Completed

TITLE: **Diagnostic tools for efficient N management of vegetables produced in the low desert (1997-1998).**

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B. STATEMENT OF OBJECTIVES

Our objectives were to evaluate diagnostic tissue test for lettuce, broccoli, and cauliflower, evaluate quick tests for monitoring N status, and evaluate reflectance technologies as potential tools for monitoring N status. Our specific objectives during 1997-1998 were to continue to evaluate tissue diagnostic standards developed during the1995-1997 period, work toward the development of soil test diagnostic standards, and provide in-field demonstrations of these technologies and resulting N management strategies to growers.

C. EXECUTIVE SUMMARY

In 1995, we initiated a project aimed at evaluating several diagnostic tools for efficient N management of desert vegetables. We focused our effort on broccoli (Brassica oleracea L Italica Group), cauliflower (Brassica oleracea L. Botrytis Group), and lettuce (Lactuca sativa L.) because these crops occupy the largest acreage of all cool season crops produced in the desert. During 1995-1996, we conducted N rate studies to correlate several diagnostic technologies to the N nutritional status of these commodities. Diagnostic tools evaluated included the traditional dry midrib (or petiole) nitrate-N test, the sap nitrate-N test using the Cardy meter, absorbance using the chlorophyll meter, and various reflectance technologies, including digital analysis of aerial photographs. Generally, we observed a curvilinear response to N which allowed us to correlate several diagnostic tools to growth and yield. Overall, the dry midrib or petiole tests and

the sap nitrate-N test appeared to be correlated to plant growth and yield during later growth stages. The chlorophyll meter was not a sensitive indicator of the N nutritional status and further evaluation of this technology was discontinued. Preliminary evaluation showed that canopy reflectance, including digital analysis of aerial photographs, was correlated to N nutritional status of cool season vegetables in controlled N rate experiments. Nevertheless, because these technologies respond to differences in plant color and plant biomass, they are affected by other stresses that impact these responses including insect and disease pressure. At present, aerial photographs (or digital images) are at best a qualitative tool which can be used to trouble shoot fields. However, the nature of the stress must be verified or determined by data collection on the ground. We discontinued our effort with reflectance technologies to focus our effort on more user friendly quantitative tools.

Studies conducted during 1996-1997 were designed to evaluate the response of broccoli, cauliflower, and lettuce to sidedress N fertilizer application and test the effectiveness of various diagnostic plant tests as predictive tools. During this season we also began preliminary evaluation of a pre-sidedress soil nitrate N test. There were both N responsive sites and non-responsive sites, thereby allowing some testing of the predictive potential of the diagnostic tools evaluated. The variability associated with the quick sap tests seemed to limit their application as a predictive diagnostic tool for the desert and we do not recommend these tests as a substitute for the dry midrib or petiole tests. Although less variable than the quick sap test, the high frequency with which the dry midrib or petiole tests resulted in incorrect diagnosis suggested that either this test needed revision or that it is an unreliable N management tool. Results from evaluations of a pre-sidedress soil nitrate-N test were inconclusive during the 1996-1997 growing season where we suspected variation in soil salinity interfered with nitrate-N readings using this potentiometric method utilized this season.

Results collected during 1997-1998 corroborated our concerns about using midrib or petiole nitrate-N testing as a basis for making fertilizer recommendations. Statistical analysis showed marketable yields were significantly reduced and economic evaluations show reduced net returns when making sidedress N fertilizer decisions exclusively on the basis of midrib or petiole nitrate-N analysis. While midrib or petiole tests give an indication of the crops N status, they are not sufficiently sensitive or reliable to serve as the sole basis of making sidedress N fertilizer decisions. During the 1997-1998 season we also evaluated a pre-sidedress soil test using conventional laboratory analysis and a colorimetric paper quick test approach. Overall, results show soil testing was superior to midrib testings in that it resulted in a higher frequency of correct diagnosis. Nevertheless, there is some economic risk of basing fertilizer applications exclusively on a pre-sidedress soil testing program, although the risk is considerably smaller than that associated with a midrib test based program. We speculate that genetic variation, inefficient irrigation, and perhaps other unknown factors interact to limit the precision and reliability of midrib or petiole nitrate-N tests. We expect inefficient irrigation practices or perhaps inappropriate critical levels are the factors reducing the predictability of the pre-sidedress soil test. It is our opinion that the pre-sidedress soil test will work reasonably well with some modification and under conditions of efficient irrigation.

D. WORK DESCRIPTION (Tasks 1.1 through 3.1, 1.2 through 3.2, 1.3 through 3.3, 1.4 through 3.4, 1.6 through 3.6, and 1.7 through 3.7)

Brief Summary of 1995-1996 Studies

Details of experiment-demonstrations conducted during 1995-1996 have been provided in a previous report. Nevertheless, for continuity these studies will be briefly summarized in this report. Six field experiment-demonstrations were conducted in 1995-1996 to evaluate, and demonstrate to growers, several diagnostic tools to aid in the efficient N management of vegetables produced in the low desert. Two experiments with cauliflower (experiments 29C and 29D were designated as experiments 2 and 6 in 1995-1996 report) and two experiments with lettuce (experiments 15J and 15K were designated as experiments 1 and 5 in 1995-1996 report) were conducted in the Lower Colorado River Valley. One experiment with lettuce (experiment 32 but designated as experiment 1 in 1995-1996 report) and one experiment with broccoli (experiment 32A but designated as experiment 4 in 1995-1996 report) were conducted in the Imperial Valley and the Coachella Valley, respectively. This data was presented in the 1995-1996 report. Additionally, data from other sites not funded by FREP were included in the analysis to enhance the rigor of these evaluations. These experiments were N rate and N management studies primarily designed to generate N response curves from which we could correlate several diagnostic technologies to crop responses. Diagnostic tools evaluated included the traditional dry midrib (or petiole) nitrate-N test, the sap nitrate-N test using the Cardy meter, absorbance using the chlorophyll meter, and various reflectance technologies, including digital analysis of aerial photographs.

Brief Summary of 1996-1997 Studies

During this season, twelve field experiment-demonstrations were conducted to test and improve tissue diagnostic standards developed during 1995-1996, work toward the development of soil test diagnostic standards, and provide in-field demonstrations of these technologies and resulting N management strategies to growers. Eight experiment-demonstrations were with iceberg lettuce (experiments 32D, 32E, 32F, 32G, 32J, 32K, 32L, and 32N) three were with broccoli (32B, 32C, and 32H), and one was with cauliflower (32I). We selected sites in the Coachella Valley (CV), the Imperial Valley (IV), and the Lower Colorado River Valley (LCRV). During 1996-1997, we also completed correlation analysis for broccoli and cauliflower using a previous data base combined with data collected during the 1995-1997 period.

1997-1998 Studies

Twenty-one field experiment-demonstrations were conducted during the 1997-1998 growing season. As in 1996-1997, these experiment-demonstrations were conducted to test and improve tissue diagnostic standards developed during the1995-1997 period, work toward the development of soil test diagnostic standards, and provide in-field demonstrations of these technologies and resulting N management strategies to growers. Thirteen experiment-demonstrations were with iceberg lettuce, five were with broccoli, and three were with cauliflower. We selected sites in the Coachella Valley (CV), the Imperial Valley (IV), and the Lower Colorado River Valley (LCRV). All these experiments were conducted in grower fields. Harvest data on two experiment-demonstrations with lettuce were lost because the grower cooperator harvested before contacting us. The crop, planting date, final harvest date, and location of each experiment-demonstration are shown below.

Experiment	Crop	Planting date	Harvest date	Location
32O	Lettuce	9/19/97	12/19/97	LCRV
32P	Broccoli	9/19/97	12/10/97	LCRV
32Q	Cauliflower	9/19/97	12/29/97	LCRV
32R	Lettuce	9/3/97	11/26/97	LCRV
32S	Lettuce	9/25/97	12/11/97	LCRV
32U	Lettuce	10/8/97	1/20/98	LCRV
32V	Lettuce	10/14/97	1/21/98	LCRV
32W	Lettuce	10/21/97	1/30/98	LCRV
32X	Lettuce	11/22/97	3/16/98	LCRV
32Y	Lettuce	11/20/97	3/17/98	LCRV
32Z	Broccoli	10/21/97	2/5/98	CV
32AA	Cauliflower	10/22/97	1/26/98	CV
32AB	Broccoli	10/13/97	1/28/98	LCRV
32AC	Broccoli	10/9/97	1/29/98	LCRV
32AD	Lettuce	11/5/97	LOST	LCRV
32AE	Cauliflower	11/15/97	2/19/98	CV
32AF	Lettuce	11/13/97	3/2/98	LCRV
32AG	Broccoli	11/5/97	2/4/98	IV
32AH	Lettuce	11/3/97	2/25/98	LCRV
32AI	Lettuce	11/17/97	LOST	LCRV
32AJ	Lettuce	12/1/97	3/25/98	LCRV
32AK	Lettuce	12/1/97	3/25/98	LCRV

The cooperator in the Coachella Valley (CV) was Ocean Mist Farms (Experiments 32Z, 32AA, and 32AE). The growers were Jeff Percy and Todd Brendlin. Jose Aguiar, Farm Advisor from Riverside County was actively involved with all aspects of these experiments. Only one experiment (32AG) was conducted in the Imperial Valley during the 1997-1998 season. The agronomist with Western Farm Services assisted us with this site.

Because of the large number of sites we implemented this season, we selected eighteen locations in the Lower Colorado River Valley (LCRV). Grower cooperators included Barkely Farms (32R, 32S, 32V, 32X, 32Y, 32AC), Troy Edwards (32AB), Mellon Farms (32AF) and Hernandez (32O, 32P, 32Q, 32U, 32W, 32AH, 32AJ, and 32AK).

In experiments 320, 32R, 32S, 32U, 32V, 32W, 32X, 32Y, 32AD, 32AF, 32AH, 32AJ and 32AK, lettuce was seeded in elevated-double row beds on 1.07 m centers and thinned at the four-leaf-stage to approximately 60,000 plants/ha. In experiments 32Z and 32AB, broccoli was seeded to stand (70,000 plants/ha) in elevated double row beds. In experiments 32P, 32AC, and 32AG, broccoli was seeded in double row beds and thinned to stand. In experiment 32Q, cauliflower was seeded in elevated-single-row beds and thinned at the four leaf stage to approximately 27,000 plants/ha. In experiments 32AA and 32AE, cauliflower was transplanted to stand. Individual plots in all sites were approximately $65m^2$ (15.24 by 4.26 m) in size. All pest control and cultural operations were performed using standard practices. All stands were established using sprinkler irrigation. After stand establishment, water was applied to all experiments by furrow irrigation.

Because lettuce typically receives two N fertilizer applications after planting (not including preplant application), the experiment-demonstrations with lettuce consisted of the following four treatments in a 2^2 factorial design.

1. No sidedress N fertilization
2. First sidedress N only
3. Second sidedress only
4. First and second sidedress

Because broccoli and cauliflower often receive three N fertilizer applications after planting, the experiment-demonstrations with these crops often consisted of the following eight treatments in a 2^3 factorial design.

1. No sidedress N
2. First sidedress N only
3. Second sidedress N only
4. Third sidedress N only
5. First and second sidedress
6. First and third sidedress
7. Second and third sidedress
8. First, second, and third sidedress

In some instances, only two sidedress N applications were applied to the broccoli (32AB, 32AC, and 32AG) in a 2^2 factorial design. Rates of N used in each sidedress application were those actually used by cooperating growers and ranged from 50 to 160 kg N ha^{-1} (Appendix Tables 1A though 20A).

Midrib and soil samples were collected immediately prior to each sidedress fertilizer N application to test diagnostic accuracy. The sample dates for each experiment are summarized in Appendix Tables 1A through 20A. Individual midribs or petioles in each sample were split in half to yield two subsets of samples (subset A and B). One subset (subset A) was expressed fresh and nitrate-N was determined using the Cardy meter. The other subset (subset B) was weighed, dried, re-weighed, ground, and nitrate-N was determined using the method of Baker and Smith (1969).

Soil samples were also split into two subsets (A and B) of samples. For subset A, nitrate-N in field moist soil samples were determined using the quick test procedure developed by Hartz (1998). Briefly, 30 ml of 0.01 $CaCl_2$ solution was measured into volumetrically marked tubes. Soil was then added until the level of extracting solution in the tubes had risen to 40 ml. The tubes were capped, shaken, and allowed to settle. Nitrate-N was then determined on an aliquot of the clear supernatant solution collected from the top of the tubes using colorimetric test strips. The other soil subset (B) was air dried, extracted with KCl, and ammonium-N and nitrate-N was determined using steam distillation (Keeney and Nelson, 1982).

Diagnostic accuracy was initially evaluated by comparing predicted and observed response to N fertilizer. For the first sidedress of lettuce or broccoli in the 2^2 experiments , we determined the response by comparing growth and/or yield of treatments 1 and 3 to that of treatments 2 and 4. For the second sidedress of lettuce, we compared treatment 1 to 3 and treatment 2 to 4. For the first sidedress of the 2^3 broccoli and cauliflower experiments, we determined the response by comparing treatments 1, 3, 4, and 7 to treatments 2, 5, 6, and 8. For the second sidedress we compared treatments 1 and 4 to 3 and 7 and 2 and 6 to 5 and 8. For the third sidedress we compared treatments 1 to 4, 3 to 7, 2 to 6, and 5 to 8. We initially included growth in these evaluations for all experiments because of a previous study (Scaife, 1988) which concluded that growth was a more valid indicator of early response to fertilizer than final yield. However, because growth response of lettuce were not statistically significant (data not shown) we based these evaluations on yield data only. Growth responses were frequently statistically significant for broccoli and cauliflower and growth rate assessments were included in these evaluations. For testing a given sidedress N application, we used the growth rate during the period after that sidedress but before the next. We used final yields in all testing. A response was designated positive if growth was increased by 15% or yields were increased by 10%.

While this approach provided for a preliminary evaluation of diagnostic accuracy, final conclusions had to be based on a more rigorous statistical and economic analyses. For the lettuce experiments-demonstrations we had only four treatments, and even where we had four replications we lacked sufficient degrees of freedom for a sensitive statistical evaluation on individual sites. Therefore, for lettuce we had to rely exclusively on a combined analysis across all sites. However, because site by treatment interactions were sometimes statistically significant, we also calculated economic returns on individual sites. For broccoli and cauliflower, there were several significant site by treatment interactions and we chose to make our economic evaluations from data on selected individual sites.

Economic returns were calculated using the following equation: $NR=(P_y*Y)-(C_n*N)-(SDC)-(HC*Y)-(GC)-(MRC)$; where NR=net returns ($), P_y=Crop value ($/Mg), Y is crop yield, N=N rate (kg ha^{-1}), C_n is N cost ($/kg), SDC is sidedress cost ($/ha), HC=harvest costs ($/Mg), and GC=growing costs ($/ha), and MRC is cost of midrib or soil analysis ($/ha). We assumed costs were N at $0.72/kg, sidedress applications at $20.0/ha, growing costs at $2,965.0/ha, harvest costs at $144.5/Mg, and midrib or soil testing at $5.0/ha. For lettuce we calculated economic returns at crop values of $219/Mg, $438/Mg, and $876/Mg. For broccoli and cauliflower we calculated returns at $600/Mg and $1200/Mg.

E. RESULTS AND DISCUSSION

Brief Summary of 1995-1996 studies

Lettuce yields showed a curvilineal response to N in most experiments which allowed for correlation of several diagnostic technologies. Generally, the dry midrib nitrate-N test and the sap nitrate-N test correlated to growth and yield of lettuce after the folding stage of growth. The dry midrib nitrate-N test and the sap test were also significantly correlated to each other although there was variability. From this correlation analysis, a preliminary critical sap level for lettuce was proposed. The chlorophyll meter was not a sensitive indicator of the N nutritional status of lettuce and further evaluation of this technology was discontinued. Preliminary evaluation showed that canopy reflectance, including digital analysis of aerial photographs, was correlated to N nutritional status of lettuce in controlled N rate experiments. Nevertheless, because these technologies respond to differences in plant color and plant biomass, they are affected by other stresses that impact these responses including insect and disease pressure. Hence, at present, aerial photographs (or digital images) are at best a qualitative tool which can be used to trouble shoot fields. However, the nature of the stress must be verified or determined by data collection on the ground. We made the decision to discontinue our effort with reflectance technologies to focus our effort on more quantitative tools.

Brief Summary of 1996-1997 studies

After the completion of the 1996-1997 season we had a data base sufficiently large to complete correlations for broccoli and cauliflower sap tests. Interestingly, the equations generated with our data base are very similar to those generated by others (Kubota et al., 1996; 1997). However, our data showed appreciably greater variability. In the correlation reported by Kubota et al., (1996;1997) data were all collected on one experimental site, whereas the data used in the correlations we report were collected from sites across the entire low desert region. The variability we observed for broccoli and cauliflower was similar to that which we reported in our 1995-1996 report for lettuce. During this season we also began preliminary evaluation of a pre-sidedress soil nitrate N test.

Studies conducted during 1996-1997 were designed to evaluate the response of broccoli, cauliflower, and lettuce to sidedress N fertilizer applications and test the effectiveness of various diagnostic plant tests as predictive tools. There were both N responsive sites and non-responsive sites, thereby allowing some testing of the predictive potential of the diagnostic tools evaluated. The variability associated with the quick sap tests seemed to limit their application as a predictive diagnostic tool for the desert and at present we concluded that these tests were not reliable substitutes for the dry midrib or petiole nitrate-N tests. Although less variable than the quick sap test, the high frequency with which the dry midrib test resulted in incorrect diagnosis suggested that either this test needed revision, or that it is an unreliable N management tool. Results from evaluations of a post-thinning (and pre-sidedress) soil nitrate-N tests were inconclusive during the 1996-1997 growing season. Results were confounded and we suspect variation in soil salinity interfered with nitrate-N readings using this potentiometric method.

1997-1998 Studies

As in the previous season, experiment-demonstrations conducted during 1997-1998 were designed to test the diagnostic accuracy of both dry midrib or petiole tests and sap midrib or petiole tests. Again, there were both N responsive sites and non-responsive sites, thereby allowing some testing of the predictive potential of the diagnostic tools evaluated. Based on previous data collected for lettuce we used a critical level of 8000 mg/kg nitrate-N and 480 mg/L nitrate-N for the dry midrib test and quick sap tests, respectively. As noted in 1996-1997, because the regression equations comparing the dry petiole test to the quick sap test for broccoli and cauliflower that we generated were almost identical to those reported by Kubtoa et al. (1996; 1997), we used critical concentrations they proposed. These critical concentrations for broccoli were 10,000 mg/kg at the 4 to 6 leaf stage, 9000 mg/kg at the 10 to 12 leaf stage, 6000 mg/kg at first buds, 3500 at head development, and 2000 mg/kg at harvest. Corresponding values for the sap test would be 810 mg/L, 770 mg/L, 630 mg/L, 510 mg/L, and 440 mg/L. Critical concentrations for cauliflower were 11,000 mg/kg at the 4- to 6-leaf stage, 9000 mg/kg at the 10- to 12-leaf stage, 7000 mg/kg at the folding stage, 6000 mg/kg at buttoning, 2500 mg/kg at curd development, and 1500 mg/kg at harvest. Corresponding values for the sap test would be 740 mg/L, 640 mg/L, 550 mg/L, 500 mg/L, 340 mg/L, and 290 mg/L.

In these studies, tissue tests were collected before the N sidedress was to be applied, the diagnosis and predicted response was determined, and based on the resulting positive or negative response the diagnostic accuracy was determined. Diagnostic accuracy was designated as being either correct or in error. However, there were two types of error. We designated as Type 1 error (E_1), the situation where we predict a positive response to sidedress N based on our diagnosis but no response (negative) occurred. In fact, this situation may not be a real error since a number of factors interact to affect final yields. The failure to obtain a yield response may result from a situation where some factor other than N was limiting yields. We designated as Type 2 error (E_2), the situation where we predict no response to sidedress N based on the diagnosis but a positive response occurred. This latter error is generally considered more critical because it has the potential to negatively impact the grower economically. Therefore, the inclination would be to try and minimize the frequency of E_2 at the risk of increasing the occurrence of E_1.

A comparison of diagnostic accuracy of the dry midrib test for lettuce is shown in Table 1 for all data collected during 1996-1997 and 1997-1998. Only 50% of the diagnosis were correct using current critical values. Approximately 18% of the time we predicted no response to sidedress N and one occurred (E_2). In a previous report (1995-1996), we noted that tissue samples collected at the earliest growth stages are not consistently reliable. Although we anticipated frequent errors at our first sampling date, we did not expect the frequency with which they occurred at the second sample date. The results for the sap test are even more disappointing where we observed an E_2 frequency of 29% (Table 2).

In the 1996-1997 report, we stated that results were more encouraging for broccoli and cauliflower. However, as we expanded our data base during 1997-1998 we found the frequency of inaccurate diagnosis increased. For the broccoli sites, we encountered E_2 with a frequency of 39% and 47% for dry petioles and sap, respectively (Tables 3 and 4). For cauliflower, the frequencies of E_2 were 25% and 32% for dry petioles and sap, respectively (Tables 5 and 6).

While the aforementioned approach provided for a preliminary evaluation of diagnostic accuracy, final conclusions had to be based on a more rigorous statistical and economic analysis. We limited our statistical and economic analysis to the dry midrib or petiole data because they appeared more reliable than the sap tests. As noted in the methods section, for lettuce we had to rely on a combined statistical analysis across all sites because we had insufficient degrees of freedom for a sensitive statistical evaluation on individual sites. For the 2^2 lettuce experiments, we performed three separate statistical analysis. The first method was simply a combined factorial analysis of all site seasons (Table 7). The second was an analysis of variance and mean separation of the four treatment means (Figure 1). The third approach was done as the basis of our economic evaluation. For this approach we modified the data set for a comparison of three treatments (management programs) of economic interest. The treatments were a program where we would never apply the first sidedress N fertilization, a program where we would always apply the first sidesdress N fertilization, and a program where we would make all sidedress N fertilization decisions based on midrib nitrate-N analysis (Tables 8 and 9 and Figures 2 and 3). For this analysis, subsequent or previous sidedress N applications were treated as sub-site effects. For example, when comparing plots that received and did not receive the first sidedress we treated the plots that did not receive the second sidedress as one sub-site and those that did receive it as another sub-site. We did the opposite when evaluating the second sidedress application.

The combined statistical analysis indicates that lettuce generally showed significant yield responses to the first sidedress. Yields obtained by always applying the first sidedress were significantly greater than those obtained when never applying the first sidedress and when applying the first sidedress based on a midrib testing program. There were small differences in yield in some experiments to the second sidedress but the combined analysis indicated they were not statistically significant (Table 7). The site*sub-site*treatment interaction was significant in the modified analysis (Table 9), but we had insufficient sensitivity for meaningful statistical evaluation of individual sites. Therefore, we restricted our economic evaluation to the first sidedress. Overall, the highest net returns would be realized if we always applied the second sidedress fertilization (Table 10). The reduced economic returns associated with the midrib-N based sidedress program was the result of frequently predicting no response although a positive yield occurred (E_2) (Figures 4, 5, and 6). Note that at the lowest lettuce price net returns were generally negative. However, they were usually less negative when the first sidedress N fertilization was always made.

For broccoli and cauliflower we have a smaller data base and there were sometimes significant interactions with site on the combined analysis (Tables 11, 12, and 13 and Appendix Tables 21A through 29A). Therefore, we assessed potential economic returns using selected data on individual sites. This was possible for these evaluations because we had more degrees of freedom on the 2^3 factorial experiments. We selected experiments 32B for broccoli and 32Q for cauliflower, respectively (Tables 14 and 15). Both these experiments show statistically significant yield responses to the first and second sidedress N applications. As noted previously, responses to individual sidedress application were evaluated at each sub-site (previous or subsequent sidedress combination).

In experiment 32B, we predicted that broccoli did not need the first sidedress N application based on a midrib nitrate-N analysis. However, the yield response was highly significant. We would have predicted the need for the second sidedress only on plots that did not receive the first sidedress. However, the yield response was significant on both plots that did and did not receive the first sidedress fertilization. The data in Tables 16 and 17 show the potential economic losses associated with midrib based sidedress decisions. For cauliflower, we failed to diagnose the need for the first sidedress but incorrectly diagnosed the need for the second sidedress, again potentially resulting in economic losses (Table 18 and 19).

In the 1996-1997 report, we stressed that the variability associated with the sap test limited its utility. We attributed our erratic observations to variation in salinity and moisture conditions for vegetables produced in the desert, We further noted that we collected this data under the very best of conditions. We always made these determinations in the laboratory under reasonably constant temperatures, were-calibrated with standards frequently, and we almost always took readings in duplicate or triplicate (simultaneously on two or three Cardy meters to monitor instrument stability and reliability). Growers using this technology would typically make these determinations in the field, re-calibrate infrequently, and only use one Cardy meter. Our recommendation was that the sap tests be used only as an adjunct but not as a substitute to the traditional dry midrib or petiole testing program.

Based on the results of the data collected past two years, I now believe midrib testing in general is not sufficiently sensitive or reliable to be used as a stand alone tool for making sidedress N fertilization decisions for furrow irrigated vegetables. The midrib nitrate-N test was first developed 20 years ago on a cultivar of lettuce no longer used.. At present, over 80 cultivars of lettuce are currently produced in the desert and we have to consider the possibility that genetic variation may have reduced the sensitivity of this test.

Although we began evaluation of a post-thinning (and pre-sidedress) soil nitrate-N test in 1996-1997, results were inconclusive. During 1996-1997 we used the Cardy meter which is a potentiometric determination and there is a potential for interference from salinity (chloride). We speculated that variation in salinity across desert soils was a contributing factor to our inexplicable results. During 1997-1998 we used nitrate sensitive colorimetric test papers which are less sensitive to salinity than the Cardy meter.

Overall, we found the conventional and the quick test using colorimetric test papers to be highly correlated to each other if we separated the soils by texture. For coarse textured soils with moisture contents ranging from 8 to 12%, the relationship between quick and conventional was almost 1:1. However, for fine textured soils with field soil moisture contents from 15 to 30%, the relationship was almost 1.6:1. We corrected the quick tests using these empirical corrections. Additional work is needed to develop a means of accurately estimating soil moisture under field conditions.

The diagnostic accuracy associated with conventional and quick pre-sidedress soil testings are shown in Tables 20 through 25. Overall, soil testing was superior to midrib testings. The percentage of E_2 for lettuce were 10% and 7% for the conventional and quick test, respectively (Tables 20 and 21). For broccoli, the frequency of E_2 was 7% for the conventional soil test and 0% for the sap test (Table 22 and 23). It should be noted that we had data for the conventional test in experiment 32B but we had no data for the quick colorimetric paper test. The inclusion of this experiment in the conventional analysis accounts for the differences in E_2 percentages between the conventional and quick soil tests for broccoli. For cauliflower, we did not do as well where the percentages of E_2 were 24% and 33% for the conventional and sap tests respectively (Tables 24 and 25).

The statistical analysis shows that although lettuce yields were slightly lower when using a soil test based program, they were not significantly different from the always sidedress program (Table 26). Therefore, we cannot conclude the differences in economic returns between these two programs were real overall sites (Table 27). Economic evaluation of individual sites shows the potential for occasional losses from soil tests indicating fertilizer was not needed when it was (Figure 7). However, these situations were infrequent and generally balanced against situations where we appropriately delayed fertilizer application based on soil tests. Yields, with the always sidedress program, were significantly greater than those produced on a no sidedress program and we can conclude this economic difference was real.

The results for the first sidedress for broccoli and cauliflower in experiments 32B and 32H show favorable economic returns (Tables 28 and 30). Overall, soil tests correctly predicted the need for this first sidedress N application whereas the midrib test did not. Nevertheless, soil tests failed to predict the need for a second sidedress on two occasions for broccoli in experiment 32B thereby causing economic losses (Table 29). Hence, although smaller than the risk associated with using a midrib based program, there is some economic risk of basing fertilizer applications exclusively on a pre-sidedress soil testing program.

We looked closely at the situations where the soil test failed and have concluded that inefficient irrigation practices were a contributing factor. For example, in experiment 32Y for lettuce where the soil tested 23.9 ppm, it contained approximately 100 kg N/ha in top 30 cm. By the second sampling date, the soil nitrate level where fertilizer was not applied, had decreased to 2.8 ppm or approximately 12 kg N/ha in the surface 30 cm of soil. However, based on dry matter accumulation, crop uptake over this period could not have exceeded 50 kg N/ha. The difference must of leached out in the irrigations that occurred between the first and second sample dates.

We used 20 ppm as the critical level based on work by Hartz (1998) in the coastal regions of California. It is possible that desert soils might require a slightly higher critical level because of lower N mineralization rates and lower N concentrations of irrigation water. Interestingly, if we would have used a critical soil test level of 25 ppm for the conventional soil test there would have been no E_2. As we expand our data base for soils, we might consider adjustment of this value.

Interestingly, the cauliflower experiments where we had the frequent errors in diagnosis were transplanted rather than direct seeded. It may be that for the first sidedress, the cauliflower root system was not sufficiently developed to recover soil nitrogen.

Although the FREP project ended in 1997-1998, we obtained funds from another source to continue these studies during 1998-1999. The major objectives of studies conducted during 1998-1999 are to expand our data base for the evaluation and improvement of the pre-sidedress soil test. I am optimistic that the pre-sidedress soil test can be a useful tool under conditions of efficient irrigation.

Subtask 3.5 Field Days. The following presentation were made during 1997-1998 in an attempt to comply with the outreach component of this project:

January 22, 1998	Gave presentation at Sacramento during California-ASA meetings.
April 8, 1998	Workshop in Coachella Valley.
June 18, 1998	Gave presentation at training session in Holtville (Imperial Valley), California.

The most meaningful outreach achieved during the 1997-1998 season was the large number of demonstrations conducted in grower fields. We received a lot of feedback from participating growers regarding their observations and the results of these demonstrations.

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Table 1. A comparison of predicted and actual response of lettuce to sidedress N based on dry midrib nitrate-N values.

Experiment	Sidedress	Midrib nitrate-N	Diagnosis	Predicted Response	Actual Response	Diagnostic Accuracy
					Yield	
32D	1	17666	S	-	+	E_2
32E	1	6701	D	+	-	E_1
32F	1	11389	S	-	-	C
32G	1	3312	D	+	+	C
32J	1	14445	S	-	-	C
32K	1	10287	S	-	-	C
32L	1	10004	S	-	+	E_2
32N	1	6032	D	+	-	E_1
32O	1	11350	S	-	+	E_2
32R	1	13325	S	-	-	C
32S	1	12736	S	-	+	E_2
32U	1	25348	S	-	-	C
32W	1	14790	S	-	-	C
32X	1	11386	S	-	-	C
32Y	1	6605	D	+	+	C
32AF	1	7883	D	+	+	C
32AH	1	6520	D	+	-	E_1
32AJ	1	8493	S	-	-	C
32AK	1	4078	D	+	-	E_1
32D	2	5287	D	+	-	E_1
	2	11389	S	-	+	E_2
32E	2	5000	D	+	+	C
	2	6250	D	+	+	C
32F	2	9000	S	-	-	C
	2	12019	S	-	-	C
32G	2	2707	D	+	-	E_1
	2	5352	D	+	-	E_1
32J	2	2000	D	+	+	C
	2	2000	D	+	+	C
32K	2	5500	D	+	-	E_1
	2	6000	D	+	-	E_1
32N	2	5000	D	+	-	E_1
	2	4500	D	+	-	E_1
32O	2	2426	D	+	+	C
	2	2935	D	+	-	E_1
32S	2	4517	D	+	-	E_1
	2	9302	S	-	-	C
32U	2	11284	S	-	+	E_2
	2	16745	S	-	-	C
32W	2	9218	S	-	-	C
	2	9919	S	-	+	E_2

Table 1 continued.

32Y	2	5000	D	+	-	E_1
	2	6834	D	+	-	E_1
32AF	2	11152	S	-	+	E_2
	2	12243	S	-	-	C
32AH	2	6750	D	+	+	C
	2	7750	D	+	-	E_1
32AJ	2	9364	S	-	-	C
	2	10058	S	-	+	E_2
32AK	2	6017	D	+	-	E_1
	2	9990	S	-	-	C

S=Sufficient; D=Deficient; (+)= positive response; (-)= negative response; E_1= Error in diagnosis by predicting positive response that did not occur; E_2= Error in diagnosis by predicting no response to N but a positive response occurred; C= correct response.

Table 2. A comparison of predicted and actual response of lettuce to sidedress N based on sap nitrate-N values.

Experiment	Sidedress	SAP nitrate-N	Diagnosis	Predicted Response	Actual Response Yield	Diagnostic Accuracy
32D	1	644	S	-	+	E_2
32E	1	273	D	+	-	E_1
32F	1	759	S	-	-	C
32G	1	127	D	+	+	C
32J	1	1132	S	-	-	C
32K	1	277	D	+	-	E_1
32L	1	694	S	-	+	E_2
32N	1	949	S	-	-	C
32O	1	811	S	-	+	E_2
32R	1	758	S	-	-	C
32S	1	610	S	-	+	E_2
32U	1	1118	S	-	-	C
32V	1	293	D	+	+	C
32W	1	1078	S	-	-	C
32X	1	1274	S	-	-	C
32Y	1	1046	S	-	+	E_2
32AF	1	1035	S	-	+	E_2
32AH	1	971	S	-	-	C
32AJ	1	1256	S	-	-	C
32AK	1	591	S	-	-	C
32D	2	553	S	-	-	C
	2	429	D	+	+	C
32E	2	1121	S	-	+	E_2
	2	1302	S	-	+	E_2
32F	2	328	D	+	-	E_1
	2	497	S	-	-	C
32G	2	160	D	+	-	E_1
	2	177	D	+	-	E_1
32J	2	621	S	-	+	E_2
	2	644	S	-	+	E_2
32K	2	305	D	+	-	E_1
	2	339	D	+	-	E_1
32N	2	559	S	-	-	C
	2	463	D	+	-	E_1
32O	2	416	D	+	+	C
	2	272	D	+	-	E_1
32S	2	311	D	+	-	E_1
	2	483	S	-	-	C
32U	2	817	S	-	+	E_2
	2	1027	S	-	-	C
32W	2	755	S	-	-	C

Table 2 continued.

	2	817	S	-	+	E_2
32Y	2	397	D	+	-	E_1
	2	608	S	-	-	C
32AF	2	935	S	-	+	E_2
	2	1107	S	-	-	C
32AH	2	666	S	-	+	E_2
	2	689	S	-	-	C
32AJ	2	534	S	-	-	C
	2	602	S	-	+	E_2
32AK	2	427	D	+	-	E_1
	2	649	S	-	-	C

S=Sufficient; D=Deficient; (+)= positive response; (-)= negative response; E_1= Error in diagnosis by predicting positive response that did not occur; E_2= Error in diagnosis by predicting no response to N but a positive response occurred; C= correct response.

Table 3. A comparison of predicted and actual response of broccoli to sidedress N based on dry midrib nitrate-N values.

Experiment	Sidedress	Midrib nitrate-N	Diagnosis	Predicted Response	Actual Response		Diagnostic Accuracy
					Growth	Yield	
32B	1	21868	S	-	+	+	E_2
32H	1	7299	D	+	+	+	C
32P	1	12194	S	-	+	+	E_2
32AB	1	21801	S	-	+	-	E_2
32AC	1	17114	S	-	+	-	E_2
32AG	1	6737	D	+	-	-	E_1
32B	2	3695	D	+	-	+	C
	2	17675	S	-	-	+	E_2
32C	2	1345	D	+	+	+	C
	2	1648	D	+	-	-	E_1
32H	2	3000	D	+	+	-	C
	2	10000	S	-	-	+	E_2
32P	2	1417	D	+	-	+	C
	2	4500	D	+	-	-	E_1
32Z	2	16953	S	-	-	-	C
	2	18368	S	-	-	+	E_2
32AB	2	10000	S	-	+	-	E_2
	2	12500	S	-	-	-	C
32AC	2	17674	S	-	+	-	E_2
	2	17500	S	-	+	+	E_2
32AG	2	11667	S	-	+	+	E_2
	2	11667	S	-	-	+	E_2
32B	3	6000	D	+	-	+	C
	3	11088	S	-	-	-	C
	3	3911	D	+	+	+	C
	3	8691	S	-	-	-	C
32C	3	2899	D	+	+	+	C
	3	7284	D	+	-	+	C
	3	8715	D	+	+	-	C
	3	10000	S	-	-	-	C
32P	3	2334	D	+	+	-	C
	3	2000	D	+	-	+	C
	3	2500	D	+	-	-	E_1
	3	2500	D	+	-	-	E_1
32Z	3	15000	S	-	+	-	E_2
	3	22500	S	-	+	+	E_2
	3	20000	S	-	-	+	E_2
	3	22906	S	-	-	-	C

S=Sufficient; D=Deficient; (+)= positive response; (-)= negative response; E_1= Error in diagnosis by predicting positive response that did not occur; E_2= Error in diagnosis by predicting no response to N but a positive response occurred; C= correct response.

Table 4. A comparison of predicted and actual response of broccoli to sidedress N based on sap nitrate-N values.

Experiment	Sidedress	SAP nitrate-N	Diagnosis	Predicted Response	Actual Response		Diagnostic Accuracy
					Growth	Yield	
32B	1	1684	S	-	+	+	E_2
32H	1	677	D	+	+	+	C
32P	1	1112	S	-	+	+	E_2
32AB	1	1717	S	-	+	-	E_2
32AC	1	2134	S	-	+	-	E_2
32AG	1	1491	S	-	-	-	C
32B	2	995	S	-	-	+	E_2
	2	1531	S	-	-	+	E_2
32C	2	853	S	-	+	+	E_2
	2	697	D	+	-	-	E_1
32H	2	565	D	+	+	-	C
	2	1208	S	-	-	+	E_2
32P	2	403	D	+	-	+	C
	2	596	D	+	-	-	E_1
32Z	2	1565	S	-	-	-	C
	2	1658	S	-	-	+	E_2
32AB	2	1363	S	-	+	-	E_2
	2	1496	S	-	-	-	C
32AC	2	1426	S	-	+	-	E_2
	2	1219	S	-	+	+	E_2
32AG	2	1444	S	-	+	+	E_2
	2	1641	S	-	-	+	E_2
32B	3	792	S	-	-	+	E_2
	3	1253	S	-	-	-	C
	3	587	D	+	+	+	C
	3	1079	S	-	-	-	C
32C	3	222	D	+	+	+	C
	3	283	D	+	-	+	C
	3	339	D	+	+	-	C
	3	384	D	+	-	-	E_1
32P	3	345	D	+	+	-	C
	3	416	D	+	-	+	C
	3	298	D	+	-	-	E_1
	3	337	D	+	-	-	E_1
32Z	3	1474	S	-	+	-	E_2
	3	1883	S	-	+	+	E_2
	3	1750	S	-	-	+	E_2
	3	2015	S	-	-	-	C

S=Sufficient; D=Deficient; (+)= positive response; (-)= negative response; E_1= Error in diagnosis by predicting positive response that did not occur; E_2= Error in diagnosis by predicting no response to N but a positive response occurred; C= correct response.

Table 5. A comparison of predicted and actual response of cauliflower to sidedress N based on dry midrib nitrate-N values.

Experiment	Sidedress	Midrib nitrate-N	Diagnosis	Predicted Response	Actual Response		Diagnostic Accuracy
					Growth	Yield	
32I	1	19051	S	-	+	+	E_2
32Q	1	19317	S	-	-	+	E_2
32AA	1	19851	S	-	-	-	C
32AE	1	5908	D	+	-	-	E_1
32I	2	3250	D	+	+	+	C
	2	7500	D	+	+	+	C
32Q	2	1333	D	+	-	-	E_1
	2	4417	D	+	-	-	E_1
32AA	2	20000	S	-	+	+	E_2
	2	18750	S	-	-	+	E_2
32AE	2	8125	D	+	-	-	E_1
	2	8500	D	+	-	-	E_1
32I	3	4000	D	+	+	+	C
	3	3000	D	+	-	+	C
	3	5500	D	+	+	-	C
	3	3000	D	+	+	+	C
32Q	3	4333	D	+	-	+	C
	3	5833	D	+	-	-	E_1
	3	3000	D	+	-	+	C
	3	4000	D	+	-	-	E_1
32AA	3	12500	S	-	-	-	C
	3	15000	S	-	-	-	C
	3	11500	S	-	-	-	C
	3	15000	S	-	-	-	C
32AE	3	9750	S	-	+	-	E_2
	3	9500	S	-	+	+	E_2
	3	9500	S	-	-	-	C
	3	9750	S	-	-	+	E_2

S=Sufficient; D=Deficient; (+)= positive response; (-)= negative response; E_1= Error in diagnosis by predicting positive response that did not occur; E_2= Error in diagnosis by predicting no response to N but a positive response occurred; C= correct response.

Table 6. A comparison of predicted and actual response of cauliflower to sidedress N based on sap nitrate-N values.

Experiment	Sidedress	SAP nitrate-N	Diagnosis	Predicted Response	Actual Response		Diagnostic Accuracy
					Growth	Yield	
32I	1	1655	S	-	+	+	E_2
32Q	1	1118	S	-	-	+	E_2
32AA	1	2235	S	-	-	-	C
32AE	1	2037	S	-	-	-	C
32I	2	524	D	+	+	+	C
	2	1106	S	-	+	+	E_2
32Q	2	815	S	-	-	-	C
	2	773	S	-	-	-	C
32AA	2	1269	S	-	+	+	E_2
	2	1311	S	-	-	+	E_2
32AE	2	1814	S	-	-	-	C
	2	1708	S	-	-	-	C
32I	3	156	D	+	+	+	C
	3	210	D	+	-	+	C
	3	211	D	+	+	-	C
	3	283	D	+	+	+	C
32Q	3	655	S	-	-	+	E_2
	3	676	S	-	-	-	C
	3	489	D	+	-	+	C
	3	537	D	+	-	-	E_1
32AA	3	1327	S	-	-	-	C
	3	1301	S	-	-	-	C
	3	804	S	-	-	-	C
	3	1344	S	-	-	-	C
32AE	3	1279	S	-	+	-	E_2
	3	1321	S	-	+	+	E_2
	3	1307	S	-	-	-	C
	3	1321	S	-	-	+	E_2

S=Sufficient; D=Deficient; (+)= positive response; (-)= negative response; E_1= Error in diagnosis by predicting positive response that did not occur; E_2= Error in diagnosis by predicting no response to N but a positive response occurred; C= correct response.

Table 7. Yield responses of lettuce over all sites to sidedress N fertilization.

Treatment	Head Weight (g)	Head Diameter (cm)	Marketable Yield (Mg/ha)
No Sidedress	592.6	11.3	29.3
First Sidedress	651.4	11.9	33.1
Second Sidedress	601.4	11.4	30.7
First and Second Sidedress	642.8	11.8	32.6
<u>Statistics</u>			
Site	***	***	***
Rep	NS	***	NS
SD1	***	***	***
SD2	NS	NS	NS
SD1*SD2	NS	NS	NS
Site*SD1	NS	NS	***
Site*SD2	NS	NS	NS
Site*SD1*SD2	NS	NS	NS

***Significant response at the 0.1% level. NS=P>10%.

Table 8. **Yield of lettuce over all sites to no first sidedress N fertilization, always first sidedress N fertilization, and first sidedress N fertilization based on midrib nitrate-N analysis.**

Treatment	Head Weight (g)	Head Diameter (cm)	Marketable Yield (Mg/ha)
No sidedress N	601.1	11.4	30.1
Sidedress N	650.8	11.9	32.9
Sidedress based on Midrib N test	613.1	11.5	31.0
<u>Statistics</u>			
Site	***	***	***
Rep	NS	***	NS
Sub-site (SD2)	NS	NS	NS
Treatment	***	***	**
Site*Treatment	NS	NS	**
Sub-site*Treatment	NS	NS	NS
Site*Subsite*Treatment	NS	NS	NS
LSD	25.9	0.2	1.6

***, **Significant response at the 0.1% and 1% levels, respectively. NS=P>10%.

Table 9. **Yield responses of lettuce over all sites when no application of second sidedress N fertilizer was made, when second sidedress N fertilizer application was always made, and when the second sidedress N fertilization was made based on midrib nitrate-N analysis.**

Treatment	Head Weight (g)	Head Diameter (cm)	Marketable Yield (Mg/ha)
No sidedress N	575.0	11.1	28.1
Sidedress N	580.7	11.2	28.8
Sidedress based on Midrib N test	571.8	11.2	28.0
<u>Statistics</u>			
Site	**	***	***
Rep	NS	***	NS
Sub-site (SD1)	**	***	***
Treatment	NS	NS	NS
Site*Treatment	NS	NS	NS
Sub-site*Treatment	NS	NS	NS
Site*Sub-site*Treatment	NS	NS	***

***, **Significant response at the 0.1% and 1% levels, respectively. NS=P>10%.

Table 10. **Average N rate, average yield, and net returns at three lettuce prices to no first sidesdress N fertilization, always sidedress N fertilization, and sidedress N fertilization based on midrib nitrate-N tests.**

Treatment	Average N Rate	Average Yield	Average Net Returns ($/ha) at three lettuce prices		
	(kg/ha)	(Mg/ha)	$219/Mg	$438/Mg	$876/Mg
No N Sidesdress	0	30.1	-723	5869	19,053
Always N Sidedress	103	32.9	-608	6597	21,007
Midrib based N Sidesdress	33.5	31.0	-705	6084	19,662

Table 11. **Yield responses of broccoli over all 2^3 factorial sites to three sidedress N fertilizations.**

Treatment	Head Weight (g)	Head Diameter (cm)	Marketable Yield (Mg/ha)
No Sidedress	76.9	7.6	4.3
First Sidedress	97.5	8.7	6.3
Second Sidedress	76.4	8.3	4.8
Third Sidedress	71.1	7.7	4.8
First and Second Sidedress	100.1	8.7	6.8
First and Third Sidedress	114.2	9.4	6.2
Second and Third Sidedress	83.0	8.5	5.6
First, Second, and Third	98.2	8.6	6.4
<u>Statistics</u>			
Site	NS	**	***
Rep	NS	NS	.*
SD1	**	***	***
SD2	NS	NS	NS
SD3	NS	NS	NS
SD1*Site	NS	NS	NS
SD2*Site	NS	NS	NS
SD3*Site	NS	NS	NS
SD1*SD2	NS	.*	NS
SD1*SD3	NS	NS	NS
SD2*SD3	NS	NS	NS
SD1*SD2*SD3	NS	NS	NS
Site*SD1*SD2*SD3	NS	NS	NS

This analysis included experiments 32B, 32C, 32P , and 32Z .
***,**,.*Significant response at the 0.1%, 1% and 10% levels, respectively. NS=P>10%.

Table 12. Yield responses of broccoli over four 2^2 factorial sites to sidedress N fertilization.

Treatment	Head Weight (g)	Head Diameter (cm)	Marketable Yield (Mg/ha)
No Sidedress	165.0	10.3	10.2
First Sidedress	157.1	10.4	10.1
Second Sidedress	165.6	10.9	9.8
First and Second Sidedress	165.7	11.0	10.8
<u>Statistics</u>			
Site	***	***	***
Rep	NS	**	***
SD1	NS	NS	NS
SD2	NS	*	NS
SD1*SD2	NS	NS	NS
Site*SD1	NS	NS	*
Site*SD2	NS	NS	*
Site*SD1*SD2	NS	NS	NS

This analysis includes experiments 32H, 32AB, 32AC, and 32AG.
***,**,*Significant response at the 0.1%, 1%, and 10% levels, respectively. NS=P>10%.

Table 13. **Yield responses of cauliflower over all 2^3 factorial sites to three sidedress N fertilizations.**

Treatment	Head Weight (g)	Head Diameter (cm)	Marketable Yield (Mg/ha)
No Sidedress	403.9	11.8	9.7
First Sidedress	512.2	11.9	13.0
Second Sidedress	593.2	11.7	13.1
Third Sidedress	429.3	11.9	10.0
First and Second Sidedress	539.5	13.3	13.7
First and Third Sidedress	501.6	13.6	12.0
Second and Third Sidedress	448.2	11.6	11.2
First, Second, and Third	524.3	12.5	13.2
<u>Statistics</u>			
Site	***	NS	***
Rep	NS	NS	*
SD1	NS	*	NS
SD2	NS	NS	NS
SD3	NS	NS	NS
SD1*SD2	NS	NS	NS
SD1*SD3	NS	NS	NS
SD2*SD3	NS	NS	NS
Site*SD1	NS	*	NS
Site*SD2	*	NS	*
Site*SD3	*	NS	*
SD1*SD2*SD3	NS	NS	NS
Site*SD1*SD2*SD3	NS	NS	NS

This analysis included experiments 32I, 32Q, 32AA, and 32AE.

**,*Significant response at the 0.1% and 10% levels, respectively. NS=P>10%.

Table 14. **Yield responses of broccoli to three sidedress N fertilizations for experiment 32B.**

Treatment	Head Weight (g)	Head Diameter (cm)	Marketable Yield (Mg/ha)
No Sidedress	67.9	8.2	7.3
First Sidedress	81.2	9.0	8.8
Second Sidedress	78.5	8.5	8.6
Third Sidedress	70.6	7.8	8.0
First and Second Sidedress	103.3	9.6	11.1
First and Third Sidedress	88.8	9.2	10.7
Second and Third Sidedress	78.2	9.3	8.5
First, Second, and Third	106.1	9.8	11.7
<u>Statistics</u>			
Rep	.*	NS	.*
SD1	**	***	**
SD2	.*	**	.*
SD3	NS	NS	NS
SD1*SD2	NS	NS	NS
SD1*SD3	NS	NS	NS
SD2*SD3	NS	NS	NS
SD1*SD2*SD3	NS	NS	NS

***,**,.*Significant response at the 0.1%, 1% and 10% levels, respectively. NS=P>10%.

Table 15. **Yield responses of cauliflower to three sidedress N fertilizations for experiment 32Q.**

Treatment	Head Weight (g)	Head Diameter (cm)	Marketable Yield (Mg/ha)
No Sidedress	266.1	11.5	6.2
First Sidedress	313.6	11.2	7.2
Second Sidedress	221.0	8.8	4.4
Third Sidedress	328.5	11.9	6.7
First and Second Sidedress	361.4	13.6	9.0
First and Third Sidedress	459.2	14.7	10.7
Second and Third Sidedress	238.1	9.5	4.5
First, Second, and Third	363.9	12.6	6.9
Statistics			
Rep	NS	NS	NS
SD1	***	**	***
SD2	.*	NS	.*
SD3	.*	NS	NS
SD1*SD2	NS	.*	NS
SD1*SD3	NS	NS	NS
SD2*SD3	.*	NS	.*
SD1*SD2*SD3	NS	.*	NS

***,**,.*Significant response at the 0.1%, 1% and 10% levels, respectively. NS=P>10%.

Table 16. **Economic returns for broccoli in experiment 32B as affected by never applying the first sidedress N application, always applying the first sidedress N application, and applying the first sidedress N application based on a midrib nitrate-N test.**

Treatment	Sub-site[z]	N rate	Yield	Net Returns at two crop prices	
		(kg/ha)	(Mg/ha)	$600/Mg	$1200/Mg
No SD1	1 (0,0)	0	7.3	360	4740
SD1	1 (0,0)	159	8.8	909	6189
Midrib SD1	1 (0,0)	0	7.3	355	4735
No SD1	2 (SD2,0)	0	8.6	952	6112
SD1	2 (SD2,0)	159	11.1	1957	8617
Midrib SD1	2 (SD2,0)	0	8.6	947	6107
No SD1	3 (0,SD3)	0	7.8	588	5268
SD1	3 (0,SD3)	159	9.2	1091	6611
Midrib SD1	3 (0,SD3)	0	7.8	583	5263
No SD1	4 (SD2,SD3)	0	8.5	907	6007
SD1	4 (SD2,SD3)	159	11.7	2230	9250
Midrib SD1	4 (SD2,SD3)	0	8.5	902	6002
No SD1	**Overall**	**0**	**8.1**	**702**	**5532**
SD1	**Overall**	**159**	**10.2**	**1547**	**7667**
Midrib SD1	**Overall**	**0**	**8.1**	**697**	**5528**

[z]Sub-sites represent previous or subsequent sidedress applications. SD1,SD2, and SD3 represent first, second, and third sidedress N application, respectively.

Table 17. **Economic returns for broccoli in experiment 32B as affected by never applying the second sidedress N application, always applying the second sidedress N application, and applying the second sidedress N application based on a midrib nitrate-N test.**

Treatment	Sub-site[z]	N rate	Yield	Net Returns at two crop prices	
		(kg/ha)	(Mg/ha)	$600/Mg	$1200/Mg
No SD2	1 (0,0)	0	7.3	360	4740
SD2	1 (0,0)	159	8.6	818	5978
Midrib SD2	1 (0,0)	159	8.6	812	5973
No SD2	2 (SD1,0)	0	8.8	1043	6323
SD2	2 (SD1,0)	159	11.1	1957	8617
Midrib SD2	2 (SD1,0)	0	8.8	1038	6318
No SD2	3 (0,SD3)	0	8	679	5479
SD2	3 (0,SD3)	159	8.5	772	5872
Midrib SD2	3 (0,SD3)	159	8.5	767	5867
No SD2	4 (SD1,SD3)	0	10.7	1909	8329
SD2	4 (SD1,SD3)	159	11.7	2230	9250
Midrib SD2	4 (SD1,SD3)	0	10.7	1904	8323
No SD2	**Overall**	**0**	**8.7**	**998**	**6218**
SD2	**Overall**	**159**	**10.0**	**1444**	**7429**
Midrib SD2	**Overall**	**80**	**9.2**	**1131**	**6688**

[z]Sub-sites represent previous or subsequent sidedress applications. SD1,SD2, and SD3 represent first, second, and third sidedress N application, respectively.

Table 18. **Economic returns for cauliflower in experiment 32Q as affected by never applying the first sidedress N application, always applying the first sidedress N application, and applying the first sidedress N application based on a midrib nitrate-N test.**

Treatment	Sub-site[z]	N rate	Yield	Net Returns at two crop prices	
		(kg/ha)	(Mg/ha)	$600/Mg	$1200/Mg
No SD1	1 (0,0)	0	6.2	-141	3579
SD1	1 (0,0)	107	7.2	218	4538
Midrib SD1	1 (0,0)	0	6.2	-146	3574
No SD1	2 (SD2,0)	0	4.4	-961	1679
SD1	2 (SD2,0)	107	9	1037	6438
Midrib SD1	2 (SD2,0)	0	4.4	-966	1674
No SD1	3 (0,SD3)	0	6.7	87	4107
SD1	3 (0,SD3)	107	10.7	1812	8232
Midrib SD1	3 (0,SD3)	0	6.7	82	4102
No SD1	4 (SD2,SD3)	0	4.5	-915	1785
SD1	4 (SD2,SD3)	107	6.9	81	4221
Midrib SD1	4 (SD2,SD3)	0	4.5	-920	1780
No SD1	**Overall**	**0**	**5.5**	**-483**	**2788**
SD1	**Overall**	**107**	**8.5**	**787**	**5857**
Midrib SD1	**Overall**	**0**	**5.5**	**-488**	**2782**

[z]Sub-sites represent previous or subsequent sidedress applications. SD1,SD2, and SD3 represent first, second, and third sidedress N application, respectively.

Table 19. **Economic returns for cauliflower in experiment 32Q as affected by never applying the second sidedress N application, always applying the second sidedress N application, and applying the second sidedress N application based on a midrib nitrate-N test.**

Treatment	Sub-site[z]	N rate	Yield	Net Returns at two crop prices	
		(kg/ha)	(Mg/ha)	$600/Mg	$1200/Mg
No SD2	1 (0,0)	0	6.2	-141	3579
SD2	1 (0,0)	107	4.4	-1058	1582
Midrib SD2	1 (0,0)	107	4.4	-1063	1577
No SD2	2 (SD1,0)	0	7.2	315	4635
SD2	2 (SD1,0)	107	9	1037	6437
Midrib SD2	2 (SD1,0)	107	9	1032	6432
No SD2	3 (0,SD3)	0	6.7	87	4107
SD2	3 (0,SD3)	107	4.5	-1012	1688
Midrib SD2	3 (0,SD3)	107	4.5	-1017	1683
No SD2	4 (SD1,SD3)	0	10.7	1909	8329
SD2	4 (SD1,SD3)	107	6.9	81	4221
Midrib SD2	4 (SD1,SD3)	107	6.9	76	4216
No SD2	**Overall**	**0**	**7.7**	**542**	**5162**
SD2	**Overall**	**107**	**6.2**	**-238**	**3482**
Midrib SD2	**Overall**	**107**	**6.2**	**-243**	**3477**

[z]Sub-sites represent previous or subsequent sidedress applications. SD1,SD2, and SD3 represent first, second, and third sidedress N application, respectively.

Table 20. A comparison of predicted and actual response of lettuce to sidedress N based on conventional soil values.

Experiment	Sidedress	Conventional Soil (ppm)	Diagnosis	Predicted Response	Actual Response Yield	Diagnostic Accuracy
32O	1	5.0	D	+	+	C
32R	1	8.6	D	+	-	E_1
32S	1	17.9	D	+	+	C
32U	1	30.4	S	-	-	C
32V	1	5.1	D	+	+	C
32W	1	29.2	S	-	-	C
32X	1	17.7	D	+	-	E_1
32Y	1	23.9	S	-	+	E_2
32AF	1	5.4	D	+	+	C
32AH	1	33.4	S	-	-	C
32AJ	1	13.5	D	+	-	E_1
32AK	1	8.1	D	+	-	E_1
32O	2	0.9	D	+	+	C
	2	1.6	D	+	-	E_1
32S	2	4.8	D	+	-	E_1
	2	12.4	D	+	-	E_1
32U	2	21.6	S	-	+	E_2
	2	21.1	S	-	-	C
32W	2	13.1	D	+	-	E_1
	2	23.4	S	-	+	E_2
32Y	2	2.8	D	+	+	C
	2	9.8	D	+	-	E_1
32AF	2	12.7	D	+	+	C
	2	27.2	S	-	-	C
32AH	2	10.8	D	+	+	C
	2	23.6	S	-	-	C
32AJ	2	8.5	D	+	-	E_1
	2	10.4	D	+	+	C
32AK	2	1.7	D	+	-	E_1
	2	4.5	D	+	-	E_1

S=Sufficient; D=Deficient; (+)= positive response; (-)= negative response; E_1= Error in diagnosis by predicting positive response that did not occur; E_2= Error in diagnosis by predicting no response to N but a positive response occurred; C= correct response.

Table 21. A comparison of predicted and actual response of lettuce to sidedress N based on quick soil values.

Experiment	Sidedress	Quick Soil	Diagnosis	Predicted Response	Actual Response Yield	Diagnostic Accuracy
32O	1	2.2	D	+	+	C
32R	1	*5.9	D	+	-	E_1
32S	1	*12.6	D	+	+	C
32U	1	*31.7	S	-	+	E_2
32V	1	*9.4	D	+	+	C
32W	1	*31.5	S	-	+	E_2
32X	1	*13.9	D	+	+	C
32Y	1	*8.0	D	+	+	C
32AF	1	*3.8	D	+	+	C
32AH	1	*18.1	D	+	+	C
32AJ	1	*5.8	D	+	+	C
32AK	1	*1.3	D	+	-	E_1
32O	2	3.5	D	+	+	C
	2	1.0	D	+	-	C
32S	2	*1.8	D	+	-	E_1
	2	*7.7	D	+	-	C
32U	2	*19.7	D	+	+	C
	2	*39.2	S	-	-	C
32W	2	*6.4	D	+	-	C
	2	*13.6	D	+	+	C
32Y	2	*0.0	D	+	+	C
	2	*3.7	D	+	-	E_1
32AF	2	*7.7	D	+	+	C
	2	*27.2	S	-	-	C
32AH	2	*6.2	D	+	+	C
	2	*9.0	D	+	-	E_1
32AJ	2	*2.7	D	+	-	E_1
	2	*6.2	D	+	+	C
32AK	2	*2.2	D	+	-	E_1
	2	*4.0	D	+	-	E_1

S=Sufficient; D=Deficient; (+)= positive response; (-)= negative response; E_1= Error in diagnosis by predicting positive response that did not occur; E_2= Error in diagnosis by predicting no response to N but a positive response occurred; C= correct response.

*Original values multiplied by 1.6 to correct for soil moisture.

Table 22. A comparison of predicted and actual response of broccoli to sidedress N based on conventional soil values.

Experiment	Sidedress	Conventional Soil	Diagnosis	Predicted Response	Actual Response		Diagnostic Accuracy
					Growth	Yield	
32B	1	10.8	D	+	+	+	C
32P	1	5.5	D	+	+	+	C
32Z	1	19.9	D	+	ND	+	C
32AB	1	4.1	D	+	+	-	C
32AC	1	3.4	D	+	+	-	C
32AG	1	33.2	S	-	-	-	C
32B	2	4.0	D	+	-	+	C
	2	27.4	S	-	-	+	E_2
32P	2	0.0	D	+	-	+	C
	2	1.1	D	+	-	-	E_1
32Z	2	9.6	D	+	-	-	E_1
	2	9.1	D	+	-	+	C
32AB	2	5.4	D	+	+	-	C
	2	8.8	D	+	-	-	E_1
32AC	2	7.7	D	+	+	-	C
	2	15.3	D	+	+	+	C
32AG	2	2.9	D	+	+	+	C
	2	8.6	D	+	-	+	C
32B	3	6.4	D	+	-	+	C
	3	25.5	S	-	-	-	C
	3	25.5	S	-	+	+	E_2
	3	38.5	S	-	-	-	C
32P	3	0.0	D	+	+	-	C
	3	0.0	D	+	-	+	C
	3	1.3	D	+	-	+	C
	3	0.4	D	+	-	-	E_1
32Z	3	7.1	D	+	+	-	C
	3	15.5	D	+	+	+	C
	3	11.0	D	+	-	+	C
	3	16.9	D	+	-	-	E_1

S=Sufficient; D=Deficient; (+)= positive response; (-)= negative response; E_1= Error in diagnosis by predicting positive response that did not occur; E_2= Error in diagnosis by predicting no response to N but a positive response occurred; C= correct response.

Table 23. A comparison of predicted and actual response of broccoli to sidedress N based on quick soil values.

Experiment	Sidedress	Quick Soil	Diagnosis	Predicted Response	Actual Response		Diagnostic Accuracy
					Growth	Yield	
32P	1	6.0	D	+	+	+	C
32Z	1	3.3	D	+	-	+	C
32AB	1	*3.5	D	+	+	-	C
32AC	1	*5.6	D	+	+	-	C
32AG	1	*3.6	S	-	-	-	C
32P	2	4.0	D	+	-	+	C
	2	4.5	D	+	-	-	E_1
32Z	2	5.9	D	+	+	+	C
	2	7.1	D	+	-	-	E_1
32AB	2	*7.7	D	+	+	-	C
	2	*4.0	D	+	-	-	E_1
32AC	2	*5.0	D	+	+	+	C
	2	*3.5	D	+	+	+	C
32AG	2	*4.5	D	+	+	+	C
	2	*10.6	D	+	-	+	C
32P	3	2.6	D	+	+	-	C
	3	3.5	D	+	-	+	C
	3	3.7	D	+	-	-	E_1
	3	4.9	D	+	-	-	E_1
32Z	3	3.1	D	+	+	-	C
	3	17.0	D	+	+	+	C
	3	8.5	D	+	-	+	C
	3	28.3	S	-	-	-	C

S=Sufficient; D=Deficient; (+)= positive response; (-)= negative response; E_1= Error in diagnosis by predicting positive response that did not occur; E_2= Error in diagnosis by predicting no response to N but a positive response occurred; C= correct response.
*Original values multiplied by 1.6 to correct for soil moisture.

Table 24. A comparison of predicted and actual response of cauliflower to sidedress N based on conventional soil values.

Experiment	Sidedress	Conventional Soil (ppm)	Diagnosis	Predicted Response	Actual Response		Diagnostic Accuracy
					Growth	Yield	
32Q	1	3.7	D	+	+	+	C
32AA	1	109.6	S	-	-	-	C
32AE	1	62.3	S	-	-	-	C
32Q	2	3.3	D	+	-	-	E_1
	2	4.5	D	+	-	-	E_1
32AA	2	46.3	S	-	+	+	E_2
	2	63.7	S	-	-	+	E_2
32AE	2	32.9	S	-	-	-	C
	2	29.9	S	-	-	-	C
32Q	3	0.9	D	+	-	-	E_1
	3	1.3	D	+	-	+	C
	3	1.5	D	+	-	+	C
	3	2.4	D	+	-	-	E_1
32AA	3	32.3	S	-	-	-	C
	3	29.4	S	-	-	-	C
	3	68.3	S	-	-	-	C
	3	46.5	S	-	-	-	C
32AE	3	39.7	S	-	+	-	E_2
	3	49.8	S	-	+	+	E_2
	3	44.3	S	-	-	-	C
	3	41.6	S	-	-	+	E_2

S=Sufficient; D=Deficient; (+)= positive response; (-)= negative response; E_1= Error in diagnosis by predicting positive response that did not occur; E_2= Error in diagnosis by predicting no response to N but a positive response occurred; C= correct response.

Table 25. A comparison of predicted and actual response of cauliflower to sidedress N based on quick soil values.

Experiment	Sidedress	Quick Soil	Diagnosis	Predicted Response	Actual Response		Diagnostic Accuracy
					Growth	Yield	
32Q	1	1.6	D	+	+	+	C
32AA	1	93.9	S	-	-	-	C
32AE	1	16.2	D	+	-	-	E_1
32Q	2	2.1	D	+	-	-	E_1
	2	1.6	D	+	-	-	E_1
32AA	2	48.0	S	-	+	+	E_2
	2	80.5	S	-	-	+	E_2
32AE	2	39.5	S	-	+	+	E_2
	2	52.2	S	-	-	+	E_2
32Q	3	3.6	D	+	-	+	C
	3	5.7	D	+	-	+	C
	3	6.0	D	+	-	+	C
	3	7.0	D	+	-	-	E_1
32AA	3	56.4	S	-	-	-	C
	3	39.5	S	-	-	-	C
	3	98.8	S	-	-	-	C
	3	84.7	S	-	-	-	C
32AE	3	22.6	S	-	+	-	E_2
	3	36.7	S	-	+	+	E_2
	3	17.0	D	+	-	-	E_1
	3	31.1	S	-	-	+	E_2

S=Sufficient; D=Deficient; (+)= positive response; (-)= negative response; E_1= Error in diagnosis by predicting positive response that did not occur; E_2= Error in diagnosis by predicting no response to N but a positive response occurred; C= correct response.

Table 26. **Yield of lettuce over all sites to no first sidedress N fertilization, always first sidedress N fertilization, and first sidedress N fertilization based on soil nitrate-N analysis.**

Treatment	Head Weight (g)	Head Diameter (cm)	Marketable Yield (Mg/ha)
No sidedress N	534.2	11.0	27.2
Sidedress N	585.9	11.4	29.4
Sidedress based on Soil N test	570.5	11.3	28.5
Statistics			
Site	***	***	***
Rep	.*	***	.*
Sub-site (SD2)	NS	NS	NS
Treatment	**	.*	.*
Site*Sub-site	.*	NS	.*
Site*Treatment	NS	NS	NS
Sub-site*Treatment	NS	NS	NS
Site*Subsite*Treatment	NS	NS	NS
LSD	28.8	0.3	1.8

***,**,*Significant response at the 0.1%, 1% and 10% levels, respectively. NS=P>10%.

Table 27. **Average N rate, yield, and net returns at three lettuce prices to no first sidesdress N fertilization, always sidedress N fertilization, and sidedress N fertilization based on soil nitrate-N tests.**

Treatment	Average N Rate	Average Yield	Average Net Returns ($/ha) at three lettuce prices		
	(kg/ha)	(Mg/ha)	$219/Mg	$438/Mg	$876/Mg
No N Sidesdress	0	27.2	-939	5018	16,932
Always N Sidedress	109	29.4	-873	5566	18,443
Soil Test based N Sidesdress	32.8	28.5	-890	5351	17,834

Table 28. **Economic return to broccoli in experiment 32B as affected by never applying the first sidedress N application, always applying the first sidedress N application, and applying the first sidedress N application based on a soil nitrate-N test.**

Treatment	Sub-site[z]	N rate	Yield	Net Returns at two crop prices	
		(kg/ha)	(Mg/ha)	\$600/Mg	\$1200/Mg
No SD1	1 (0,0)	0	7.3	360	4740
SD1	1 (0,0)	159	8.8	909	6189
Soil Test SD1	1 (0,0)	159	8.8	904	6184
No SD1	2 (SD2,0)	0	8.6	952	6112
SD1	2 (SD2,0)	159	11.1	1957	8617
Soil Test SD1	2 (SD2,0)	159	11.1	1952	8612
No SD1	3 (0,SD3)	0	7.8	588	5268
SD1	3 (0,SD3)	159	9.2	1091	6611
Soil Test SD1	3 (0,SD3)	159	9.2	1086	6606
No SD1	4 (SD2,SD3)	0	8.5	907	6007
SD1	4 (SD2,SD3)	159	11.7	2230	9250
Soil Test SD1	4 (SD2,SD3)	159	11.7	2225	9245
No SD1	**Overall**	**0**	**8.1**	**702**	**5532**
SD1	**Overall**	**159**	**10.2**	**1547**	**7667**
Soil Test SD1	**Overall**	**159**	**10.2**	**1542**	**7662**

[z]Sub-sites represent previous or subsequent sidedress applications. SD1,SD2, and SD3 represent first, second, and third sidedress N application, respectively.

Table 29. Economic returns for broccoli in experiment 32B as affected by never applying the second sidedress N application, always applying the second sidedress N application, and applying the second sidedress N application based on a soil nitrate-N test.

Treatment	Sub-site[z]	N rate	Yield	Net Returns at two crop prices	
		(kg/ha)	(Mg/ha)	$600/Mg	$1200/Mg
No SD2	1 (0,0)	0	7.3	360	4740
SD2	1 (0,0)	159	8.6	818	5978
Soil Test SD2	1 (0,0)	159	8.6	813	5973
No SD2	2 (SD1,0)	0	8.8	1043	6323
SD2	2 (SD1,0)	159	11.1	1957	8617
Soil Test SD2	2 (SD1,0)	0	8.8	1038	6318
No SD2	3 (0,SD3)	0	8	679	5479
SD2	3 (0,SD3)	159	8.5	772	5872
Soil Test SD2	3 (0,SD3)	0	8	674	5474
No SD2	4 (SD1,SD3)	0	10.7	1909	8329
SD2	4 (SD1,SD3)	159	11.7	2230	9250
Soil Test SD2	4 (SD1,SD3)	0	10.7	1904	8324
No SD2	**Overall**	**0**	**8.7**	**998**	**6218**
SD2	**Overall**	**159**	**10.0**	**1444**	**7429**
Soil Test SD2	**Overall**	**40**	**9.0**	**1107**	**6556**

[z]Sub-sites represent previous or subsequent sidedress applications. SD1,SD2, and SD3 represent first, second, and third sidedress N application, respectively.

Table 30. **Economic return to cauliflower in experiment 32Q as affected by never applying the first sidedress N application, always applying the first sidedress N application, and applying the first sidedress N application based on a soil nitrate-N test.**

Treatment	Sub-site[z]	N rate	Yield	Net Returns at two crop prices	
		(kg/ha)	(Mg/ha)	\$600/Mg	\$1200/Mg
No SD1	1 (0,0)	0	6.2	-141	3579
SD1	1 (0,0)	107	7.2	218	4538
Midrib SD1	1 (0,0)	107	7.2	213	4533
No SD1	2 (SD2,0)	0	4.4	-961	1679
SD1	2 (SD2,0)	107	9	1037	6438
Midrib SD1	2 (SD2,0)	107	9	1032	6432
No SD1	3 (0,SD3)	0	6.7	87	4107
SD1	3 (0,SD3)	107	10.7	1812	8232
Midrib SD1	3 (0,SD3)	107	10.7	1807	8227
No SD1	4 (SD2,SD3)	0	4.5	-915	1785
SD1	4 (SD2,SD3)	107	6.9	81	4221
Midrib SD1	4 (SD2,SD3)	107	6.9	76	4216
No SD1	Overall	0	5.5	-483	2788
SD1	Overall	107	8.5	787	5857
Midrib SD1	Overall	107	8.5	782	5852

[z]Sub-sites represent previous or subsequent sidedress applications. SD1,SD2, and SD3 represent first, second, and third sidedress N application, respectively.

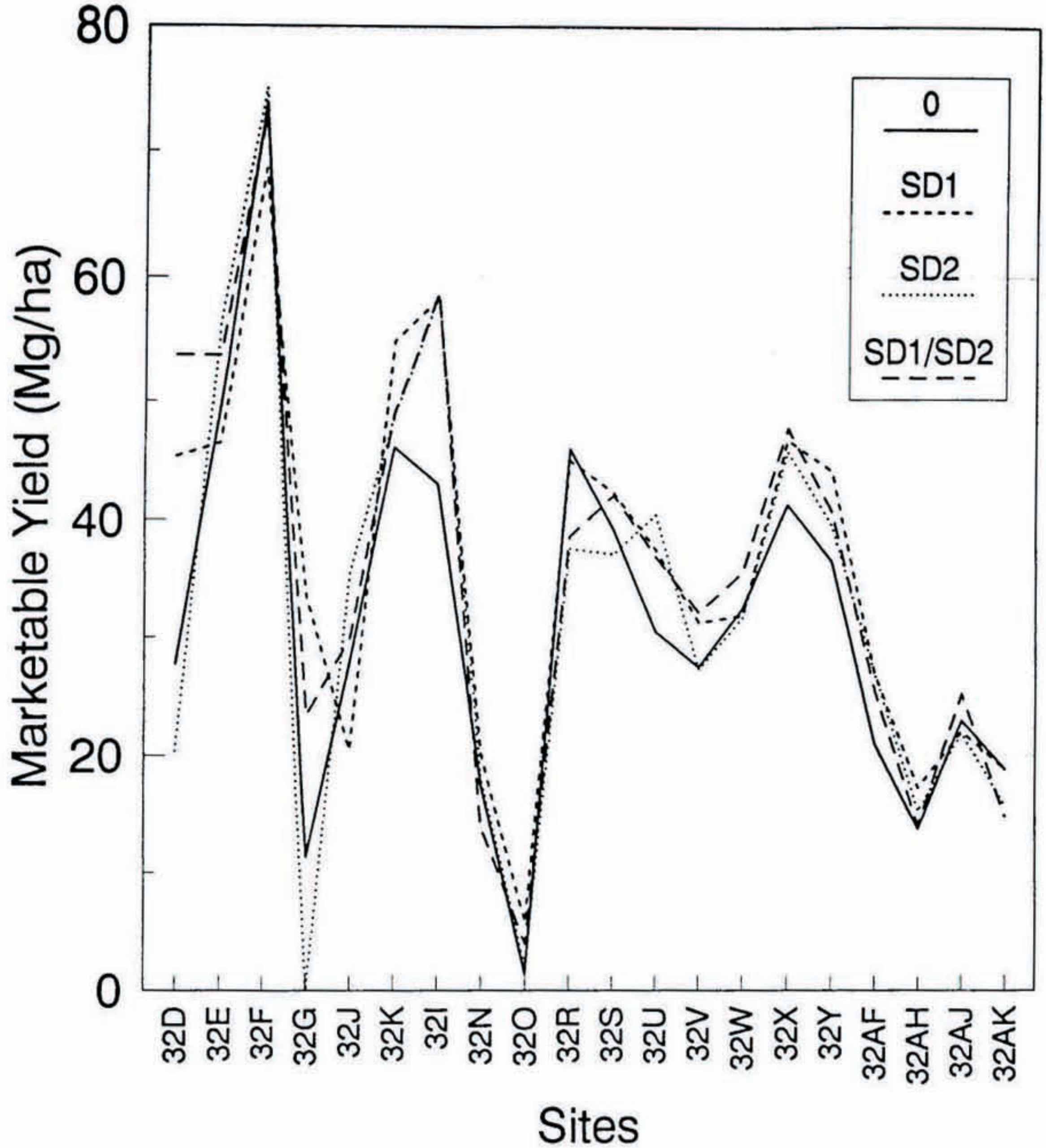

Figure 1. Yield responses of lettuce to no sidedress N fertilization (0), first sidedress N fertilization (SD1), second sidedress N fertilization (SD2), and first and second sidedress N fertilization (SD1/SD2) across all experimental sites. Overall LSD is 2.3 Mg/ha.

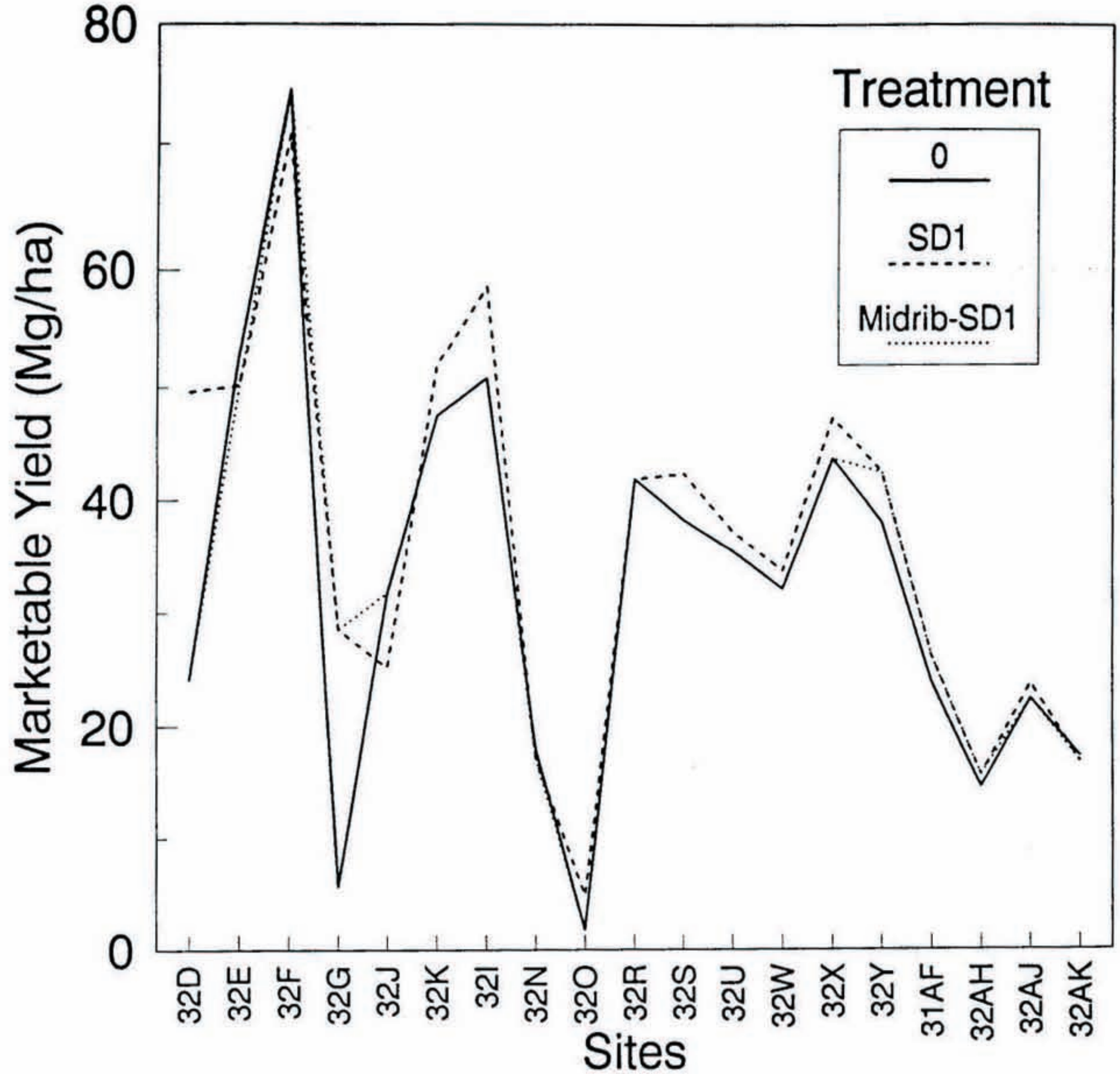

Figure 2. Yield responses of lettuce across all sites as affected by never applying first sidesdress N (0), always applying first sidedress N (SD1), and applying first sidesdress N based on a midrib nitrate-N test (Midrib-SD1). Overall LSD is 1.6 Mg/ha.

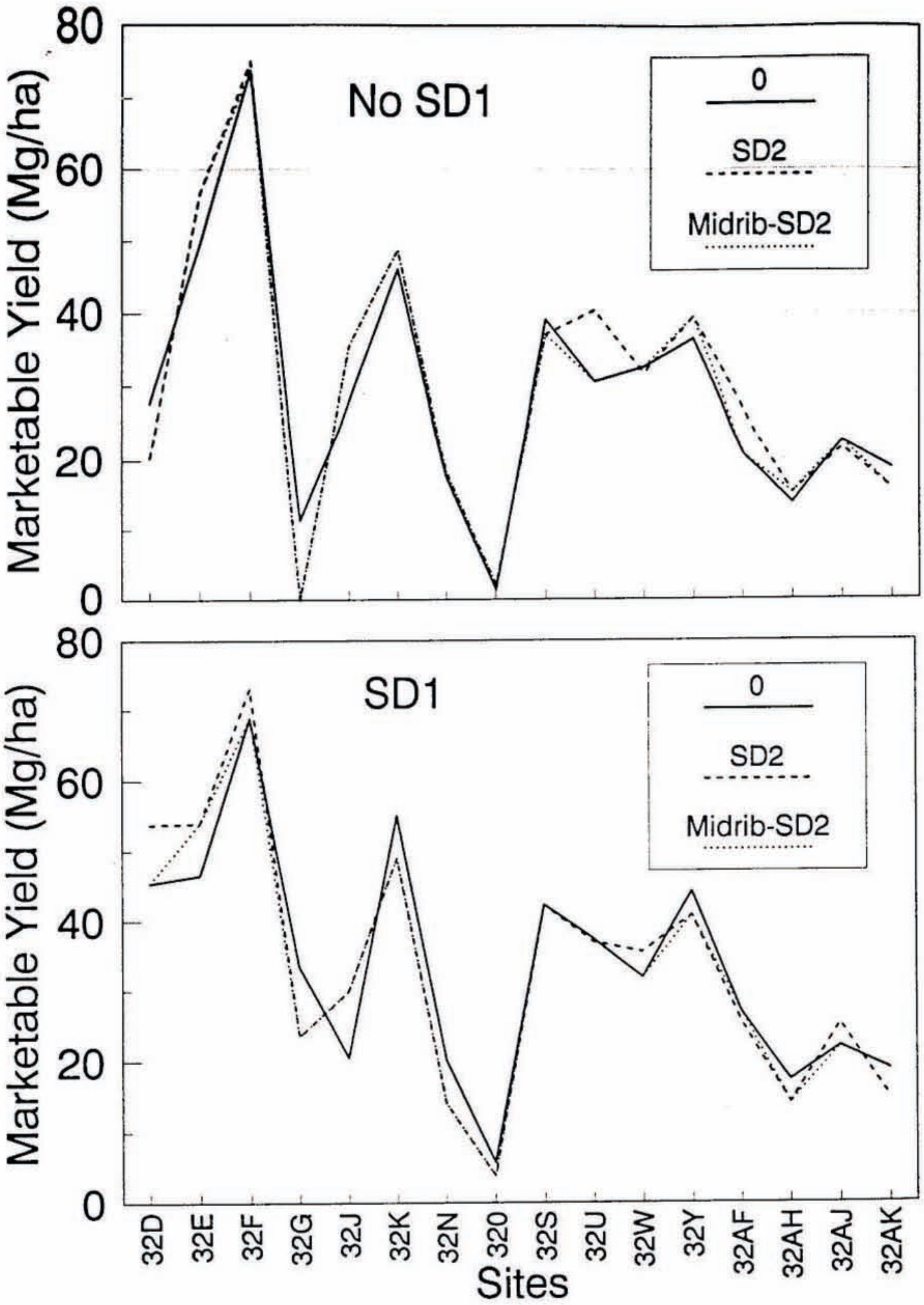

Figure 3. Yield responses of lettuce across all sites as affected by never applying second sidedress N (0), always applying second sidedress N (SD2) and applying second sidedress based on a midrib nitrate-N test on sub-sites that did not and did receive first sidedress. The main effect of yield was not significantly different.

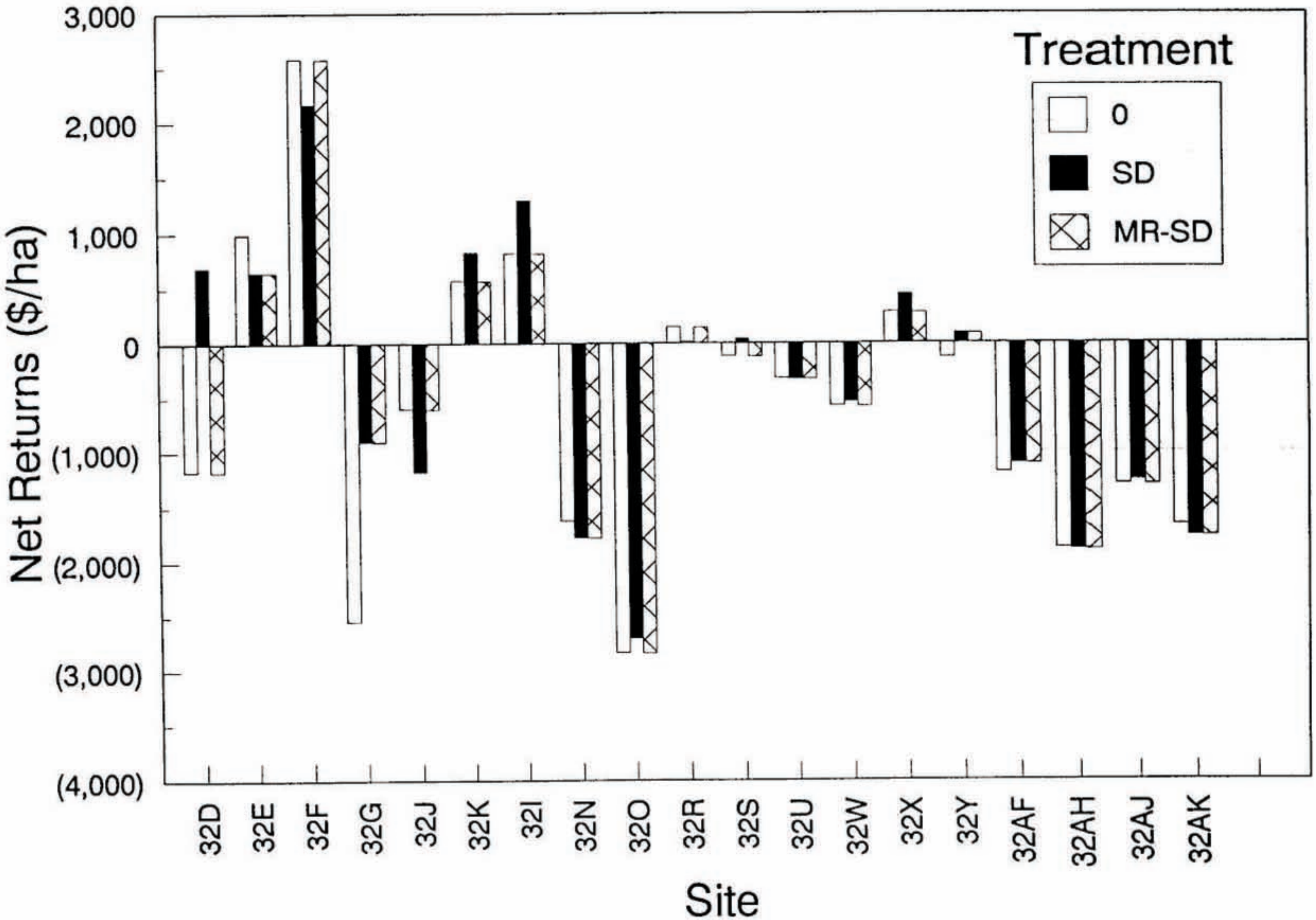

Figure 4. Economic returns for lettuce when first sidedress N was never applied (0), always applied (SD), or applied based on midrib nitrate-N tests (MR-SD) for a lettuce market value of $219/Mg at individual sites.

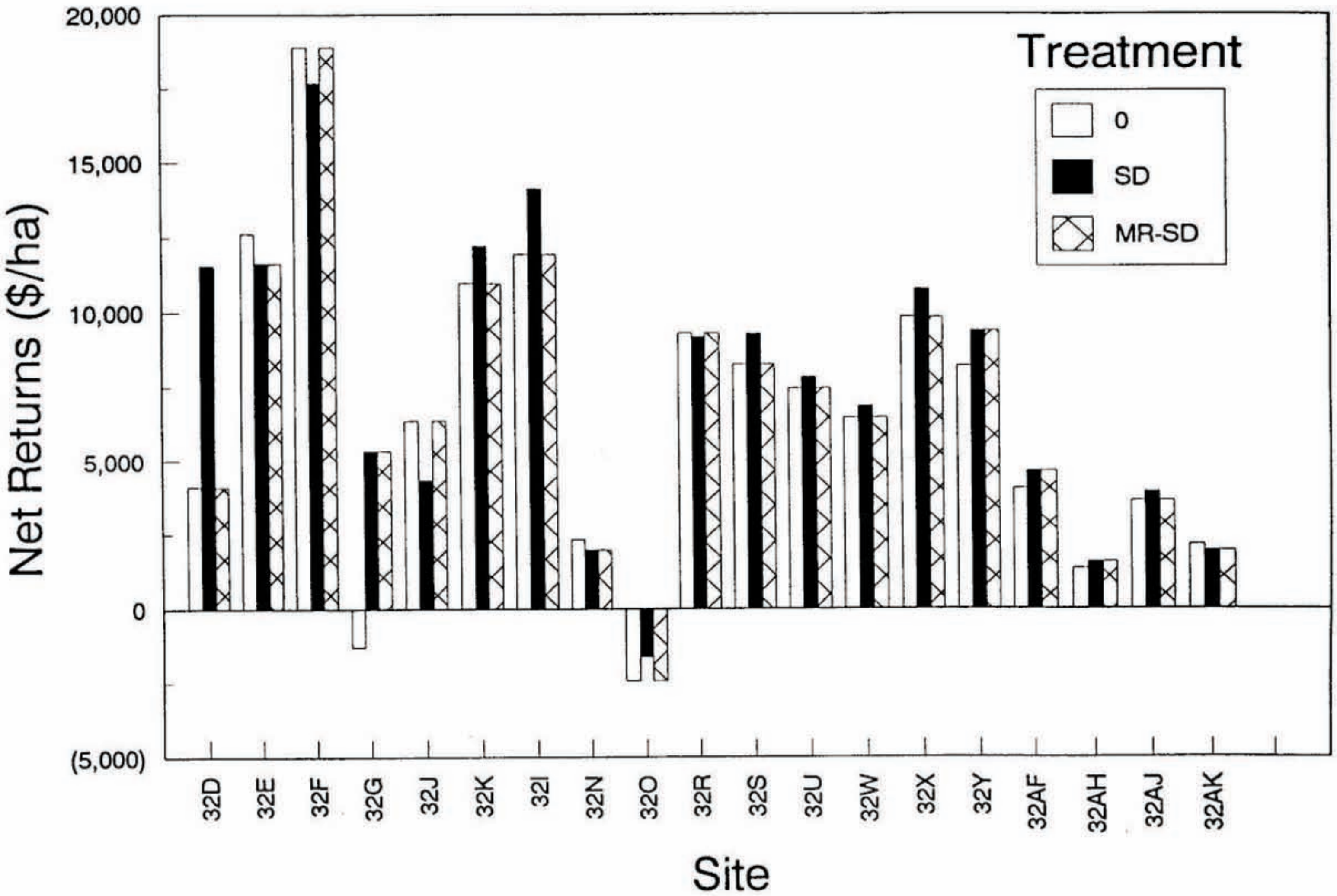

Figure 5. Economic returns for lettuce when first sidedress N was never applied (0), always applied (SD), or applied based on midrib nitrate-N tests (MR-SD) for a lettuce market value of $438 /Mg at individual sites.

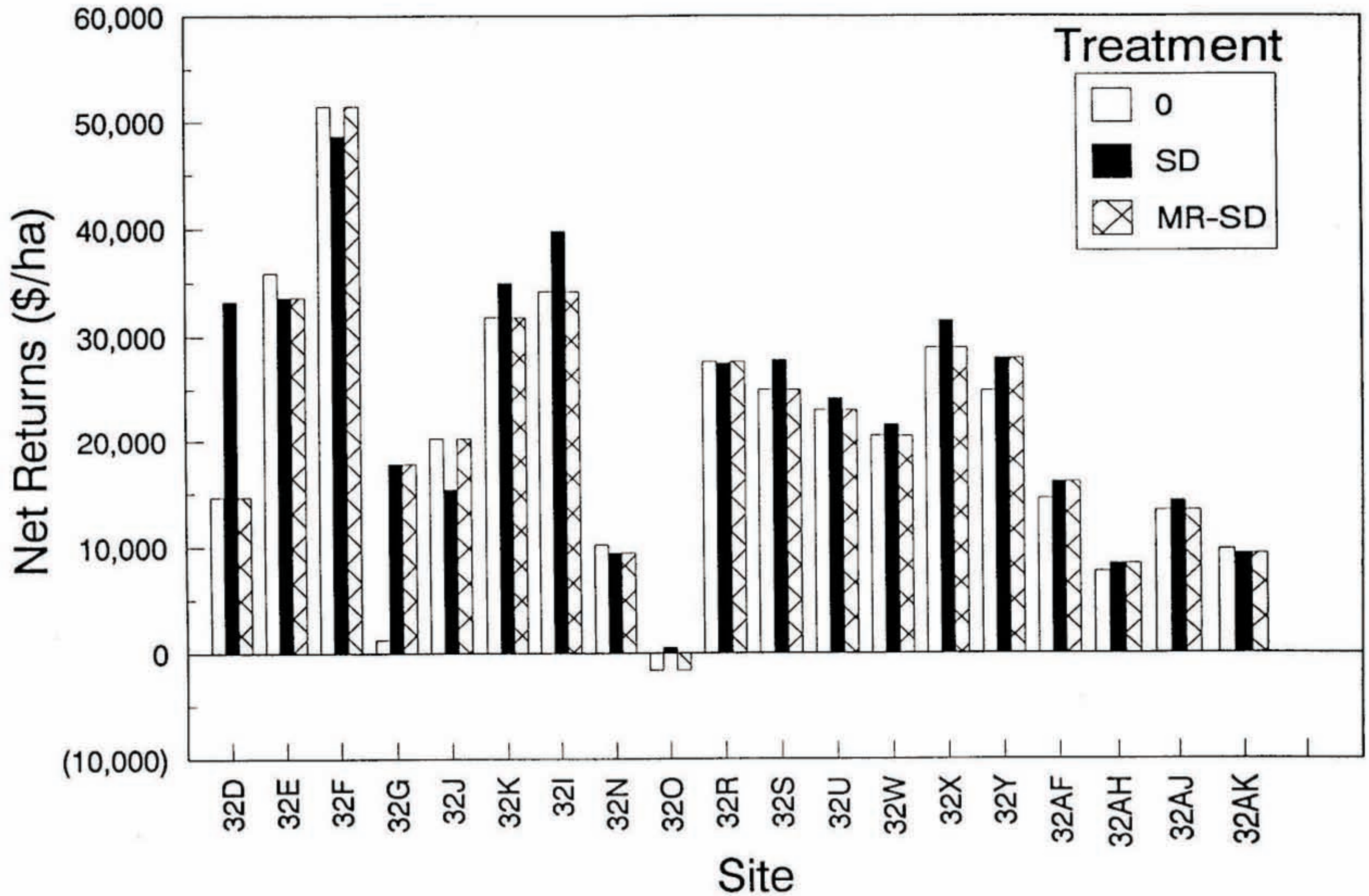

Figure 6. Economic returns for lettuce when first sidedress N was never applied (0), always applied (SD), or applied based on midrib nitrate-N tests (MR-SD) for a lettuce market value of $876/Mg at individual sites.

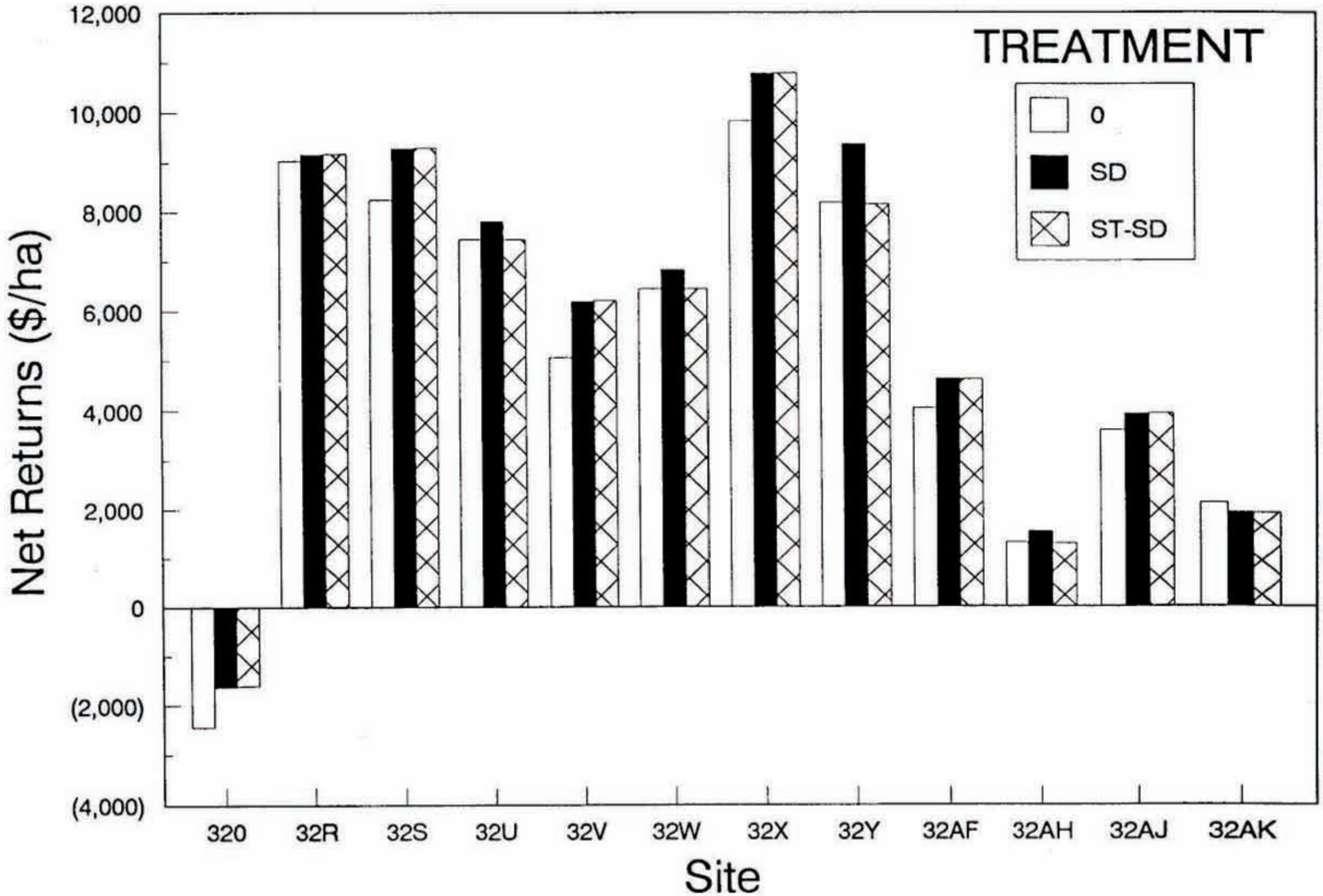

Figure 7. Economic returns for lettuce when first sidedress N was never applied (0), always applied (SD), or applied based on soil nitrate-N tests (ST-SD) for a lettuce market value of $438/Mg at individual sites.