The Diagnosis and Recommendation Integrated System (DRIS) method of interpreting nutrient content of plant tissue has received considerable attention since being detailed by Beaufils (1973). The DRIS approach stresses nutrient balance and provides a means for comparing the degree to which various nutrients limit yield, either as a result of deficiency or excess (Walworth and Sumner, 1987). Because the DRIS approach uses nutrient ratios, it is sometimes less sensitive than the sufficiency range (SR) approach to differences caused by leaf position, tissue age, climate, soil conditions, and cultivar effects. However, a shortcoming of using nutrient ratios is that DRIS may indicate a nutrient limitation for a nutrient that is low relative to others, even though the nutrient may not be limiting yield (Beverly et al., 1984). The incorporation of nutrient concentrations in the DRIS evaluation has been proposed and used as a means of minimizing these erroneous diagnoses (Hallmark et al., 1987; Parent and Granger, 1989).

The DRIS approach has been found to provide reliable diagnosis for agronomic crops (Elwali and Gascho, 1984; Sumner, 1977; Walworth et al., 1986) and for orchard crops (Beverly et al., 1984; Parent and Granger, 1989). However, the possibility of using the DRIS approach for fast-growing short-season leafy vegetables, such as crisphead lettuce, has not been evaluated. The objectives of this work were to derive DRIS norms for crisphead lettuce and perform a preliminary evaluation of the DRIS approach as a tool for diagnosing nutritional deficiencies in lettuce.

The data used for this investigation consisted of 3316 observations from numerous lettuce field fertility experiments conducted between 1971 and 1989 on both mineral and organic soils in southern Florida. About 20% of the observations came from experiments conducted on mineral soils, and 80% of the observations came from experiments conducted on organic soils (Histosols). Details of experimental procedures are presented elsewhere (Sanchez and Burdine, 1988; Sanchez et al., 1988, 1990).

The outermost sound leaf was collected from several plants in each plot in each experiment during the growing season (generally early to midgrowth). The leaves were dried at 60°C and ground for analysis. From 1972 to 1983, N was determined by steam distillation after micro-Kjeldahl digestion. During this same period, P was determined colorimetrically, K and Na by flame-emission spectroscopy, and Ca, Mg, Fe, Zn, Mn, and Cu by atomic absorption spectroscopy, after digestion with HNO₃/HClO₄ acid. During this period, B was determined using the quininalizarin method (McDougall and Biggs, 1952). In 1984, our laboratory changed to a H₂O₂/H₂SO₄ digestion (Wolf, 1982), after which time N was determined colorimetrically and B by inductively coupled plasma spectroscopy. Comparisons of digestion methods before the change was made indicated that both methods gave similar results. Because quality is often the overriding factor determining the market value of lettuce, we used a combined yield-quality index to separate superior and inferior subpopulations rather than yield alone. Lettuce yields were assigned a rating ranging from 1 through 5 for marketable yield levels of O to 14, 15 to 28, 29 to 42, 43 to 56, and >56 Mg·ha⁻¹, respectively. The quality of lettuce was rated from 1 to 5 as very poor, poor, fair, good, and excellent, respectively. The lettuce was rated based on head firmness, head size, and the presence of marketing defects, such as tipburn, cracked stems, ribs, biness, and rib discoloration (U.S. Dept. Agr., 1973). A yield-quality index was calculated as the multiple of the yield and quality ratings. Marketable yields >50 Mg·ha⁻¹ are generally only obtainable in the winter–spring (January to March) growing period when the weather is cool and irradiance is relatively high. Limiting yields in the range of 40 to 56 Mg·ha⁻¹ are more frequent; hence, a yield-quality index of 16 was used to separate the subpopulations.
The nutritional data were expressed in all possible ratios and reciprocal ratios. Additionally, actual concentrations of nutrients (i.e., N/dry matter) were included on the basis of recent evidence indicating that their inclusion may reduce the number of erroneous diagnoses of deficiencies. The mean, standard deviation, and variance were calculated for each nutrient concentration and all ratios between nutrient concentrations for both populations. The form of expression (N : P vs. P : N) with the greater variance ratio (s\textsuperscript{superior}/s\textsuperscript{inferior}) was selected (Table 1). Equations used in the calculation of DRIS indices are described in detail elsewhere (Sumner, 1977; Walworth and Sumner, 1987). SRS currently used in southern Florida to diagnose nutrient deficiencies of lettuce (Table 2) were used to compare DRIS to the SR approach. These SRS closely agree with the common ranges found in lettuce leaves, as reported by Geraldsen et al. (1973).

The diagnostic accuracy of DRIS and the SR approach was evaluated using two separate factorial experiments conducted in southern Florida. A nutrient was considered deficient by DRIS when its index was more negative than the DM index (Hallmark et al., 1987; Walworth et al., 1986). For brevity, only the progressive diagnosis (treatment 1 and other treatments indicated by SR or DRLS diagnosis) are shown. The first evaluation compared the response of lettuce to P and K fertilization (Table 3). Both the DRIS and SR approach correctly diagnosed the significant (P < 0.01) linear response to P and K fertilizer. The second evaluation compared the response of lettuce to N, P, K, and S (Table 4). In southern Florida, S is often applied as an acidifying amendment primarily to increase the availability of Mn (Sanchez, 1990). Both the SR and DRLS evaluation of the N-P-K-S treatment diagnosed a P and Mn deficiency, indicating the need for the N-P-K-S treatment. After this addition, both SR and DRIS indicated a need for additional P (N-P-K-S treatment), although no response was obtained. This observation suggests that SR and DRIS diagnostic norms for P may be too high. However, after addition of the second P treatment, DRIS correctly diagnosed a K deficiency; whereas the SR approach did not. It is possible that current SR values used for K are too low. Although many investigators have reported K sufficiency ranges from 3% to 5%, recent studies have indicated that lettuce produced in Florida may require a K leaf concentration >5% (Beverly, 1984; Sanchez et al., 1988). However, even setting the lower end of the SR at 6% would not have identified the K limitation in this study. Nutrient balance may be a major factor influencing the K nutritional status of lettuce. Furthermore, the K requirements of lettuce may be confounded by the level of Na (Costigan and Mead, 1987). While we had the data base to integrate Na into the DRIS norms, we, unfortunately, did not have the data base to integrate Na into the DRIS norms, we, unfortunately, did not have the data base to integrate Na into the DRIS norms.
not have data to evaluate the relationship between K and Na in the nutrition of lettuce. Overall, these evaluations indicate that DRIS is a useful tool in diagnosing the nutritional status of lettuce. Additional testing of these norms across various plant growth stages, in lettuce-producing areas outside Florida, and for other nutrient responses in Florida is needed.

**Literature Cited**


