca
783	1.34	-3		5	-12	-9	16	4					47	Ca>Mg>N>Fe>K>Mn
784	1.34	6		11	-30	-3	13	3					66	Ca>Mg>Fe>N>K>Mn
785	1.33	-5	-9	4	20	-9							47	P>Mg>N>K>Ca
786	1.33	-24	7	1	17	-2							51	N>Mg>K>P>Ca
787	1.33	-8		3	1	4	6	-3	-2				26	N>Fe>Zn>Ca>K>Mg>Mn
788	1.32	6	-3	6	14	9	-20	4	0	-8	-3	-7	81	Mn>Al>B>P>Cu>Zn>Fe>N>K>Mg>Ca
789	1.32	8		13	-18	-3							42	Ca>Mg>N>K
790	1.32	-3	-20	0	-5	-1	28	1					58	P>Ca>N>Mg>K>Fe>Mn
791	1.31	-11	-13	6	-0	10	2	6					48	P>N>Ca>Mn>Fe>K>Mg
792	1.30	-25	-37	-1	51	13							128	P>N>K>Mg>Ca
793	1.30	-1		25	-18	-7							49	Ca>Mg>N>K
794	1.29	31		33	-51	-13							128	Ca>Mg>N>K
795	1.28	-3	-15	5	-6	2	14	2					48	P>Ca>N>Mg>Fe>K>Mn
796	1.28	-11		23	-11	-1							45	Ca>N>Mg>K
797	1.28	-4		8	-13	-10	16	3					53	Ca>Mg>N>Fe>K>Mn
798	1.28	-4		7	-5	-5	5	2					27	Mg>Ca>N>Fe>Mn>K
799	1.27	-9		-7	-23	-13	33	21	-2				108	Ca>Mg>N>K>Zn>Fe>Mn
800	1.27	-21		26	4	-8							60	N>Mg>Ca>K
801	1.27	1	-7	6	7	4	-6	3	-6	-1	-5	3	50	P>Zn>Mn>Cu>Al>N>B>Fe>Mg>K>Ca
802	1.27	-27	-40	2	54	11							133	P>N>K>Mg>Ca
803	1.27	-8	-23	-6	-11	20	20	12			-3		103	P>Ca>N>K>Cu>Fe>Mg>Mn
804	1.26	2		13	-15	0	-11	11					54	Ca>Mn>Mg>N>Fe>K
805	1.26	-0		-5	-2	-12	10	9					38	Mg>K>Ca>N>Fe>Mn
806	1.26	-11	-22	-9	37	5							84	P>N>K>Mg>Ca
807	1.24	-5		-3	-1	-8	24	-7					48	Mg>Fe>N>K>Ca>Mn
808	1.22	-7		4	-5	-1	5	5					26	N>Ca>Mg>K>Fe>Mn
809	1.22	-15		50	-34	-2							101	Ca>N>Mg>K
810	1.22	-8		-5	-4	-4	3	-1	18				42	N>K>Mg>Ca>Fe>Mn>Zn
811	1.21	-3		11	-8	-1							23	Ca>N>Mg>K
812	1.20	-1		17	-10	-7							35	Ca>Mg>N>K
813	1.19	-9		0	0	-6	17	-2					36	N>Mg>Fe>K>Ca>Mn
814	1.19	-9		28	-18	-1							56	Ca>N>Mg>K
815	1.19	-3		26	-20	-3							53	Ca>N>Mg>K
816	1.19	-25		20	10	-5							60	N>Mg>Ca>K
817	1.19	-9		-4	16	-9	-2	9					50	Mg>N>K>Mn>Fe>Ca
818	1.19	4	-7	9	8	5	-12	2	0	-8	-1	1	57	Mn>Al>P>Cu>Zn>B>Fe>N>Mg>Ca>K
819	1.18	-16		5	7	-5	2	7					40	N>Mg>Mn>K>Ca>Fe
820	1.18	-5		12	1	-7							25	Mg>N>Ca>K
821	1.17	-30	-22	-6	36	22							116	N>P>K>Mg>Ca
822	1.17	15		31	21	-8	33	-92					198	Fe>Mg>N>Ca>K>Mn
823	1.17	-8		-2	5	-3	13	-5					36	N>Fe>Mg>K>Ca>Mn
824	1.17	-1		9	-7	1	20	5	-28				70	Zn>Ca>N>Mg>Fe>K>Mn
825	1.17	-4		27	-16	-7							53	Ca>Mg>N>K

Table 2. Cont'd.

YIELD														RELATIVE ORDER OF NUTRIENT REQUIREMENTS
ID	kg/bush	N	P	K	Ca	Mg	Mn	Fe	Zn	Al	Cu	B	NII	
826	1.17	-6		4	-9	-4	14	1					39	Ca > N > Mg > Fe > K > Mn
827	1.16	-16		-0	-43	-31	98	-7					196	Ca > Mg > N > Fe > K > Mn
828	1.15	-30	-21	-8	36	22							118	N > P > K > Mg > Ca
829	1.15	-0		18	-12	-5							35	Ca > Mg > N > K
830	1.14	5		2	-13	6							26	Ca > K > N > Mg
831	1.14	-20		2	11	-6	9	5					52	N > Mg > K > Fe > Mn > Ca
832	1.14	-12	-55	-16	-13	9	61	36			-11		212	P > K > Ca > N > Cu > Mg > Fe > Mn
833	1.14	-14	-29	-6	-12	12	43	15			-9		140	P > N > Ca > Cu > K > Mg > Fe > Mn
834	1.14	-0	-8	24	16	20	-7	-51	-2		22	-14	165	Fe > B > P > Mn > Zn > N > Ca > Mg > Cu > K
835	1.13	-22	6	7		6							44	N > Mg > K > P
836	1.12	-3	-21	4	-2	-2	23	1					56	P > N > Mg > Ca > Fe > K > Mn
837	1.12	2		2	-5	-11	3	10					33	Mg > Ca > K > N > Mn > Fe
838	1.11	-4		0	-5	2	12	-5					30	Fe > Ca > N > K > Mg > Mn
839	1.11	-7	-24	-5	34	2							71	P > N > K > Mg > Ca
840	1.10	-26	-21	-3	30	19							98	N > P > K > Mg > Ca
841	1.10	4		1	-13	-4	18	3	-9				53	Ca > Zn > Mg > K > Fe > N > Mn
842	1.10	-10	-19	3	0	5	16	5					58	P > N > Ca > K > Mg > Fe > Mn
843	1.08	-8		6	-1	-1	1	4					20	N > Mg > Ca > Mn > Fe > K
844	1.08	-2	-21	5	-4	-4	22	3					61	P > Mg > Ca > N > Fe > K > Mn
845	1.07	-11	-43	-1	1	7	49	8			-11		131	P > Cu > N > K > Ca > Mg > Fe > Mn
846	1.07	-16	-11	5	5	10	2	5					55	N > P > Mn > Ca > Fe > K > Mg
847	1.07	-6		30	-11	-13							59	Mg > Ca > N > K
848	1.07	-25		28	1	-4							59	N > Mg > Ca > K
849	1.07	-26	-22	-7	36	21							113	N > P > K > Mg > Ca
850	1.06	-22		7	13	4	13	-58	44				161	Fe > N > Mg > K > Mn > Ca > Zn
851	1.06	-14	-39	6	-11	3	56	12			-11		153	P > N > Ca > Cu > Mg > K > Fe > Mn
852	1.05	-8	-21	-21	43	8							101	P > K > N > Mg > Ca
853	1.05	-1		11	-9	-1							22	Ca > Mg > N > K
854	1.05	-9	-26	-1	36	1							72	P > N > K > Mg > Ca
855	1.05	-19	-14	-10	29	14							85	N > P > K > Mg > Ca
856	1.04	-24		22	3	-1							50	N > Mg > Ca > K
857	1.04	-5		-2	2	2	6	-4					21	N > Fe > K > Mg > Ca > Mn
858	1.04	-6		7	-14	-13	24	2					66	Ca > Mg > N > Fe > K > Mn
859	1.03	-2		23	-12	-9							45	Ca > Mg > N > K
860	1.03	1		19	-15	-5							42	Ca > Mg > N > K
861	1.03	-7	-21	-4	-20	2	43	14			-7		117	P > Ca > Cu > N > K > Mg > Fe > Mn
862	1.01	-20	-12	-6	26	12							76	N > P > K > Mg > Ca
863	1.01	-27		47	-15	-6							94	N > Ca > Mg > K
864	1.01	-7		11	-0	-3							22	N > Mg > Ca > K
865	1.01	-1		7	-2	-8	6	-2					25	Mg > Ca > Fe > N > Mn > K
866	1.00	-2		1	-21	-7	30	2	-3				66	Ca > Mg > Zn > N > K > Fe > Mn
867	1.00	5		26	-15	-16							62	Mg > Ca > N > K
868	1.00	-11		-6	-11	5	1	-2	23				58	N > Ca > K > Fe > Mn > Mg > Zn
869	1.00	-18		12	9	-3							42	N > Mg > Ca > K
870	0.99	-9		1	15	-11	6	-0					42	Mg > N > Fe > K > Mn > Ca
871	0.99	-27	-21	-3	32	19							102	N > P > K > Mg > Ca
872	0.99	-9	-30	2	-10	3	38	10			-5		107	P > Ca > N > Cu > K > Mg > Fe > Mn
873	0.99	-7	-10	2	2	9	2	1					33	P > N > Fe > Ca > K > Mn > Mg
874	0.99	-8	-20	7	4	1	10	7					57	P > N > Mg > Ca > Fe > K > Mn
875	0.98	2		20	-15	-8							45	Ca > Mg > N > K
876	0.98	-8	-16	-11	38	-1							75	P > K > N > Mg > Ca
877	0.97	-29	-23	-5	36	21							113	N > P > K > Mg > Ca
878	0.97	-29	-45	12	55	7							148	P > N > Mg > K > Ca
879	0.97	-7	-23	-8	33	4							75	P > K > N > Mg > Ca
880	0.97	-6		8	4	0	14	-4	-17				52	Zn > N > Fe > Mg > Ca > K > Mn
881	0.97	-10		-2	2	2	6	1					24	N > K > Fe > Mg > Ca > Mn
882	0.96	-11	-21	6	3	3	14	7					64	P > N > Mg > Ca > K > Fe > Mn
883	0.96	-4		13	-8	-1							27	Ca > N > Mg > K
884	0.96	-0		16	-7	-8							31	Mg > Ca > N > K
885	0.96	-18		12	10	13	-16	-1					69	N > Mn > Fe > Ca > K > Mg
886	0.96	-23	-14	-4	30	10							81	N > P > K > Mg > Ca
887	0.96	-6		17	-4	-7							35	Mg > N > Ca > K
888	0.93			0	-2	-6	8	-0					17	Mg > Ca > Fe > K > Mn
889	0.91	-29	-45	-2	68	8							151	P > N > K > Mg > Ca
890	0.90	-23	-17	-4	31	14							89	N > P > K > Mg > Ca
891	0.90	-23	-14	-8	31	14							90	N > P > K > Mg > Ca
892	0.90	3	-2	4	14	7	-13	3	-2	-6	-4	-3	64	Mn > Al > Cu > B > P > Zn > Fe > N > K > Mg > Ca
893	0.90	-2		10	-19	-6	7	9					54	Ca > Mg > N > Mn > Fe > K
894	0.90			-1	21	-8	-6	-6					42	Mg > Fe > Mn > K > Ca

Table 2. Cont'd.

YIELD														RELATIVE ORDER OF NUTRIENT REQUIREMENTS	
ID	kg/bush	N	P	K	Ca	Mg	Mn	Fe	Zn	Al	Cu	B	NH		
895	0.90	-13		5	13	-5								36	N > Mg > K > Ca
896	0.90	-10		16	1	-7								34	N > Mg > Ca > K
897	0.89	18		18	-40	4								80	Ca > Mg > N > K
898	0.88	-24	-14	-14	34	19								104	N > P > K > Mg > Ca
899	0.88	-34		28	4	2								68	N > Mg > Ca > K
900	0.87	-3		13	-1	-9								25	Mg > N > Ca > K
901	0.87	-3		13	-3	-7								26	Mg > Ca > N > K
902	0.87	-7		-4	3	14	-9	3						40	Mn > N > K > Ca > Fe > Mg
903	0.87	-29		32	6	-9								76	N > Mg > Ca > K
904	0.86	-21	-49	5	-3	8	58	10			-8			163	P > N > Cu > Ca > K > Mg > Fe > Mn
905	0.86	-5		-0	-7	-3	7	2	6					29	Ca > N > Mg > K > Fe > Zn > Mn
906	0.86	-10		6	-12	-4	13	7						52	Ca > N > Mg > K > Fe > Mn
907	0.86	-10	-19	2	-8	10	23	10			-7			89	P > N > Ca > Cu > K > Fe > Mg > Mn
908	0.85	-20	-34	-4	52	5								115	P > N > K > Mg > Ca
909	0.85	4	-2	7	19	11	-26	3	-1	-7	-4	-3		88	Mn > Al > Cu > B > P > Zn > Fe > N > K > Mg > Ca
910	0.85	3		3	-14	-5	2	9						36	Ca > Mg > Mn > N > K > Fe
911	0.84	-16	-32	-3	-7	5	35	29			-11			138	P > N > Cu > Ca > K > Mg > Fe > Mn
912	0.84			31	-16	-15								62	Ca > Mg > K
913	0.84	-7	-19	2	1	3	21	-1						54	P > N > Fe > Ca > K > Mg > Mn
914	0.82	-2		-1	-1	4	20	-4	-17					49	Zn > Fe > N > Ca > K > Mg > Mn
915	0.82	-12		25	-1	-12								50	N > Mg > Ca > K
916	0.81	-2		-7	2	-0	3	5						19	K > N > Mg > Ca > Mn > Fe
917	0.81	1		31	-28	-5								64	Ca > Mg > N > K
918	0.81	0		7	-16	-17	20	6						66	Mg > Ca > N > Fe > K > Mn
919	0.81	-11	-17	2	1	7	11	6						56	P > N > Ca > K > Fe > Mg > Mn
920	0.80			-2	-24	27	-1							53	Mg > Ca > Fe > Mn
921	0.80	-10		19	-6	-4								39	N > Ca > Mg > K
922	0.79	-15	-26	-7	47	1								96	P > N > K > Mg > Ca
923	0.78	11		3	-19	-12	1	15						61	Ca > Mg > Mn > K > N > Fe
924	0.78	-6		2	2	-1	5	-2						17	N > Fe > Mg > Ca > K > Mn
925	0.78			10	-4	-6								20	Mg > Ca > K
926	0.77	-11		34	-8	-15								68	Mg > N > Ca > K
927	0.77	-25	-32	2	-10	2	65	8			-10			152	P > N > Ca > Cu > Mg > K > Fe > Mn
928	0.76	-10		14	-5	2	1	-9						40	N > Fe > Ca > Mn > Mg > K
929	0.76	-3		8	-3	-11	4	2						31	Mg > Ca > N > Fe > Mn > K
930	0.76	-16	-27	-4	47	0								94	P > N > K > Mg > Ca
931	0.75	-20	-37	1	56	-0								114	P > N > Mg > K > Ca
932	0.74	-0	-16	5	-4	-2	16	1						44	P > Ca > Mg > N > Fe > K > Mn
933	0.74	-18	-32	-20	50	12								142	P > K > N > Mg > Ca
934	0.73	-7		8	6	11	9	-10	-16					67	Zn > Fe > N > Ca > K > Mn > Mg
935	0.72	-270		31	137	102								541	N > K > Mg > Ca
936	0.72	-37		10	21	5								73	N > Mg > K > Ca
937	0.72	-13	-29	-0	-12	2	40	22			-10			129	P > N > Ca > Cu > K > Mg > Fe > Mn
938	0.71	-11	-80	-25	-7	2	141	-8			-11			285	P > K > Cu > N > Fe > Ca > Mg > Mn
939	0.70	-3		13	-5	-5								25	Ca > Mg > N > K
940	0.70			18	-19	1								38	Ca > Mg > K
941	0.70	-12	-30	-5	8	11	40	-5			-8			119	P > N > Cu > K > Fe > Ca > Mg > Mn
942	0.69	-40		43	-2	-2								86	N > Mg > Ca > K
943	0.68	-13		30	-14	-3								60	Ca > N > Mg > K
944	0.68	6		13	-9	-8	16	5	-24					81	Zn > Ca > Mg > Fe > N > K > Mn
945	0.68	-17		-1	35	-3	1	-15						72	N > Fe > Mg > K > Mn > Ca
946	0.67	-7		6	2	1	-1	-1						17	N > Mn > Fe > Mg > Ca > K
947	0.67	10		38	-69	-16	30	8						172	Ca > Mg > Fe > N > Mn > K
948	0.67	-30		35	6	-11								82	N > Mg > Ca > K
949	0.65	-12	-7	28		-9								56	N > Mg > P > K
950	0.65	-16	-30	-1	-4	24	31	10			-14			129	P > N > Cu > Ca > K > Fe > Mg > Mn
951	0.64	-9		16	-11	3								39	Ca > N > Mg > K
952	0.62	-25		32	6	-13								75	N > Mg > Ca > K
953	0.62	-6	-19	4	4	2	15	1						51	P > N > Fe > Mg > K > Ca > Mn
954	0.61	-26		33	5	-12								77	N > Mg > Ca > K
955	0.60	-16		17	7	-2	-3	-7	-2					54	N > Fe > Mn > Mg > Zn > Ca > K
956	0.60	-21		5	24	-13	5	-0						68	N > Mg > Fe > K > Mn > Ca
957	0.60	-5		8	-1	-5	1	2	-2					23	Mg > N > Zn > Ca > Mn > Fe > K
958	0.59	-20	-27	-12	58	1								117	P > N > K > Mg > Ca
959	0.59	-8	-33	4	-2	18	25	6			-10			105	P > Cu > N > Ca > K > Fe > Mg > Mn
960	0.58	4		14	-3	-15								36	Mg > Ca > N > K
961	0.57	-4		-6	-8	5	22	-9						53	Fe > Ca > K > N > Mg > Mn
962	0.56	-2		-4	4	-1	1	3						15	K > N > Mg > Mn > Fe > Ca
963	0.56	-2		8	-5	-2								17	Ca > N > Mg > K

Table 2. Cont'd.

YIELD														RELATIVE ORDER OF NUTRIENT REQUIREMENTS	
ID	kg/bush	N	P	K	Ca	Mg	Mn	Fe	Zn	Al	Cu	B	NH		
964	0.56	-32			14	12	6							65	N > Mg > Ca > K
965	0.55	-42			24	15	4							85	N > Mg > Ca > K
966	0.55	-23			29	1	-7							60	N > Mg > Ca > K
967	0.54	-6	-31		-3	6	12	29	1			-8		95	P > Cu > N > K > Fe > Ca > Mg > Mn
968	0.54	-4	-4		4	-7	9	-11	-28	27		-0	15	109	Fe > Mn > Ca > N > P > Cu > K > Mg > B > Zn
969	0.53	-10			8	-2	-2	4	3					28	N > Mg > Ca > Fe > Mn > K
970	0.53	-10	-26		-3	-15	9	37	13			-5		118	P > Ca > N > Cu > K > Mg > Fe > Mn
971	0.51	-8	-17		2	5	1	16	1					49	P > N > Mg > Fe > K > Ca > Mn
972	0.51	-8	-21		5	2	2	10	11					57	P > N > Ca > Mg > K > Mn > Fe
973	0.50	-6	-22		-1	0	12	30	1			-14		84	P > Cu > N > K > Ca > Fe > Mg > Mn
974	0.50	1			30	-14	-16							61	Mg > Ca > N > K
975	0.50	-5			1	1	-3	1	5					17	N > Mg > Mn > K > Ca > Fe
976	0.50	-7			16	-11	-14	20	-4					72	Mg > Ca > N > Fe > K > Mn
977	0.49	9			40	-56	-9	4	12					129	Ca > Mg > Mn > N > Fe > K
978	0.49	-34			22	8	4							67	N > Mg > Ca > K
979	0.49	-9	-40		1	4	19	36	0			-11		121	P > Cu > N > Fe > K > Ca > Mg > Mn
980	0.48	-13	-58		-10	2	10	90	-5			-17		204	P > Cu > N > K > Fe > Ca > Mg > Mn
981	0.47	-3			8	-24	-17	29	6					86	Ca > Mg > N > Fe > K > Mn
982	0.47	-22	-47		24	8	-1	44	4			-11		161	P > N > Cu > Mg > Fe > Ca > K > Mn
983	0.46	-8			5	-3	-6	10	1					33	N > Mg > Ca > Fe > K > Mn
984	0.45	3	-8		17	6	12	18	-34	19		20	-52	187	B > Fe > P > N > Ca > Mg > K > Mn > Zn > Cu
985	0.45	1			4	-11	-11	12	5					44	Mg > Ca > N > K > Fe > Mn
986	0.45	-21			34	1	-14							69	N > Mg > Ca > K
987	0.45	-3			2	-7	-2	8	3					25	Ca > N > Mg > K > Fe > Mn
988	0.45	-7			3	-5	-2	4	7					29	N > Ca > Mg > K > Mn > Fe
989	0.44	-10	-35		-2	11	37	29	2			-32		159	P > Cu > N > K > Fe > Ca > Mn > Mg
990	0.44	-1	-60		-8	8	10	57	6			-11		161	P > Cu > K > N > Fe > Ca > Mg > Mn
991	0.44	-12			6	-9	-2	16	0					46	N > Ca > Mg > Fe > K > Mn
992	0.44	10			38	-42	-6							97	Ca > Mg > N > K
993	0.44	4			2	-11	-11	9	8					46	Mg > Ca > K > N > Fe > Mn
994	0.43	-5			35	-18	-11							70	Ca > Mg > N > K
995	0.42	-17	-41		9	17	22	33	-10			-13		162	P > N > Cu > Fe > K > Ca > Mg > Mn
996	0.41	-44			16	24	5							89	N > Mg > K > Ca
997	0.41	-3			11	-3	-11	6	0					34	Mg > Ca > N > Fe > Mn > K
998	0.41	-31			60	-20	-9							119	N > Ca > Mg > K
999	0.41	5			6	-19	1	2	6					39	Ca > Mg > Mn > N > Fe > K
1000	0.41	0	2		-2	10	43	-34	-63	38		21	-16	227	Fe > Mn > B > K > N > P > Ca > Cu > Zn > Mg
1001	0.41	-7	-19		3	3	3	11	6					52	P > N > K > Ca > Mg > Fe > Mn
1002	0.41	11	43		14	-32	-35							134	Mg > Ca > N > K > P
1003	0.40	-5	-24		9	6	0	7	7					59	P > N > Mg > Ca > Mn > Fe > K
1004	0.40	6	83		-0	-36	-53							179	Mg > Ca > K > N > P
1005	0.40	-11	-19		3	10	5	7	4					59	P > N > K > Fe > Mg > Mn > Ca
1006	0.39	-32			23	13	-4							72	N > Mg > Ca > K
1007	0.39	-28			58	-14	-15							115	N > Mg > Ca > K
1008	0.39	-10	-20		5	4	8	1	11					60	P > N > Mn > Ca > K > Mg > Fe
1009	0.38	11	48		-33	-10	-16							118	K > Mg > Ca > N > P
1010	0.38	-1			24	-36	-30	44	-1					135	Ca > Mg > Fe > N > K > Mn
1011	0.38	-2			-4	-7	-1	9	6					29	Ca > K > N > Mg > Fe > Mn
1012	0.37	-16	-38		-10	6	6	67	4			-19		166	P > Cu > N > K > Fe > Mg > Ca > Mn
1013	0.37	-18			-2	36	-7	-5	-4					71	N > Mg > Mn > Fe > K > Ca
1014	0.37	-5			10	-23	-21	39	2					100	Ca > Mg > N > Fe > K > Mn
1015	0.36	-30			18	8	3							59	N > Mg > Ca > K
1016	0.36	-2			9	-6	-3	0	2					22	Ca > Mg > N > Mn > Fe > K
1017	0.36	-27			64	-36	-1							129	Ca > N > Mg > K
1018	0.35	-6	-23		-1	-2	6	35	2			-9		85	P > Cu > N > Ca > K > Fe > Mg > Mn
1019	0.34	-3			7	-8	-11	2	14					44	Mg > Ca > N > Mn > K > Fe
1020	0.33	-47			34	11	2							93	N > Mg > Ca > K
1021	0.33	-1			35	-19	-15							69	Ca > Mg > N > K
1022	0.32	-10			-3	19	-5	-9	7					53	N > Mn > Mg > K > Fe > Ca
1023	0.31	-12	-49		-10	-4	6	80	5			-16		182	P > Cu > N > K > Ca > Fe > Mg > Mn
1024	0.31	-10	-50		-22	11	19	81	-7			-21		222	P > K > Cu > N > Fe > Ca > Mg > Mn
1025	0.31	13	40		-8	-27	-18							105	Ca > Mg > K > N > P
1026	0.30	-8	104		16	-54	-59							239	Mg > Ca > N > K > P
1027	0.30	-26			31	5	-9							71	N > Mg > Ca > K
1028	0.29	-7			5	-9	-6	17	0					43	Ca > N > Mg > Fe > K > Mn
1029	0.28	-14	-37		8	9	8	46	-3			-18		142	P > Cu > N > Fe > Mg > K > Ca > Mn
1030	0.28	-7			5	10	1	8	-1	-17				48	Zn > N > Fe > Mg > K > Mn > Ca
1031	0.27	-10	-41		-1	-2	5	55	6			-12		131	P > Cu > N > Ca > K > Mg > Fe > Mn
1032	0.27	-9	-25		6	8	2	10	9					68	P > N > Mg > K > Ca > Fe > Mn

Table 2. Cont'd.

YIELD														RELATIVE ORDER OF NUTRIENT REQUIREMENTS
ID	kg/bush	N	P	K	Ca	Mg	Mn	Fe	Zn	Al	Cu	B	NII	
1033	0.24	-20	150	49	-56	-132							416	Mg>Ca>N>K>P
1034	0.24	2	70	-25	-18	-29							144	Mg>K>Ca>N>P
1035	0.23	-42		18	31	-7							98	N>Mg>K>Ca
1036	0.23	3		3	-28	-2	7	16					58	Ca>Mg>N>K>Mn>Fe
1037	0.23	-13		18	-3	-2							37	N>Ca>Mg>K
1038	0.22	5	65	13	-36	-47							167	Mg>Ca>N>K>P
1039	0.22	-18		17	3	20	-18	-3					80	Mn>N>Fe>Ca>K>Mg
1040	0.21	-11	-35	-11	9	27	54	-7			-24		178	P>Cu>N>K>Fe>Ca>Mg>Mn
1041	0.21	28		24	-46	-3							90	Ca>Mg>K>N
1042	0.21	-8		6	-1	-1	4	-3					20	N>Fe>Ca>Mg>Mn>K
1043	0.20	-3	35	-29	4	-7							78	K>Mg>N>Ca>P
1044	0.19	-60	37	3		20							120	N>K>Mg>P
1045	0.18	-20		8	18	13	-21	3					83	Mn>N>Fe>K>Mg>Ca
1046	0.18	-8	-26	8	6	-0	11	9					68	P>N>Mg>Ca>K>Fe>Mn
1047	0.18	-13	-28	-11	9	0	57	2			-16		137	P>Cu>N>K>Mg>Fe>Ca>Mn
1048	0.16	-33		34	7	-8							82	N>Mg>Ca>K
1049	0.16	-22	10	21		-9							61	N>Mg>P>K
1050	0.15	-11	-31	11	12	0	49	-13			-17		144	P>Cu>Fe>N>Mg>K>Ca>Mn
1051	0.14	-33	-2	3		32							71	N>P>K>Mg
1052	0.14	3		41	-28	-17							88	Ca>Mg>N>K
1053	0.14	-29	-7	-34		70							140	K>N>P>Mg
1054	0.13	8		12	-17	-18	11	4					71	Mg>Ca>Fe>N>Mn>K
1055	0.13	-66	21	-155		200							441	K>N>P>Mg
1056	0.12	-3	-23	4	2	2	7	11					52	P>N>Mg>Ca>K>Mn>Fe
1057	0.12	-5		16	-7	-7	13	1	-11				60	Zn>Ca>Mg>N>Fe>Mn>K
1058	0.10	-21		4	11	2	-2	7					46	N>Mn>Mg>K>Fe>Ca
1059	0.09	-42		24	22	-4							92	N>Mg>Ca>K
1060	0.08	1		11	-21	-9	10	7					59	Ca>Mg>N>Fe>Mn>K
1061	0.08	-47		20	-8	6	13	16					111	N>Ca>Mg>Mn>Fe>K
1062	0.08	-11		16	-3	-2	1	-2	2				38	N>Ca>Fe>Mg>Mn>Zn>K
1063	0.07	-12		6	15	7	-16	-0					56	Mn>N>Fe>K>Mg>Ca
1064	0.06	-17		65	-92	-92	135	1					401	Ca>Mg>N>Fe>K>Mn
1065	0.06	-3		9	-9	-11	14	-1					47	Mg>Ca>N>Fe>K>Mn
1066	0.06	1		-2	-6	-6	4	-0	10				29	Ca>Mg>K>Fe>N>Mn>Zn
1067	0.05	-23		30	-0	-7							61	N>Mg>Ca>K
1068	0.04	-34		20	11	3							67	N>Mg>Ca>K
1069	0.04	-2		3	-4	6	-5	2					22	Mn>Ca>N>Fe>K>Mg
1070	0.04	-49		37	18	-6							109	N>Mg>Ca>K
1071	0.03	-23		26	-8	4							60	N>Ca>Mg>K
1072	0.03	-12		10	2	-1							25	N>Mg>Ca>K
1073	0.01	-8		5	2	3	-1	-1					20	N>Mn>Fe>Ca>Mg>K
1074	0.01	-11		7	7	-1	12	-14					53	Fe>N>Mg>K>Ca>Mn

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