# Evaluation of pre-sidedress soil nitrate testing to determine N requirements of cool season vegetables

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**Objectives:**

1. Evaluate the use of pre-sidedress soil nitrate testing (PSNT) to estimate sidedress N requirement of cool-season vegetables.
2. Document the accuracy of an on-farm soil 'quick test' for $NO_3$-N determination.
3. Survey commercial vegetable fields in the Salinas and Santa Maria Valleys to determine the range of soil $NO_3$-N concentrations common at the time of first sidedressing.
4. Conduct outreach efforts to disseminate results.


**Summary:**

It is generally acknowledged that intensive vegetable production as practiced along California's central coast contributes to nitrate pollution of groundwater; the Salinas Valley, Santa Maria Valley and the Oxnard plain are all considered to be nitrate-sensitive areas. Cropping patterns and the mild Mediterranean climate have resulted in the development of soils that are extremely active in nitrogen cycling. Large soil mineral N pools and rapid N mineralization have been reported by several researchers. Early-season soil $NO_3$-N testing could help growers more accurately determine field-specific sidedress N requirements. This approach has been researched extensively in the Midwest for corn production; called the pre-sidedressing soil nitrate test (PSNT), it is now in widespread commercial use. This project proposed to adapt the PSNT technique to coastal vegetable production, and to refine a simple analytical technique for on-farm soil $NO_3$-N analysis.

During 1996-97 a total of 22 trials were conducted in conventionally irrigated commercial vegetable fields in Ventura, Santa Barbara and Monterey Counties; 11 fields were planted in head lettuce, 5 in celery, 4 in cauliflower and 2 in broccoli. Fields were chosen that had at least 20 PPM $NO_3$-N in the top 12 inches of soil immediately prior to the first scheduled sidedress N application. In each field replicated plots of two

levels of reduced N fertilization were established by skipping or reducing one or more sidedress N applications. The productivity of these plots was compared with adjacent plots receiving the grower's complete N program.

In all 22 fields, plots in which the first sidedress N application was eliminated or reduced had equal yield and product quality with those receiving the full grower program. In only 3 of the fields did the lowest rate of seasonal N application, achieved by reducing or eliminating two sidedress applications, have a detrimental effect on yield or quality. The average reduction in seasonal N application was 88 and 162 lb N/acre for the two reduced N treatments.

These trials clearly demonstrate that PSNT can identify fields in which significant reduction in N application can be achieved, through postponing or reducing sidedress applications, with no loss of crop yield or quality. A survey of 35 coastal vegetable fields, conducted from May to September, found that the majority had soil $NO_3$-N prior to first sidedressing high enough (> 20 PPM) to delay additional N application.

**Methods**:

A total of 22 field trials were conducted in commercial vegetable fields in the 1996 and 1997 seasons. Fields were located in Oxnard, Santa Maria, King City, Soledad and Salinas, farmed by six different growers. Eleven were planted in head lettuce, 5 in celery, 4 in cauliflower and 2 in broccoli. Planting dates varied from late February to September, soil texture from sandy loam to clay loam. All fields were conventionally irrigated, generally sprinkled to establish the crop, then switched to furrow irrigation to complete the season. All test fields chosen had soil $NO_3$-N at or above 20 PPM $NO_3$-N immediately prior to the first sidedress N application, as measured by an on-farm 'quick test' procedure (Appendix 1).

The N fertilization program in each field was determined solely by the participating growers. In each field two levels of reduced N application were established, usually by entirely skipping one or more sidedress N applications; in several fields a sidedress N application was reduced rather than eliminated (detail given in Appendix 2). One plot of each reduced N treatment was established in each quadrant of the field; plots were 4 beds wide by 100 ft. long. They were compared with adjacent plots receiving the growers' full N program. There were two cauliflower trials in 1997 in which the grower consented to skip the first scheduled sidedressing in the whole field, based on high soil $NO_3$-N concentration; in these trials (fields 3 and 4, Table 3) replicated plots were established that did receive that first sidedress application.

Periodic plant and soil sampling was done to document N status throughout the season. Soil samples (2-12 inches) were collected prior to each sidedressing and at harvest; $NO_3$-N concentration in 2N KC1 extracts was determined by conventional laboratory analysis. Petiole (broccoli and celery) or midrib (cauliflower and lettuce) samples, as well as whole plant samples, were collected prior to the second sidedress N application and at harvest. After oven drying the petioles and midribs were analyzed for $NO_3$-N concentration, the whole plant samples for total biomass and total N content.

Plots were harvested within three days of the scheduled commercial harvest, where possible by experienced personnel from commercial crews. Harvested plants were evaluated for size and condition based on established market standards. Celery and lettuce fields were harvested once, broccoli and cauliflower one or more times, depending upon the percentage of plants ready for harvest on the first evaluation date.

A survey of commercial vegetable fields was conducted to determine typical soil $NO_3$-N concentration at the time of first sidedress application. Thirty-five fields in the Salinas, Santa Maria and Oxnard areas were sampled from May through September in 1996 and 1997. Composite soil samples (2-12 inches depth) were collected immediately prior to the first scheduled sidedress N application. $NO_3$-N concentration, in 2N KC1 extracts of moist soil, was determined by standard laboratory technique.

The accuracy of the soil $NO_3$-N 'quick test' was examined using a set of 40 soil samples collected during the PSNT trials. The quick test extracts were prepared, and $NO_3$-N concentration estimated by the procedure outlined in Appendix 1; these extracts were then analyzed by conventional laboratory technique and soil $NO_3$-N calculated based on the actual soil:extractant ratio for each sample.

**Results:**

Eliminating one or two sidedress N applications had no effect on marketable lettuce yield in any field (Table 1). Details of production practices are given in Appendix 2. The very low fertilizer N totals of the no sidedress treatments may be somewhat misleading, since in several fields (notably #1, 9, 10 and 11) the irrigation water contained at least 10 PPM $NO_3$-N, adding between 20-60 lb N/acre seasonally. In field 3 the plots receiving no sidedress N could be visually distinguished by lighter color at harvest, documented in marginally lower leaf color as measured by a leaf reflectance meter (Minolta SPAD 502, Minolta Corporation, Japan); late season soil $NO_3$-N was also low ($<$ 5 PPM), yet yield was unaffected. The practical significance of this color difference is questionable, as all N treatments in field 5 were of still lighter color, and the grower had no problem with market acceptance. There were no visual differences in leaf color in any trials conducted in 1997 (fields 7 to 11).

Seasonal N application rate had no significant effect on size distribution or mean plant weight of celery in any of the field trials (Table 2). Details of production practices are given in Appendix 2. Average seasonal N application in these fields was 447 lb/acre, somewhat above the industry norm of 350-400 lb N/acre. In field 2 the lowest N treatment was visually lighter in color at midseason, but by harvest no color differences were apparent. No color or vigor differences were observed in any of the other fields.

In three of four cauliflower trials seasonal N rate had no effect on crop productivity (Table 3). In field 2 the lowest N rate visibly lacked vigor, and suffered clear yield loss. Given the high rates of N application in that field, the problem was clearly not the lack of N *per se*, but rather the loss of N through leaching; this light textured field (sandy loam, see Appendix 2) received more than 20 inches of irrigation.

One of the broccoli fields tested showed no crop response to reducing N application while in the other field skipping both sidedress N applications did reduce yield (Table 4). In field 2 the no sidedress treatment had received no N since a light application through sprinklers (42 lb N/acre, see Appendix 1) shortly after germination, 12 weeks before harvest. Despite a high initial soil $NO_3$-N level the combined effects of crop uptake and leaching loss reduced soil $NO_3$-N to below 10 PPM by harvest.

Taken together, these trials clearly demonstrate that, in fields with substantial residual soil $NO_3$-N concentration (> 20 PPM), early season sidedressing is not required for optimum crop performance. Table 5 emphasizes that point. Not only was there no loss of production when those early season sidedress N applications were reduced or eliminated, there are only minor differences in the amount of N taken up by the crop in the various N treatments. On average these early season N applications had an uptake efficiency of less than 10%. Clearly, there is substantial opportunity for reducing N fertilizer use in coastal production of cool-season vegetables.

Maintaining high productivity with seasonal N applications of 100 lb/acre or less may seem unlikely, but a rough N budget analysis can be instructive. Soil $NO_3$-N concentration of 25 PPM represents approximately 100 lb N/acre in the top foot, 150 lb N/acre in the top 18 inches. Net N mineralization rates of 1.0-1.5 lb N/acre per day have been documented in medium texture coastal vegetable soils; in a 70 day crop mineralization of organic N could add 70-100 lb of available N/acre. Given the $NO_3$-N concentration common in irrigation water, between 15-30 lb N/acre could be added during a cropping season. Clearly, a crop such as lettuce, which normally contains only 100-120 lb N/acre in its total biomass at harvest, could be well supplied at very modest N fertilization rates provided that irrigation was efficiently applied, minimizing leaching losses.

The commercial field survey documented that high levels of soil $NO_3$-N at the time of the first sidedress N application was common. Of the 35 fields sampled, only 6 had soil $NO_3$-N less than 20 PPM; 11 fields were 40 PPM or more. Caution is appropriate in interpreting these results. This survey concentrated on late spring-summer planted fields; fields planted in early spring would typically have much lower $NO_3$-N soil levels due to the effects of leaching winter rains. Also, a substantial portion of the soil $NO_3$-N measured in this survey undoubtedly represented N fertilizer applied preplant or through sprinklers following crop emergence. However, the main point to emphasize is that, at the time the growers were preparing to make large sidedress N applications, the majority of these fields did not need additional N, and would not for weeks to come; as the field trials demonstrated, a number of these fields would not require any additional N to achieve maximum yield and quality. In-season soil $NO_3$-N monitoring is a crucial part of efficient N management.

The soil $NO_3$-N quick test technique proved to be reasonably accurate across a range of soil $NO_3$-N concentrations (Fig. 1). Again, caution is appropriate in interpreting this information. This comparison represented the ‘best case’ scenario regarding quick test accuracy, having been done carefully by an experienced worker in a laboratory setting. The use of the soil $NO_3$-N quick test on-farm by less experienced personnel would undoubtedly be somewhat less accurate. It is clear, however, that this procedure can be effective in estimating soil $NO_3$-N concentration.

**Outreach Activities:**

Two field days were held in 1996 (one in Santa Maria, one in Salinas) to allow viewing of several of the PSNT field trials, to discuss results of field trials already completed, and to demonstrate on-farm monitoring techniques. Approximately 20 industry personnel attended each event. In 1997 a joint educational event was organized with Danyal Kasapligil and Kurt Schulbach, to showcase our related FREP-sponsored activities. The event, held in Salinas on October 9, included a seminar to discuss trials results, and viewing of a field demonstration.

From the initiation of this project to the present the Project Leader has delivered presentations on the result of PSNT trials and/or information on efficient N management at 16 public meetings around the state:

1) 'Nitrogen management in cool-season vegetables', invited presentation at the annual retreat of the Santa Maria area Vegetable Growers-Shipper Association, Mammoth Mountain, January 11, 1996; approximately 15 participants.

2) 'Optimizing N management in vegetable cropping systems', Agronomy Society of America-California Chapter, Modesto, January 18, 1996; approximately 100 participants.

3) 'Determining sidedress N requirements through in-season soil $NO_3$-N testing'. Grower meeting, Guadalupe, January 28, 1996; approximately 40 participants.

4) 'Efficient fertilizer use through effective monitoring'. Grower meeting, Hollister, February 1, 1996; approximately 35 participants.

5) 'Efficient N management in celery production'. Grower meeting, Oxnard, February 8, 1996; approximately 15 participants.

6) 'N management through on-farm monitoring'. UCCE Irrigation and Nutrient Management Conference, Salinas, February 28, 1996; approximately 150 participants.

7) 'Quick tests for soil and plant analysis'. Grower meeting, Guadalupe, February 29, 1996; approximately 30 participants.

8) 'Optimizing N fertilizer management in tomato and pepper'. Grower meeting, King City, March 5, 1996; approximately 25 participants.

9) 'N nutrition for cool-season crops'. California Fertilizer Assoc. seminar, Monterey, September 30, 1996; approximately 60 participants.

10) 'Determining sidedress N requirements in vegetables'. Grower meeting, Guadalupe, January 28, 1997; approximately 50 participants.

11) 'On-site testing of plant and soil nutrient status'. UCCE Farm Conference, Riverside, February 25, 1997; approximately 25 participants.

12) 'Using presidedress soil $NO_3$-N level to determine sidedress N requirements for cool-season vegetables'. UCCE Irrigation and Nutrient Management Conference, Salinas, February 27, 1997; approximately 150 participants.

13) 'Evaluation of presidedress soil nitrate testing to determine N requirements of cool-season vegetables'. FREP Conference, Sacramento, November 18, 1997; approximately 150 participants.

14) 'Evaluation of presidedress soil nitrate testing to determine N requirements of cool-season vegetables'. Agronomy Society of America-California Chapter, Sacramento, January 22, 1998; approximately 50 participants.

15) 'N management in vegetable crops'. Grower meeting, Hollister, February 3, 1998; approximately 35 participants.

16) 'Results of recent N fertilizer trials for cool-season vegetable crops'. UCCE Irrigation and Nutrient Management Conference, Salinas, February 27, 1998; approximately 150 participants.

In this same time period several articles appeared in trade publications highlighting the results of this project or other FREP-sponsored work conducted by the Project Leader. Articles appeared in the California Farmer (February, 1996) and the California-Arizona Farm Press (April 19, 1997).

Table 1. Response of head lettuce to varying nitrogen regimes.

| | N treatment | Soil $NO_3$-N[z] (PPM) | Seasonal N application (lb/acre) | Marketable yield: % of plants harvested[y] | Marketable yield: mean head wt. (lb.) | Leaf color[x] |
|---|---|---|---|---|---|---|
| Field 1 | grower practice | 21 | 240 | 94 | 2.3 | 19 |
| | skip sidedress 1 | | 140 | 95 | 2.3 | 19 |
| | skip sidedress 1 and 2 | | 40 | 95 | 2.2 | 19 |
| | | | | ns | ns | ns |
| Field 2 | grower practice | 29 | 210 | 92 | 2.5 | 19 |
| | skip sidedress 1 | | 160 | 94 | 2.4 | 19 |
| | skip sidedress 1 and 2 | | 100 | 93 | 2.5 | 19 |
| | | | | ns | ns | ns |
| Field 3 | grower practice | 28 | 232 | 93 | 2.1 | 18a[w] |
| | skip sidedress 2 | | 165 | 93 | 2.1 | 18a |
| | skip sidedress 1 and 2 | | 102 | 94 | 2.1 | 16b |
| | | | | ns | ns | * |
| Field 4 | grower practice | 47 | 280 | 82 | 2.0 | 23 |
| | skip sidedress 1 | | 210 | 83 | 2.0 | 23 |
| | skip sidedress 1 and 2 | | 110 | 85 | 2.1 | 23 |
| | | | | ns | ns | ns |
| Field 5 | grower practice | 19 | 130 | 86 | 1.4 | 13 |
| | reduce sidedress 1 by 50% | | 93 | 88 | 1.5 | 13 |
| | skip sidedress 1 | | 55 | 83 | 1.4 | 13 |
| | | | | ns | ns | ns |
| Field 6 | grower practice | 35 | 130 | 88 | 1.6 | 22 |
| | reduce sidedress 1 by 50% | | 93 | 81 | 1.5 | 22 |
| | skip sidedress 1 | | 55 | 82 | 1.5 | 20 |
| | | | | ns | ns | ns |

| | | | | | |
|---|---|---|---|---|---|
| Field 7 | grower practice | 39 | 264 | 80 | 1.9 |
| | skip sidedress 1 | | 184 | 83 | 1.9 |
| | skip sidedress 1 and 2 | | 104 | 78 | 1.9 |
| | | | | ns | ns |

*,ns treatment means significantly different, or not different, at p = .10

z immediately before sidedress 1

y % of plants meeting the harvest standards of the commercial crew in that field

x color of exposed wrapper leaf, measured by a Minolta 502 leaf reflectance meter

w mean separation among treatments by Duncan's Multiple Range Test, p = .10

Table 1 (con't.). Response of head lettuce to varying nitrogen regimes.

| | N treatment | Soil $NO_3$-N[z] (PPM) | Seasonal application (lb/acre) | Marketable yield: % of plants harvested[y] | Marketable yield: mean head wt. (lb.) |
|---|---|---|---|---|---|
| Field 8 | grower practice | 28 | 255 | 79 | 1.7 |
| | skip sidedress 1 | | 175 | 84 | 1.7 |
| | skip sidedress 1 and 2 | | 95 | 82 | 1.7 |
| | | | | ns | ns |
| Field 9 | grower practice | 35 | 139 | 64 | 1.9 |
| | skip sidedress 1 | | 77 | 65 | 1.9 |
| | skip sidedress 1 and 2 | | 15 | 61 | 1.9 |
| | | | | ns | ns |
| Field 10 | grower practice | 18 | 126 | 75 | 1.9 |
| | skip sidedress 1 | | 39 | 79 | 1.8 |
| | | | | ns | ns |
| Field 11 | grower practice | 28 | 168 | 75 | 1.9 |
| | skip sidedress 1 | | 119 | 77 | 2.0 |
| | skip sidedress 1 and 2 | | 39 | 73 | 1.9 |
| | | | | ns | ns |

[*,ns]treatment means significantly different, or not different, at $p = .10$
[z]immediately before sidedress 1
[y]% of plants meeting the harvest standards of the commercial crew in that field

Table 2. Response of celery to varying nitrogen regimes.

| | N Treatment | Soil $NO_3$-N[z] (PPM) | Seasonal N application (lb/acre) | Marketable yield size distribution (%) 18s | 24s | 30s | 36s | mean plant wt. (lb) | Leaf color[y] |
|---|---|---|---|---|---|---|---|---|---|
| Field 1 | grower practice | 45 | 517 | 2 | 51 | 26 | 16 | 2.3 | 33 |
| | skip sidedress 1 and 3 | | 310 | 5 | 60 | 20 | 14 | 2.4 | 33 |
| | skip sidedress 1, 2 and 3 | | 206 | 1 | 54 | 23 | 17 | 2.3 | 34 |
| | | | | ns | ns | ns | ns | ns | ns |
| Field 2 | grower practice | 35 | 535 | 2 | 26 | 36 | 29 | 1.8 | 32 |
| | skip sidedress 1 and 3 | | 329 | 5 | 20 | 40 | 27 | 1.9 | 34 |
| | skip all sidedress | | 114 | 5 | 21 | 35 | 30 | 1.8 | 31 |
| | | | | ns | ns | ns | ns | ns | ns |
| Field 3 | grower practice | 44 | 437 | | 9 | 38 | 41 | 1.8 | |
| | reduce sidedress 1 by 50% | | 366 | | 10 | 43 | 36 | 1.9 | |
| | skip sidedress 1 | | 294 | | 6 | 48 | 34 | 1.8 | |
| | | | | | ns | ns | ns | ns | |
| Field 4 | grower practice | 21 | 422 | | 2 | 31 | 46 | 2.0 | |
| | reduce sidedress 1 by 50% | | 351 | | 2 | 31 | 50 | 2.0 | |
| | reduce sidedress 1 and 2 by 50% | | 279 | | 1 | 27 | 51 | 1.8 | |
| | | | | | ns | ns | ns | ns | |
| Field 5 | grower practice | 47 | 324 | 1 | 47 | 39 | 14 | 2.0 | |
| | skip sidedress 1 | | 222 | 3 | 53 | 31 | 13 | 2.1 | |
| | skip sidedress 1 and 2 | | 180 | 1 | 48 | 38 | 14 | 2.0 | |
| | | | | ns | ns | ns | ns | ns | |

[ns]treatment means not significantly different at p = .10
[z]immediately before sidedress 1
[y]relative color of canopy leaves, as measured by leaf reflectance meter

Table 3. Response of cauliflower to varying nitrogen regimes.

| | N treatment | Soil $NO_3$-N[z] (PPM) | Seasonal N application (lb/acre) | Marketable yield size distribution (%) 9s | 12s | 16s | mean head wt. (lb) |
|---|---|---|---|---|---|---|---|
| Field 1 | grower practice | 18 | 284 | 9 | 47 | 23 | 2.2 |
| | skip sidedress 1 | | 184 | 9 | 59 | 13 | 2.2 |
| | skip sidedress 1 and 2 | | 84 | 7 | 52 | 20 | 2.2 |
| | | | | ns | ns | ns | ns |
| Field 2 | grower practice | 30 | 405 | 4 | 38 | 39 | 1.8a[y] |
| | skip sidedress 1 | | 333 | 2 | 40 | 31 | 1.6a |
| | skip sidedress 1 and 2 | | 262 | 1 | 32 | 41 | 1.3b |
| | | | | ns | ns | ns | * |
| Field 3 | grower practice | 54 | 279 | 3 | 44 | 24 | 2.1 |
| | skip sidedress 1 | | 178 | 7 | 40 | 19 | 2.2 |
| | | | | ns | ns | ns | ns |
| Field 4 | grower practice | 44 | 346 | 3 | 20 | 11 | 1.8 |
| | skip sidedress 1 | | 239 | 2 | 18 | 11 | 2.0 |
| | | | | ns | ns | ns | ns |

[*,ns]treatment means significantly different, or not different, at p = .01
[z]immediately before sidedress 1
[y]mean separation among treatments by Duncan's Multiple Range Test, p = .10

Table 4. Response of broccoli to varying nitrogen regimes.

| | N treatment | Soil $NO_3$-N[z] (PPM) | Seasonal N application (lb/acre) | Marketable yield % of plants[y] Crown | Bunch | mean head wt. (lb) |
|---|---|---|---|---|---|---|
| Field 1 | grower practice | 36 | 372 | 14b[x] | 5 | 0.86 |
| | skip sidedress 1 | | 283 | 24a | 2 | 0.81 |
| | skip sidedress 1 and 2 | | 202 | 13b | 2 | 0.84 |
| | | | | * | ns | ns |
| Field 2 | grower practice | 47 | 314 | 23a | 12 | 1.4a |
| | skip sidedress 1 | | 208 | 20a | 13 | 1.3a |
| | skip sidedress 1 and 2 | | 108 | 15b | 14 | 1.1b |
| | | | | ns | ns | * |

[*,ns]treatment means significantly different, or not different, at p = .10
[z]immediately before sidedress 1
[y]%of plants harvested in the first 2 harvests; crown and bunch represent different types of commercial packs, crowns requiring larger heads, of high cosmetic standards
[x]mean separation among N treatments by Duncan's Multiple Range Test, p = .10

Table 5. Summary of lettuce and celery pre-sidedress soil $NO_3$-N testing (PSNT) trials.

| Parameter | Grower practice | Intermediate N treatment | Low N treatment |
|---|---|---|---|
| Lettuce[z] | | | |
| applied N (lb/acre) | 197 | 132 | 68 |
| % of plants harvested | 83 | 84 | 82 |
| ave. head weight (lb) | 1.9 | 1.9 | 1.9 |
| plant N uptake[y] (% of grower practice) | 100 | 97 | 94 |
| Celery[z] | | | |
| applied N (lb/acre) | 447 | 316 | 215 |
| % 18s and 24s | 42 | 46 | 43 |
| ave. head weight (lb) | 2.0 | 2.1 | 2.0 |
| plant N uptake (% of grower practice) | 100 | 95 | 90 |

[z]average of 11 lettuce and 5 celery field trials
[y]total plant N in above-ground biomass, expressed as % of that contained in the grower practice treatment

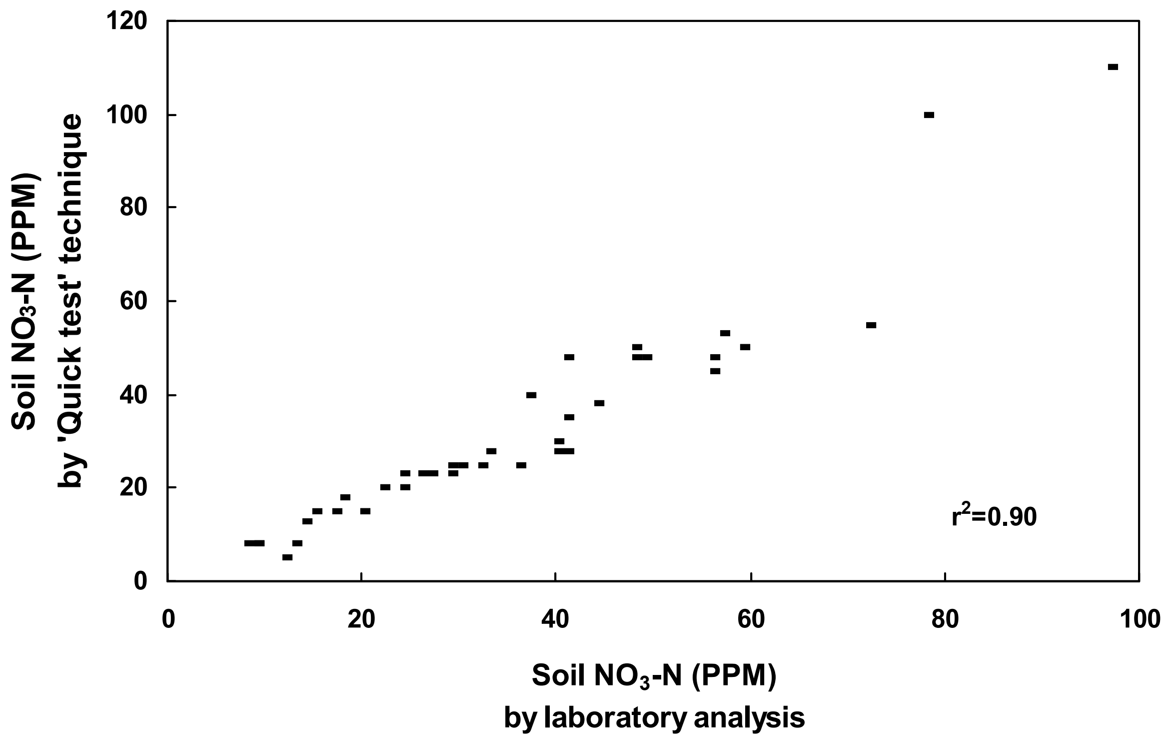


Fig. 1. Correlation of the soil ‘quick test’ techniques with conventional laboratory analysis of soil $NO_3$-N concentration.

## Appendix 1

## Soil $NO_3$-N 'Quick Test'

Procedure:

1) Collect at least 10 soil cores representative of the area surveyed. In furrow-irrigated fields don't include the top 2 inches of soil, which may be too dry for root activity. Do not sample furrow bottoms or where fertilizer bands are placed. Blend the sample thoroughly.

2) Fill a volumetrically marked tube or cylinder to the 30 ml level with .01 M calcium chloride. Any accurately marked tube or cylinder will work, but 50 ml plastic centrifuge tubes with screw caps are convenient and reusable.

3) Add the field moist soil to the tube until the level of the solution rises to 40 ml; cap tightly and shake vigorously until all clods are thoroughly dispersed. It is critical that the soil you test is representative of the sample; for moist clay soils that are difficult to blend pinch off and test several small pieces of each soil core. Testing duplicate samples will minimize variability.

4) Let the sample sit until the soil particles settle out and a clear zone of solution forms at the top of the tube. This may take only a few minutes for sandy soils, an hour or more for clay soils.

5) Dip a Merckquant® nitrate test strip into the clear zone of solution, shake off excess solution, and wait 60 seconds. Compare the color that has developed on the strip with the color chart provided.

Interpretation of results:

The nitrate test strips are calibrated in parts per million (PPM) $NO_3^-$. Conversion to PPM $NO_3$-N in dry soil requires dividing the strip reading by a correction factor based on soil texture and moisture:

strip reading ÷ correction factor = PPM $NO_3$-N in dry soil

| | Correction factor | |
|---|---|---|
| Soil texture | Moist soil | Dry soil |
| sand | 2.3 | 2.6 |
| loam | 2.0 | 2.4 |
| clay | 1.7 | 2.2 |

Soil less than 10 PPM $NO_3$-N have limited N supply and may respond to immediate fertilization. Soils between 10-20 PPM $NO_3$-N have enough N to meet immediate plant needs but a modest amount of sidedress N is appropriate. Soil $NO_3$-N greater than 20 PPM indicates that additional N application should be postponed until retesting shows that residual soil $NO_3$-N has declined.

Supply vendors:

| | |
|---|---|
| centrifuge tubes and calcium chloride | Univ. of Calif. Cooperative Extension offices in Monterey and Santa Barbara Counties; kits provided free or at nominal cost for local clientele |
| Merckquant® nitrate test strips (0-500 PPM nitrate test range) | Ben Meadows Co.<br>3589 Broad Street<br>Atlanta, GA 30314<br>(800) 241-6401 |

# Appendix 2

## Cultural Detail for PSNT Trials

Lettuce:

Field 1: Loam texture, seeded March 12, 1996. Forty lb N/acre applied through sprinklers after emergence. 2 sidedressings of 100 lb N/acre each. Harvested 6/7/96.

Field 2: Sandy loam texture, seeded April 28, 1996. Sixty lb N/acre preplant, 40 lb N/acre applied through sprinklers. 2 sidedressings of a total of 110 lb N/acre. Harvested 6/14/96.

Field 3: Sandy loam texture, seeded April 23, 1996. Sixty lb N/acre preplant, 42 lb N/acre applied through sprinklers. 2 sidedressings of a total of 130 lb N/acre. Harvested on 7/10/96.

Field 4: Loam texture, seeded April 27, 1996. Seventy lb N/acre preplant, 40 lb N/acre applied through sprinklers. 2 sidedressings of a total of 170 lb N/acre. Harvested on 7/16/96.

Field 5: Silt loam texture, seeded July 23, 1997. Fifteen lb N/acre preplant. One sidedress of 75 lb N/acre; 40 lb N/acre in the last irrigation. Plots evaluated 9/25/97, one day before commercial harvest.

Field 6: Clay loam texture, seeded July 26, 1997. Fifteen lb N/acre preplant. One sidedress of 75 lb N/acre; 40 lb N/acre in the last irrigation. Plots evaluated 9/27/97, two days before commercial harvest.

Field 7: Silty clay texture. Seeded April 8, 1997. Twenty-four lb N/acre preplant; 3 sidedressings of a total of 240 lb N/acre. Harvested 6/24/97.

Field 8: Loam texture. Seeded July 22, 1997. Fifteen lb N/acre preplant; 3 sidedressings of a total of 240 lb N/acre. Harvested 9/23/97.

Field 9: Loam texture. Seeded July 16, 1997. Fifteen lb N/acre preplant; 2 sidedressings of a total of 124 lb N/acre. Harvested 9/17/97.

Field 10: Silty loam texture. Seeded July 20, 1997. Thirty-nine lb N/acre preplant, one sidedress of 87 lb N/acre. Harvested 9/19/97, 3 days before commercial harvest.

Field 11: Silty loam texture. Seeded July 16, 1997. Thirty-nine lb N/acre preplant; 2 sidedressings of a total of 129 lb N/acre. Harvested 9/19/97.

Celery:

Field 1: Loam texture, transplanted 7/22/96. Preplant application of 55 lb N/acre; 42 lb N/acre applied through sprinklers. Four sidedress applications of a total of 420 lb N/acre. Harvested 10/29/86.

Field 2: Loam texture, transplanted 7/9/96. Preplant application of 71 lb N/acre, 42 lb N/acre (AN-20) applied through sprinklers. Four applications of a total of 421 lb N/acre. Harvested 10/15/96.

Field 3: Silt loam texture. Transplanted August 25, 1996. Thirty lb N/acre preplant; 2 sidedressings of a total of 285 lb N/acre. Water run application of 122 lb N/acre. Harvested 1/13/97.

Field 4: Loam texture. Transplanted February 26, 1997. Thirty lb N/acre preplant; 2 sidedressings of a total of 285 lb N/acre. Water run application of 108 lb N/acre. Harvested 6/16/97.

Field 5: Clay loam texture. Transplanted April 1, 1997. Twenty-eight lb N/acre preplant; 3 sidedressings of 246 lb N/acre. Water run application of 50 lb N/acre. Harvested 7/2/97.

Cauliflower:

Field 1: Loam texture, transplanted 7/5/96. Forty-two lb N/acre preplant, 42 lb N/acre applied through sprinklers. Two sidedressings of 100 lb N/acre each. First harvest 9/3/96.

Field 2: Sandy loam texture, transplanted 5/17/96. Preplant application of 82 lb N/acre, 42 lb N/acre applied through sprinklers. Three sidedressings of a total of 239 lb N/acre; late season water-run application at 42 lb N/acre. First harvest 7/17/96.

Field 3: Loam texture. Transplanted June 23, 1997. Twenty-four lb N/acre preplant; 2 sidedressings of a total of 202 lb N/acre. Water run application of 53 lb N/acre. First harvest 8/27/97.

Field 4: Sandy loam texture. Transplanted April 24, 1997. Forty-seven lb N/acre preplant, 42 lb N/acre applied through sprinklers. Two sidedressings of a total of 215 lb N/acre; water run application of 42 lb N/acre. First harvest 6/27/97.

Broccoli:

Field 1: Sandy loam texture, seeded 6/13/96. Preplant application of 51 lb N/acre; 42 lb N/acre applied through sprinklers. Three sidedress applications of a total of 241 lb N/acre. Late season water-run application at 39 lb N/acre. First harvest 8/19/96.

Field 2: Loam texture, seeded 8/15/96. Preplant application of 68 lb N/acre; 40 lb N/acre applied through sprinklers. Two sidedress applications of a total of 206 lb N/acre. Harvested 11/26/96.