Research report submitted to:

Organic Farming Research Foundation
P.O. Box 440
Santa Cruz, CA 95061
831-426-6606
www.ofrf.org

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Title: The Effects of Manure, Compost and Feather Meal on Soil Nitrogen Dynamics, Beneficial Soil Microorganisms, and Bell Pepper Yield

Principle Investigator:
Mark Gaskell, Farm Advisor
University of California Cooperative Extension
624 West Foster Rd.
Santa Maria, CA 93455
Tel: (805) 934-6240
Fax: (805) 934-6333 E-mail: mlgaskell@ucdavis.edu

Carolee T. Bull, Ph.D., Research Plant Pathologist,
USDA-ARS 1636 E. Alisal St.
Salinas, CA 93905
Telephone:(831) 755-2889.
Fax: (831) 755-2814. E-mail: CTBull@aol.com

Research Collaborators:
Helmut Klauer, General Manager
Nojoqui Farm
P.O. Box 327
Buellton, CA 93427
Tel: (805) 686-0194
Fax: (805) 6861254 E-mail: nojoqui@utech. net

Organic Farmer Liaison Committee, USDA Experiment Station, Salinas, CA

Locations:
Nojoqui Farm, Buellton, CA
USDA Station, Salinas, CA

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Note: A previous grant for this project was awarded by OFRF in Spring 1998, and is reported under project number 98-04.

This project was designed to determine the effects of applying varying rates of nitrogen (N) as compost or feather meal (FM) (pre plant and side dressed) on plots of transplanted bell peppers with or without a prior green manure crop. These treatments were applied to plots at Nojoqui Farm, a certified organic farm in Buellton (Santa Barbara Co.), CA and certified organic fields at the USDA Experiment Station in Salinas, CA. The project sought to determine the effects of these N treatments as green manure, compost, and / or feather meal on weekly soil residual nitrate-nitrogen (SNN), changes in microbial populations associated with plant disease suppression, and bell pepper yield.

Methodology

Treatments:

- Prior Green Manure (GM) or No Green Manure Crop (NOGM)
- Organic Nitrogen Fertilizer Materials
    - Dairy Manure Compost (New Era 1.5% N, 27% moisture)
    - Feather Meal (12% N)(Peaceful Valley)
- Rates of Nitrogen (lb / Acre):
    - 0
    - 120
    - 208
    - 296

Experimental Design: Split-plot with four replications (Salinas) or five replications (Buellton). Green Manure / NOGM were main plots and materials were sub-plots.

The GM treatments were seeded during November 1999 and incorporated in April 2000 prior to planting. The amounts of GM and N content of the GM between the two locations were similar. Green manure was sampled at each location prior to incorporation and samples were added and analyzed for total N**.** At the Buellton site, approximately 56,960 lb of GM were incorporated per acre.

The 120 lb N treatments received no N amendment pre-plant, the 208 lb treatment rate received 88 lb of N equivalent pre-plant, and the 296 lb N equivalent received 176 lb N equivalent pre-plant. Each of the rate treatments received 40 lb N equivalent of each material at each side dress application on May 25, June 20, and July 10, 2000 (Buellton) or on June 7, June 28, and July 24, 2000. The pre-plant application was made uniformly over the surface of the bed and incorporated. The subsequent side dress applications were banded down the rows of bell peppers and cultivated into the soil. A schematic summary of treatment rates and timing is shown in Fig 1 for the Buellton location. Treatment rates were the same at Salinas but the timing of transplanting and fertilizer application was approximately 12 -15 days later.

Field plots were 20 ft long by three beds (40") wide at Buellton and plots were three beds wide and 85 ft long at Salinas. All three beds received treatments but only the center bed was used for sampling and yield determination. "King Arthur' bell peppers were transplanted into treated plots on May 5, 2000 (Buellton) and May 17, 2000 (Salinas). Pepper transplants in reps four and five were adversely affected by sunburn following transplanting at Buellton. At Salinas, planting was delayed another two weeks beyond that of Buellton and plants were sunburned in all plots. These plants eventually began normal development again following a three-week recovery period but yield data were not usable from these plots. We suspect that the sunburning resulted from transplants that were too closely spaced in the greenhouse compounded by delays in preparation for transplanting contributing to extended internodes.

Weekly soil sampling for SNN in each field plot was done using a plastic bucket and trowel with 5-6 samples taken randomly down the row at a 2-4 inch depth, bulked together into the bucket, and a sub-sample taken from the bucket for extraction in the laboratory and subsequent analysis. Samples were refrigerated prior to transporting to the laboratory for extraction with 2 N KCL using standard procedures. Extracts were subsequently sent to the Division of Agriculture and Natural Resources (DANR) soil and plant testing laboratory at the University of California, Davis, CA for determination of nitrate - N concentration.

Results and Discussion

Soil Nitrate Nitrogen

There was a clear effect of the prior GM incorporation on weekly SNN over the season at the Buellton location (Fig. 2). There was an early burst of SNN for 2-4 weeks following GM incorporation and then at Buellton there was a continuing small but consistent positive effect of GM on SNN throughout the season. In Salinas, there was not an early release apparent from this sampling data perhaps because the GM was incorporated five weeks prior to the beginning of sampling in Salinas. At the Salinas site, the SNN increased in the GM plots at weeks 8-12, but otherwise the effect of GM was small and inconsistent during the season (Fig. 3). The early effect of the GM was likely lost by the longer period between incorporation and sampling at Salinas. The effect of GM on weekly SNN was small but consistent at Buellton and the lack of a consistent effect of GM at Salinas may have been obscured by fewer replicates.

There were marked and consistent differences in weekly residual SNN among materials and rates (Figs. 4-7). The weekly SNN was greater in FM treated plots (Figs. 5,7,8,9) than in compost treated plots (Figs. 4,6,8,9) over the course of the season at both sites. The SNN following FM application was generally related to the amount of N applied and lagged application one to three weeks at both sites (Figs. 5, 7). The weekly SNN generally follows a wave pattern over the season in FM treated plots with higher levels following higher N application as FM. The FM appears to be reliable organic source of N with a relatively large amount of the N in FM available as nitrate for the growing crop. There are research reports to support a range of 20-30 ppm nitrate-N, as a desirable soil level for vegetables and it is clear that the FM can attain and sustain those levels at the rates evaluated in this experiment.

The effect of compost application on weekly SNN was small at the Buellton location following an initial release from the pre-plant application and incorporation (Fig. 4). At Salinas, there was a more marked increase in SNN following compost application, SNN increased with increased compost application some weeks, and there was an effect of the side dress compost applications (Fig. 6). The SNN was not consistently affected by compost application at Buellton and at Salinas, compost treated

Plots did not elevate SNN sufficiently to be a reliable source of N for vegetables. The SNN of compost treated plots was always lower than similar N rate FM treated plots at both sites (Figs. 8,9). This is in agreement with prior studies indicating greater weekly SNN availability in FM treated plots than compost treated plots.

The overall inconsistency of compost as a source of N may be due to the heterogeneous nature of compost. With compost, there are marked variations in composition, particle size, and moisture content and this affects its reliability as a consistent source of SNN. There is considerable field variability in SNN regardless of the material as evidenced by the error bars in Figs. 8 and 9 and it is important to have as many field replicates as possible and continue sampling weekly to develop the pattern of SNN availability in the field. But even with attempts to minimize experimental error the SNN from compost treated plots was more variable than from FM treated plots.

Early pre-plant applications of amendments accounted for the differences in treatment rates as this experiment was designed, but the higher residual SNN evident from FM treated plots at later dates, indicates that FM was a more readily available source of N than the compost materials. It is uncertain if this due to higher solubility of the N in FM or more rapid microbial decomposition of the FM or both of these factors. The physical differences in the materials may have also contributed to more rapid mineralization by the FM over compost if it was more easily and uniformly mixed with moist soil where microbiological activity is greater. The compost material was lower analysis and bulkier than the FM at a given N application rate. The greater volume of the less homogenous compost material affects how uniformly the materials are mixed in the root zone during side dress banded applications. There is considerable field variability in SNN regardless of the material as evidenced by the error bars in Figs. 8 and 9 and it is important to have as many field replicates as possible and continue sampling weekly to develop the pattern of SNN availability in the field.

Changes in Microbial Populations

We proposed to evaluate changes in microbial populations associated with plant disease suppression and bell pepper yield with financing from USDA-ARS. The treated plots were sampled but due to unforeseen budget limitations, Dr. Bull was not able to run the sample analyses. She has indicated that she will perform the assays as part of future budget allocations and file an amendment to this report at that time.

Pepper Yield

The yield of early peppers and extra large (XL) peppers were both increased with increasing amounts of N as FM up to 208 lb N per acre (Figs. 10-1 3). Yield of extra large fruit and early harvested fruit is important because these often bring price premiums to growers. The yield of early and extra large peppers were increased by higher rates of FM whether a prior GM crop was incorporated or not but the shape of the response was different for GM and NOGM plots (Fig. 14). There was a positive response of XL sized peppers up to 208 lb N per acre as FM if there was no prior GM crop, but following a GM crop the response was apparent up to 120 lb N per acre. The plots without a prior GM crop needed approximately 208 lb of N as FM to reach XLyields similar to plots with a prior GM crop with 120 lb of N as FM (Fig. 14). Apparently incorporation of the GM material has an equivalent effect to application of an additional 1 00 lb of N as FM (Fig 14).

There were not significant differences in total yield of peppers due to the different materials or rates. The yield following application of varying rates of compost was more variable (Fig. 15) and there were no significant yield responses to varying rates of the compost. The fact that there was overall less variability and a more consistent relationship between yield and rate of FM also suggests that there are marked differences in the materials irrespective of N rate. The weekly SNN following compost application discussed above was also highly variable and not related to rate of application suggesting that compost has little effect on yield because it has little short-term effect on soil N. The data for yield overall was more variable than soil sample data because of fewer replicates available for yield determination. Yield could only be measured on three of the five replicate plots in each treatment at Bueliton because peppers in two of the five reps were sun and wind burned at transplanting. These plots eventually recovered but could not be compared to the other replicate plots. At Salinas, all plots were sunburned following transplanting and harvest was delayed and the yield data was not useful for Salinas.

The higher SNN in FM treated plots apparently contributed to a higher yield of early and extra large peppers. The higher SNN likely contributed to earlier and larger peppers but apparently even without high SNN, the longer-term N supplying power of the soil was adequate for overall pepper production. Also, it may be that the plants compensate with overall yield to some extent by setting more peppers when larger peppers take up resources on the plant.

Cost Benefit Analysis The data indicate a clear yield response of early and XL peppers to FM application, and although there is a price premium for early and XL peppers, the response was not sufficient to improve income at current costs of FM (Figs-16-17). Using $0.60/lb for early or XL peppers and $0.50/lb for all others (values from Nojoqui Farm estimates), the income calculated for the different treatments closely follows yield data which show no striking overall differences among treatments. And when the income is based on dollar value of peppers produced per dollar of fertilizer applied (compost at $2 / lb of N; FM at $2.05 / lb of N), the zero fertilizer rates show clear advantages. There appear to be unexplained yield differences among untreated plots without GM having higher yield than untreated plots with GM. These were not statistically significant differences and it is not clear why there would be such an effect. These observations should be evaluated by additional field trials.

This experiment should be repeated to verify the observed responses and to expand the number of replicates for yield determination in treated plots. Additional studies should be conducted to determine more precisely how rate and timing of the application of the different organic fertilizer materials could be optimized.

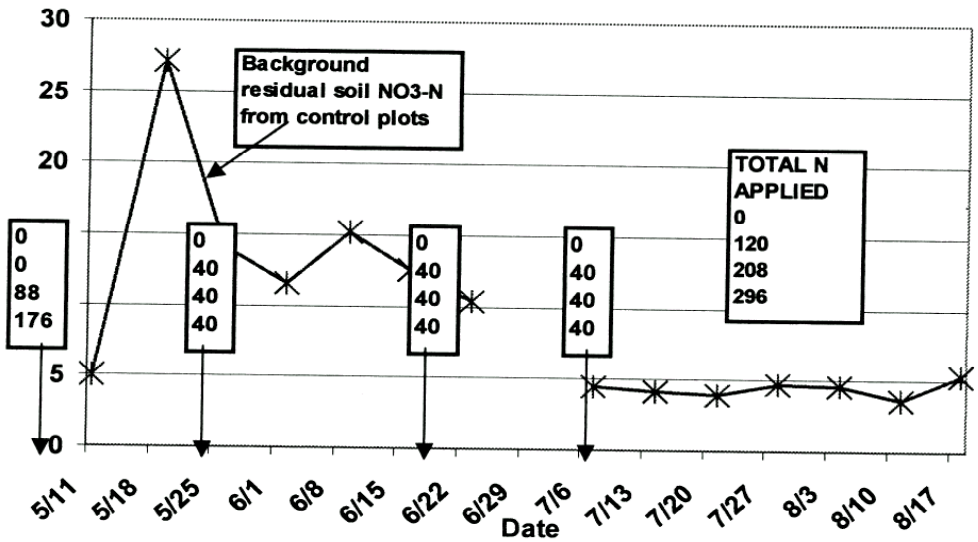

Figure 1. Treatment rates and timing of applied N for different fertilizer materials. Buellton, CA 2000 season. Treatments at Salinas were generally 20 days later.

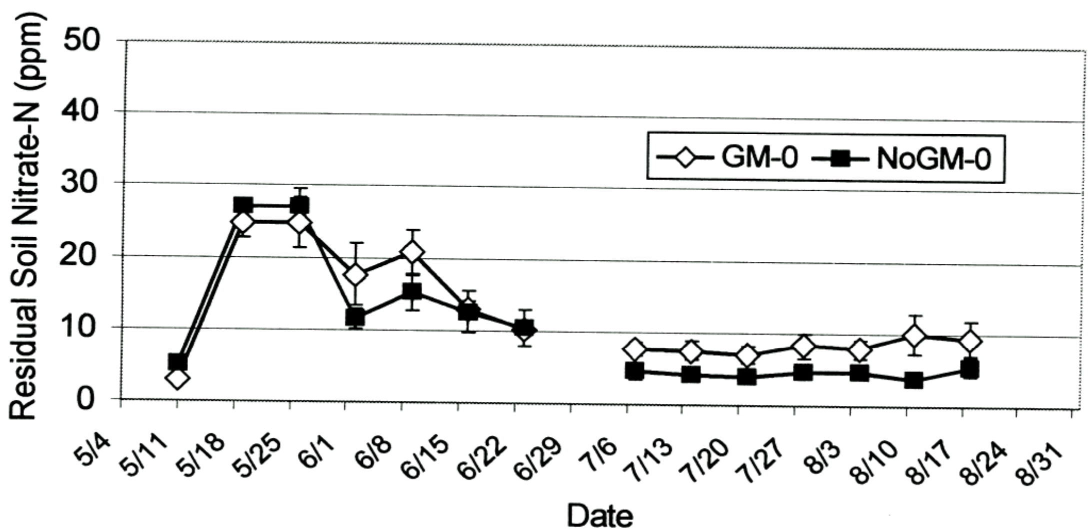

Figure 2. Weekly residual soil nitrate nitrogen following incorporation of a green manure crop or without a prior green manure crop. Buellton, CA 2000 season.

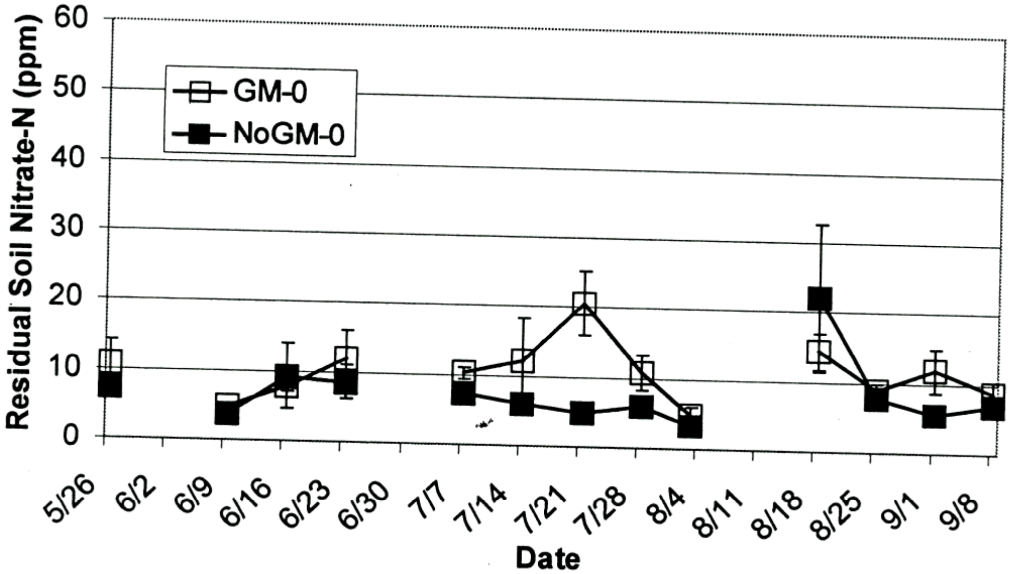

Figure 3. Weekly residual soil nitrate nitrogen following incorporation of a prior green manure crop or without a prior green manure crop. Salinas, CA 2000.

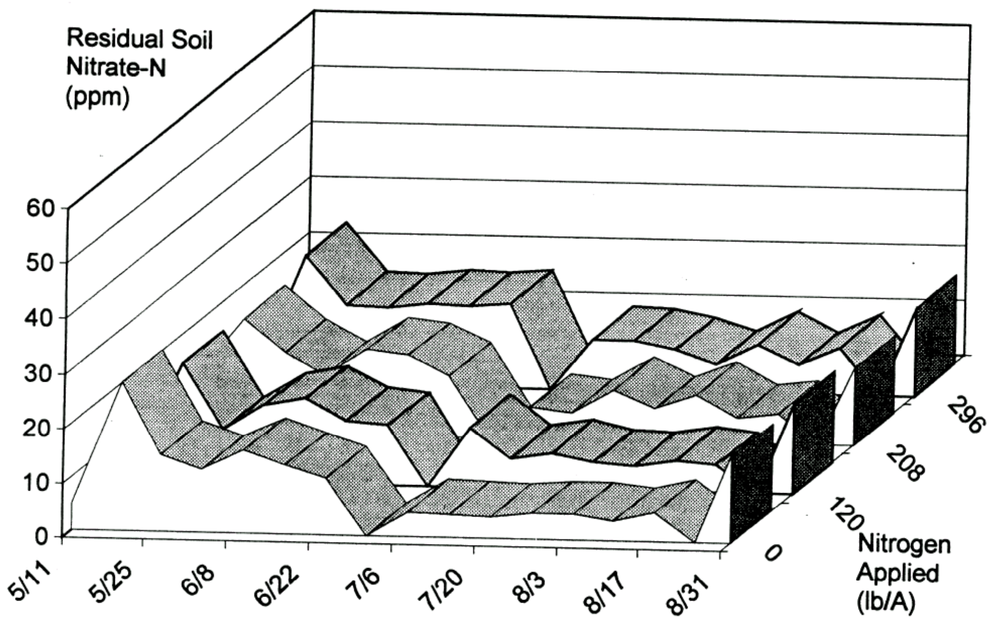

Figure 4. Weekly residual soil nitrate nitrogen (ppm) following applicaton of varying rates of compost after a prior green manure crop. Buellton, CA 2000 season.

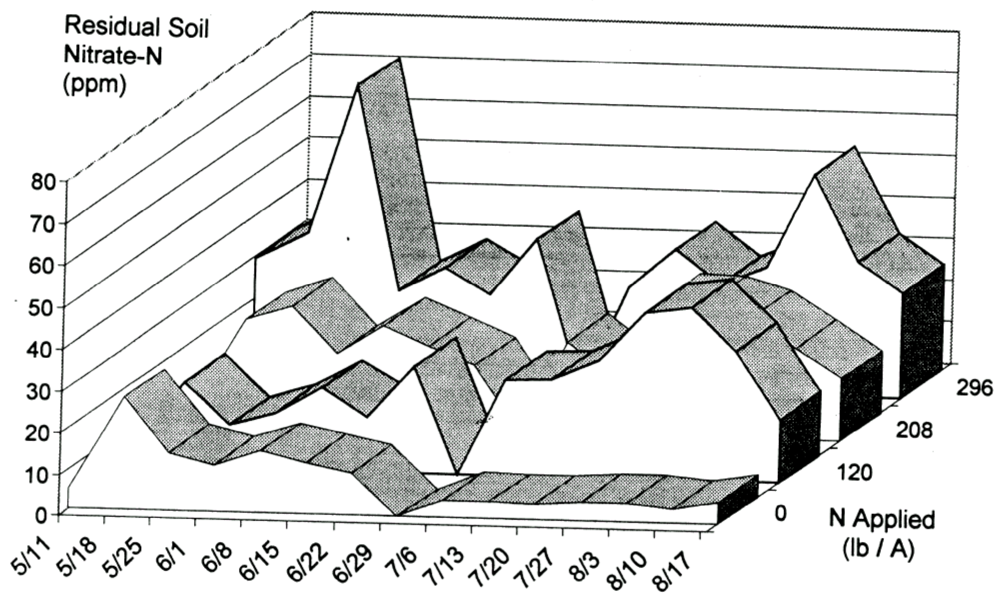

Figure 5. Weekly residual soil nitrate-N following application of varying rates of feather meal after a prior green manure crop. Buellton, CA 2000 season.

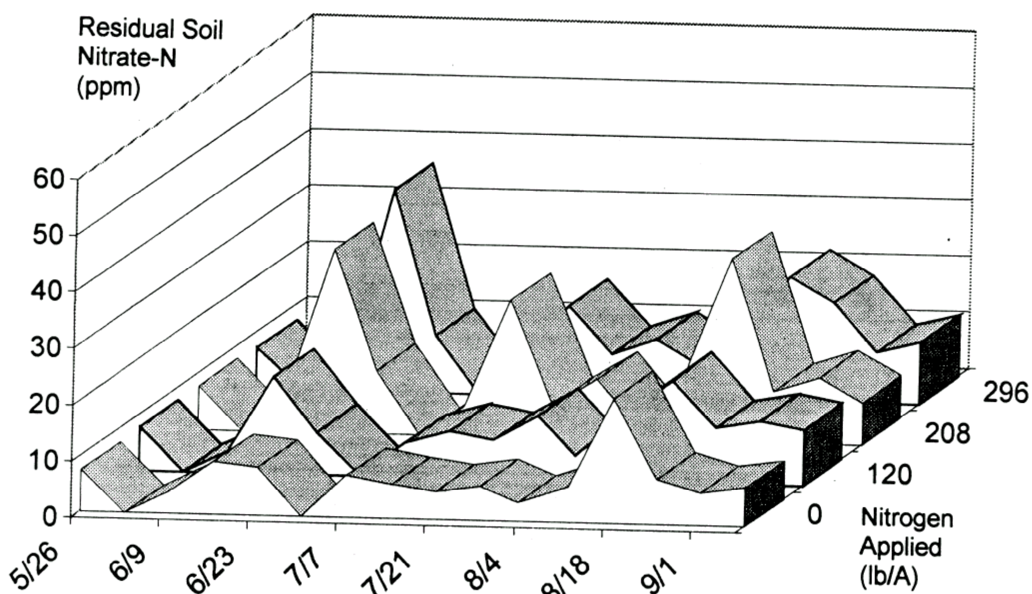

Figure 6. Weekly residual soil nitrate nitrogen following application of varying rates of compost after a prior green manure crop. Salinas, CA 2000.

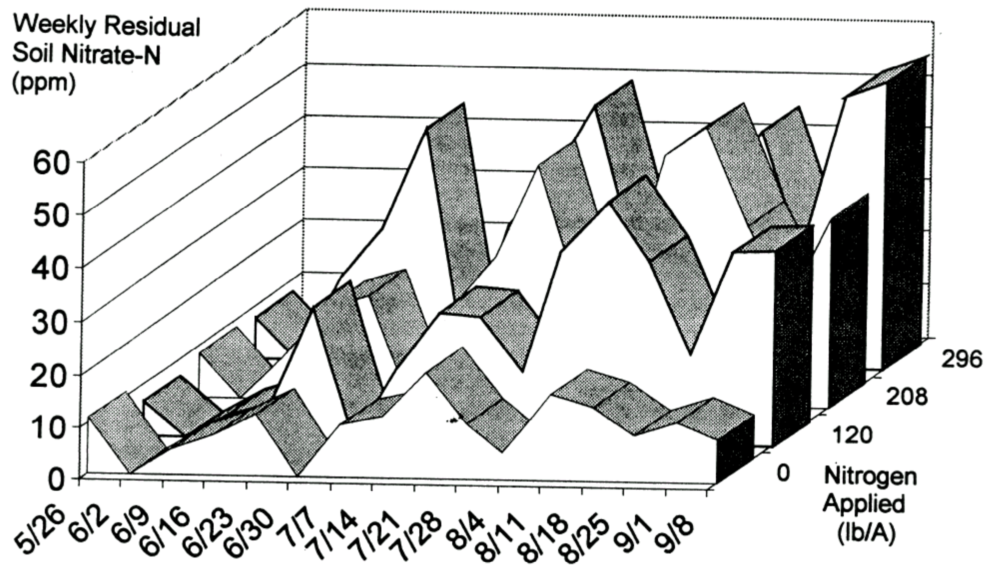

Figure 7. Weekly residual soil nitrate nitrogen following application of varying rates of feather meal after a prior green manure crop. Salinas, CA 2000 season.

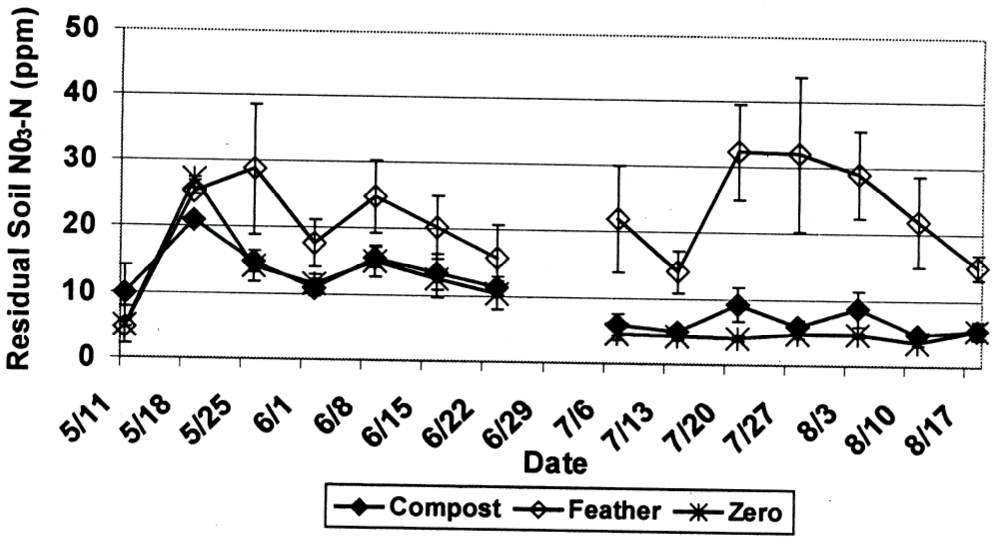

Figure 8. Weekly residual soil nitrate-N following a green manure crop plus application of 208 lb N per acre as either compost or feather meal compared to zero N application. Buellton, CA 2000 season. Error bars are plus or minus one S.E.

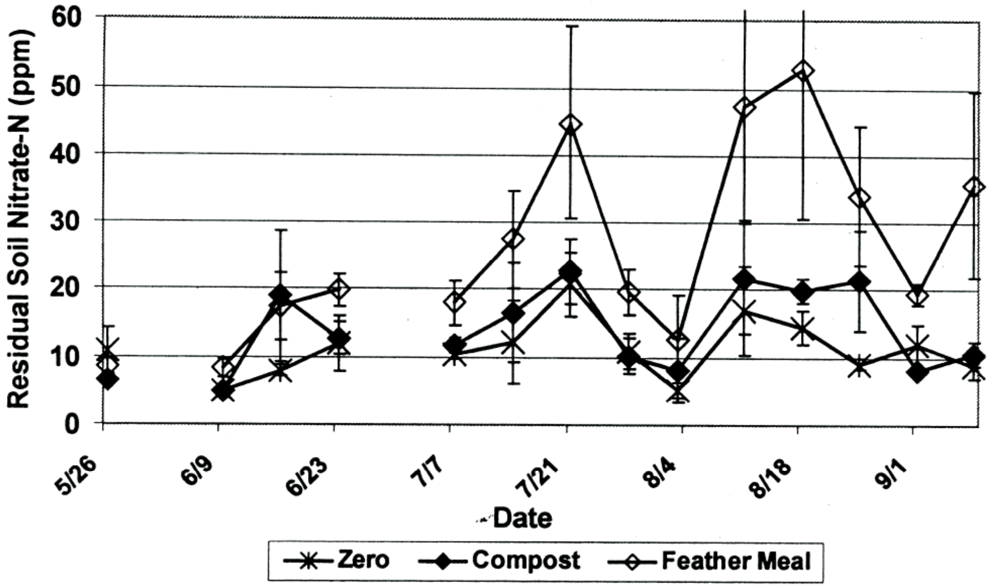

Figure 9. Weekly residual soil nitrate-N following a green manure crop plus application of 208 lb N per acre as either compost or feather meal compared to zero N application. Salinas, CA 2000 season. Error bars are plus or minus one S.E.

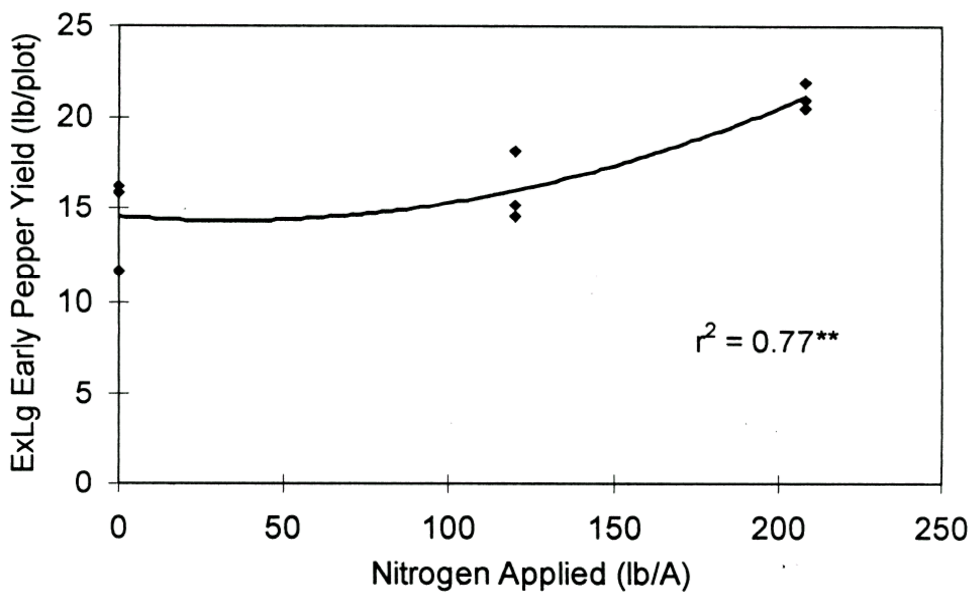

Figure 10. Early (pick 1& 2), extra large bell pepper yield following application of varying rates of feather meal (FM) without a prior green manure. Buellton, CA. 2000 season.

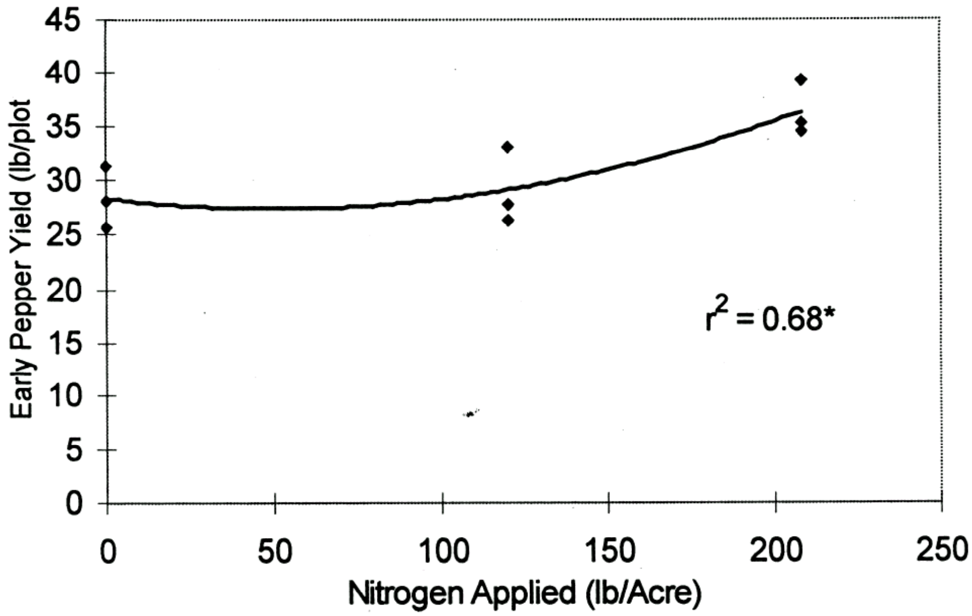

Figure 12. Early (pick 1&2) total bell pepper yield following application of varying rates of feather meal (FM) without a prior green manure. Buellton, CA 2000 season.

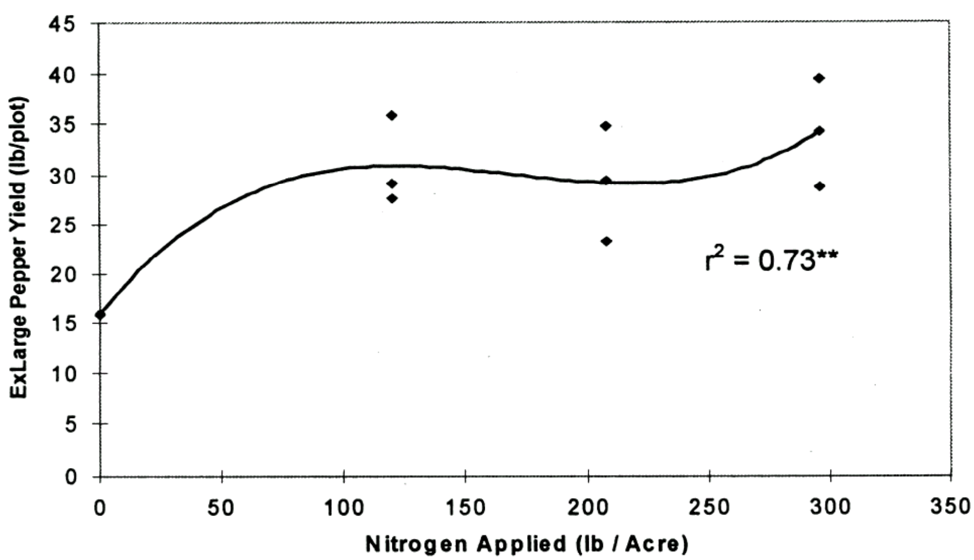

Figure 13. Extra large bell pepper yield following application of varying rates of feather meal (FM) with a prior green manure crop. Buellton, CA 2000 season.

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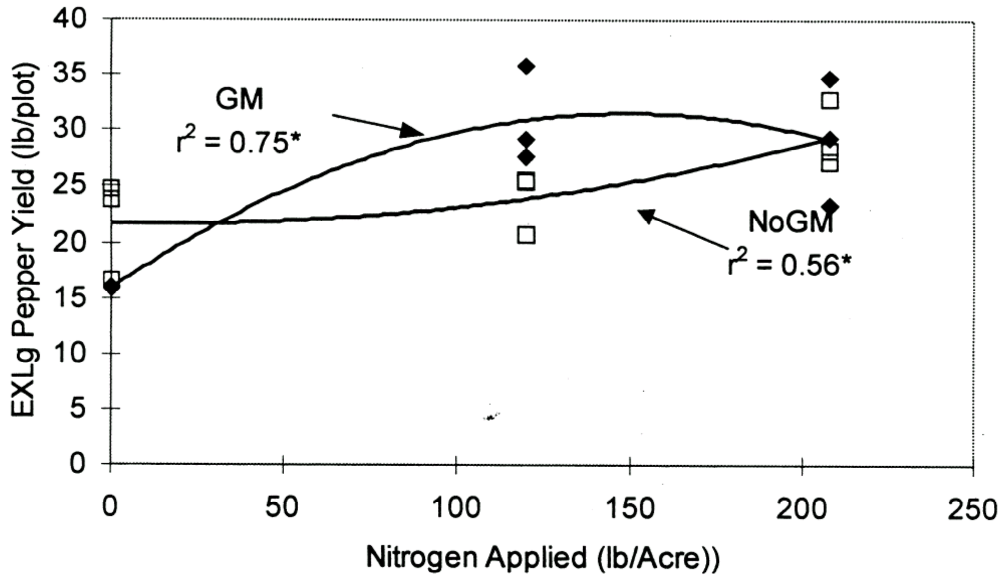

Figure 14. Extra large bell pepper yield following application of varying rates of feather meal with or without a prior green manure crop. Buellton, CA 2000 season.

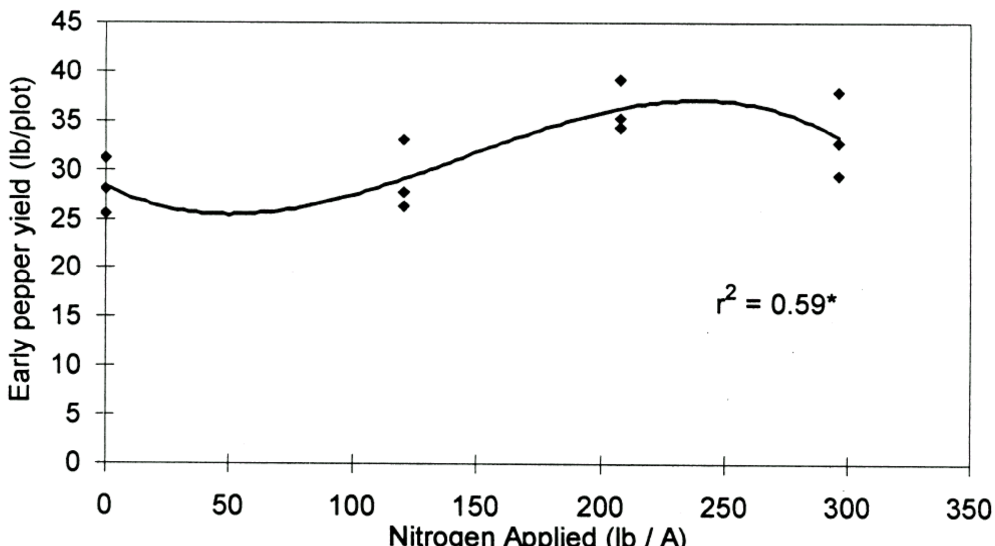

Figure 15. Early (pick 1& 2) bell pepper yield following application of varying rates of feather meal without a prior green manure. Buellton, CA 2000.

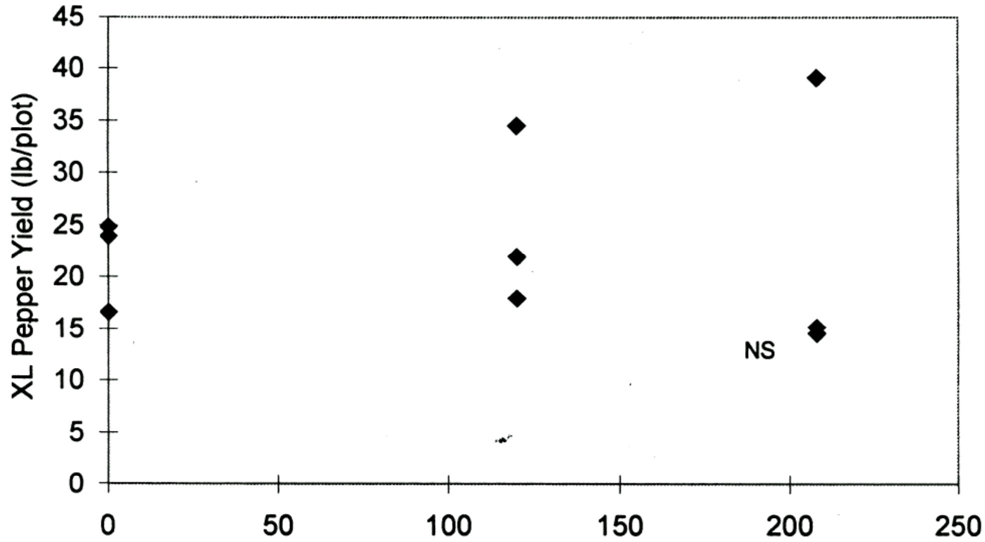

Figure 16. Extra large bell pepper yield following application of varying rates of compost with a prior green manure crop. Buellton, CA 2000 season.

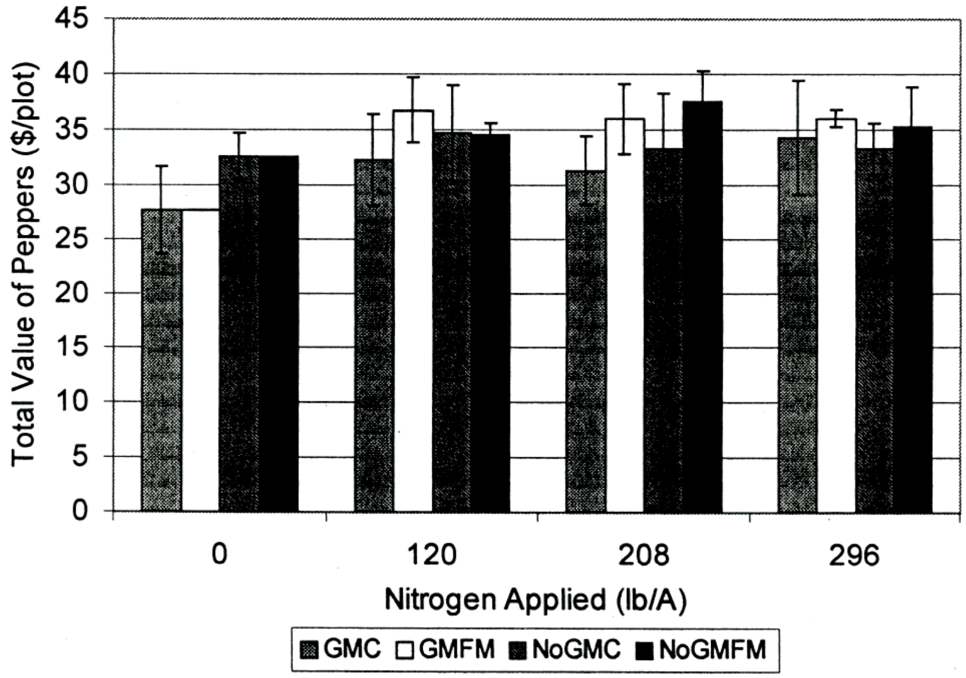

Figure 17. Total income from peppers produced with varying rates of compost (C) or feather meal (FM) with or without a prior green manure (GM) crop. Buellton, CA 2000 season.

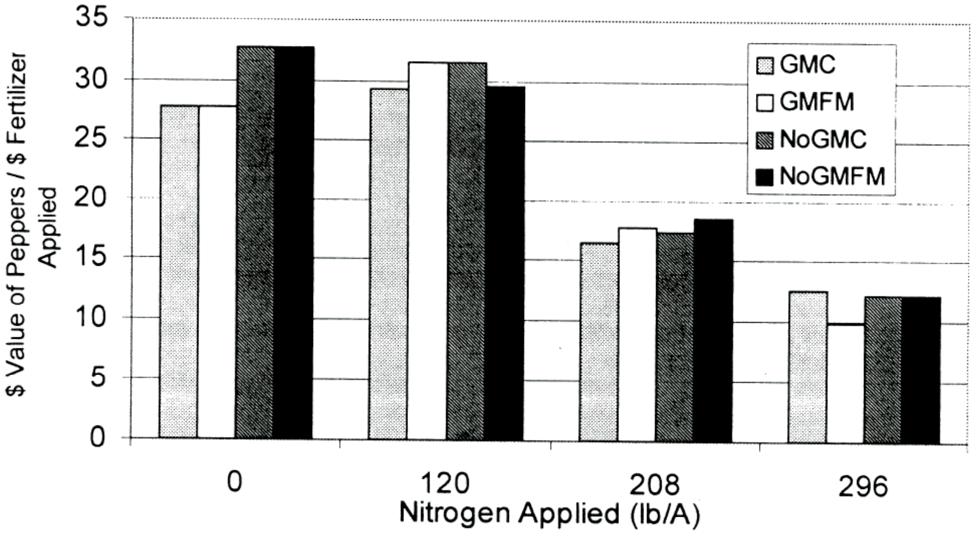

Figure 18. Income from peppers ($) per dollar of fertilizer applied as varying rates of compost (C) or feather meal (FM) with or without a prior green manure (GM) crop. Buellton, CA 2000 season.