ORGANIC FARMING RESEARCH FOUNDATION

Project Report

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FINAL REPORT
for
EFFICIENT USE OF ORGANIC NITROGEN FERTILIZER SOURCES

presented to

ORGANIC FARMING RESEARCH FOUNDATION

prepared by

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PROBLEM

Many organic growers utilize a preceding cover crop or diverse types of organic fertilizer materials for fertility management. Cover crops are one of the most economical sources of organic nitrogen and provide additional potential benefits for succeeding crops. Time or market constraints and the need to intensively farm high value land may limit the use of cover crops and increase the need to utilize organic fertilizer sources of plant nutrients.

There is a wide array of general guidelines on organic fertilization available in many texts. Many studies conducted over the years with fresh and aged manure are the basis for many of the organic fertilization guidelines. Compost and the different types of commercially available organic fertilizers are very different from manure, and little information is available on their effect on soil nitrogen dynamics and vegetable crop yield.

Compost is often the most economical source of pre-plant applied nitrogen but other organic fertilizer sources may be more convenient for subsequent side dress or fertigation application. Depending upon the composition of the compost there other factors (e.g boron content) which may limit continuous application of compost as a sole source of nitrogen. Several types of commercially available nitrogen fertilizer materials are approved for organic certification but little information exists on optimal management of these materials. Little data has been collected comparing different organic fertilizer materials and different modes of application of these materials for diverse vegetable crops.

Nitrogen (N) nutrient management is often especially critical for optimum yield and quality of organically grown vegetable crops. There are numerous organic fertilizer materials available and the effective and economical use of these materials is important to organic producers, Little information is available on the optimum form and timing of application of different organic nitrogen fertilizer sources. The cost per unit nitrogen of these materials can vary widely - from approximately $1 per pound of nitrogen for compost materials to $51 per pound of nitrogen for some liquid organic fertilizers. Greater than 50 fold differences in price per unit nitrogen are quoted for different organic fertilizer materials from commercial supply sources.

This study was designed to collect critically needed data on soil nitrogen and vegetable crop response following application of different rates and types of commercially available organic fertilizer materials.

OBJECTIVES

We sought to develop scientific data on soil nitrogen dynamics and bell pepper yield in response to the application of different types of commercially available organic nitrogen fertilizer materials. We conducted the trials on bell peppers, a long-term annual vegetable crop requiring repeated fertilizer application. We compared different rates of pre-plant incorporated application combined with varying additional amounts of side banded, incorporated application. We measured weekly soil nitrate nitrogen (SNN), plant tissue nitrogen, and bell pepper fruit yield associated with the different types of organic fertilizers at different application rates.

MATERIALS AND METHODS

We evaluated seven different organic nitrogen fertilizers during the summer of 1998 on transplanted bell peppers. The trials were conducted at Nojoqui Farm in Santa Barbara Co. near Buellton, CA. Helmut Klauer, General Manager at Nojoqui was a collaborator in the research. The materials evaluated are summarized in Table 1:

Table 1. Organic fertilizer materials, manufacturer, advertised analysis, and estimated cost per unit nitrogen.

Material	**Manufacturer / Source**	**Advertised Analysis** (% **N-P-K)**	**Cost** **($ 1 lb N)**
Compost	New Era	(2 - 1 - 3)	1.00
Pelleted Chicken Manure	Integro	(3.5 - 1 - 7)	6.50
Fish Meal	Peaceful Valley	(10 - 6 - 2)	5.50
Liquid Fish	EcoNutdent	(3.4 - 2 - 0.5)	6.00
Phytamin 800	Peaceful Valley	(7 - 0 - 0)	7.50
Feather Meal	Calif. Org. Fert.	(7 - 1 - 7)	5.50
Seabird Guano	Verditech	(11 - 8 - 2)	6.25

We evaluated each of the materials at application rates equivalent to 60, 120 and 180 lb of N (as commercial product) per acre. Treatments were replicated four times. We established field plots consisting of three 40" beds, 20 feet long. Treatments were applied to all three beds in a plot but only the center bed was used for SSN and yield sampling. Thus, measurements were taken from plots, which had been bordered from neighboring treatments. All treatments were applied by hand to individual plots and subsequently incorporated with a cultivator. Pre-plant applications were applied as broadcast applications which were subsequently incorporated and side-dress applications were applied in 6" wide bands 2" - 4" to the side of plant rows and incorporated with cultivating shoes. All plots were sprinkler irrigated.

The materials were applied as 30 lb N pre-transplant (PRE) and 30 lb. N at 20 days post transplant (POST) for the 60 lb. total N treatment; 60 lb. N PRE and 30 lb. N at 20 days POST and 30 lb. N at 40 days POST for the 120 total lb. N treatment; and 60 lb. N PRE, 30 lb. N at 20 days POST, 45 lb. N at 40 days POST, and 45 lb. N at 70 days POST for the 180 total lb. N treatment. The PRE treatments were applied May 1; side-dress one was applied June 1, side-dress two on June 20 and side-dress three on July 20, 1998. Bell peppers were transplanted on May 14 and the initial SNN sampling was made at transplanting.

The SSN sampling was done by repeated trowel samples down the row and mixed into a small bucket from which the composite sample in each plot was drawn. Samples were transported to the laboratory where they were extracted using 2N KCL according to standard procedures. The KCL extracts were sent to the Division of Agriculture and Natural Resources (DANR) laboratory at the University of California - Davis for nitrate nitrogen determinations.

RESULTS

We measured weekly soil nitrate nitrogen (SNN) over 14 weeks POST, leaf tissue N at week 14, and fresh bell pepper fruit yield for all treatments. Overall, there was frequently a statistically significant increase in SNN with increasing N application rates with each mater.... (Figures 1-7) during a given week. Weekly SNN varied from lows of 4 PPM in the 0 N treated plots to over 80 PPM in FTM treated plots at the 180 N rate. Highest SSN was often observed in FTM, SG, LSM, LF, and FM treated plots at the 180 N rate and peaks in SSN lagged fertilizer application three to four weeks

Plant tissue N also increased with increasing N application rates but these increases were only statistically significant with FTM and SG (Figures 8 - 9). Total pepper yield increased with increasing N rate with all materials (Figures 10-1 3). The different types of materials (Figures 10-1 5) did not as markedly affect total pepper yield as early yield and size. Early yield and percent extra large peppers were the yield traits that varied most among the different fertilizer materials. Highest early yield and largest sizes were observed in FTM treated plots at the high (1 80 lb**. N** rate). The higher early yields and the larger peppers tended to come from those materials such as FTM, SG, LSM, LF, and FM, that had shown higher SNN many weeks. Compost and pelleted chicken manure consistently showed the lowest SNN levels at all levels of applied N. Compost and pelleted chicken manure also produced fewer peppers than the other materials even at the highest N rates.

Weekly SNN, tissue N and yield were all analyzed using analysis of variance (ANOVA) and simple linear regression analyses. The SNN values are generally quite variable in field soils and four replications are the minimum necessary to get reasonably consistent results. The weekly SNN frequently showed statistically significant regression lines with increasing applied N with each of the materials. The relationship between SNN and applied N are never extremely close however, as evidenced by correlation coefficients ranging up to 65-70%. The correlation coefficients of SNN on N rate are not always statistically significant across weeks although the means tend to follow similar patterns. The SNN levels from the different individual treatment materials could be distinguished with 95% confidence some weeks but confidence intervals (95%) around the regression lines often over lap due to the high variability. The total harvested yield (Figure 10-13) is not significantly different (P>0.05) among the fertilizer materials and differences in extra large pepper yield (Figures 11 -13, and Table 2) and early pepper yield (Figure 15) are more useful for identifying the more promising fertilizer materials.

Table 2. Statistical mean separation of extra large grades of bell peppers fertilized with 180 lb. N per acre of the different fertilizer materials. Values followed by the same letter are not significantly different (95% confidence) using Fishers LSD.

MATERIAL	**X Large Pepper Yield (lb. / plot)**	
Feather Meal	23.7	a
Phytamin 800	17.1	ab
Liquid Fish -	16.8	bc
Fish Meal	16.7	bc
Seabird Guano	16.1	bc
Compost	14.9	bc
Pelleted Chicken Manure	11.3	bc

DISCUSSION AND CONCLUSIONS

Figures relating SNN to optimum crop productivity quoted in the scientific literature, typically range from 20 to 40 PPM nitrate nitrogen but little specific data is available for bell peppers or for weekly SNN variability. Little data is available form organic production fields. Results from these trials show higher SNN was associated with higher N application rates with each of the fertilizer materials but even at the highest rates, SSN values do not consistently remain in the range of 20 - 40 PPM. This may mean that N application rates higher than 180 lb N per acre are necessary for optimum yield. Higher N rates would be suggested by the fact that highest yields occurred in these trials at the highest N application rates although differences were not always statistically significant (Figures10-14). The weekly SNN varied markedly among the materials, and in the consistency of their response (statistical significance). Materials such as FTM and SG that frequently had higher SNN also were the only materials to show statistically significant tissue N associated with applied N (Figures 8-9). Only the FTM stands out in terms of bell pepper yield and then only related to larger pepper sizes and higher early yield (Figure 12). Yield of extra large peppers and early peppers is important because these typically carry a sales price premium.

The lack of consistent statistically significant ($P< 0.05$) differences among treatments is not unusual with a variable such as SNN in field soils. More additional study is certainly needed. The trends are very important and provide useful information for arriving at management strategies for the individual materials. The relationships and trends are consistent among materials and rates across weeks and this adds to the value of the data. It will be valuable to repeat this study during another growing season and since SNN and yield are highest at the highest rate it would be valuable to evaluate higher rates of N. It would also be valuable to evaluate the patterns associated with application of these materials during cooler cropping periods.

The different materials were compared from an economic standpoint at the highest N rate. This comparison simply compares gross dollar value of peppers produced (beyond the zero plot yields) per dollar of fertilizer applied. It uses average figures for the different treatments and assumes 50 cents a pound for peppers for the total marketable yield and 75 cents per pound for the early yield plots. These figures were consistent with Nojoqui Farm's prices during the 1998 pepper sales season. These economic analyses are summarized in Figures 16 and 17. Compost treated plots at 180 lb. N produced highest gross economic return per fertilizer dollar, because the compost had such a dramatic cost advantage over the other materials. The lower productivity of the compost overall was overwhelmed in the economic analysis by the dramatic cost advantage for compost. In this economic analysis we assumed that compost was 2% N (as advertised), 25% moisture, and cost $40 per ton applied. The compost is variable however, and cost per unit value of N for compost may vary. The economic comparison may be dramatically affected by cost and composition of the materials. Further study is needed with different types of management of compost as a fertilizer material. It is unclear whether it may be possible to manage compost material in such a way so as to attain the levels of SNN apparently necessary for optimum bell pepper yield and size.

All fertilizer materials samples have been sent to the DANR lab for analysis and nutrient content greatly different from the advertised values will change the economic analysis. Variations in values will also affect performance of the materials, of course but growers cannot be expected to analyze every material coming on to the farm. The variability in composition of organic fertilizer materials is a serious problem limiting their efficient use. Ideally the data presented here and these types of trials will provide an additional tool for growers to more effectively choose between and utilize these materials.

We are only beginning to get reliable scientific data to guide efficient and effective use of these and other important organic fertilizer materials. The results of this study add important new information on the release of **N** from different organic fertilizers and the effects on vegetable crop yield. There is an important role for green manure crops to fill depending upon the cropping intensity of a given farm operation. And economics will only be one of many key factors considered in developing fertilization and soil building strategies. There are other potential problems associated with the long-term, heavy use of compost as would be necessary in an intensive organic production environment. Clearly many other factors need to be considered in the development of a comprehensive strategy for optimum nitrogen management in an organic production environment.

INFORMATION DISSEMINATION

We hosted a field day and grower meeting at Nojoqui Farm on September 9. 1998 at which the preliminary results were discussed and participants had an opportunity to tour the field plots. Other presentations at the meeting covered various aspects of managing **N** in an organic production environment. The research results were also presented at the Santa Barbara Chapter of CCOF Annual Dinner Meeting in December 1998 and at a grower meeting hosted by UC in at the Far Western in Guadalupe, CA on February 3, 1999. An article summarizing this research entitled "Agronomic and Economic Evaluation of Organic Fertilizer Materials" also appeared in the February 1998 edition of Central Coast Highlights, a bimonthly newsletter published by UC - Cooperative Extension in Santa Barbara County. An invited presentation (in Spanish) being presented at a Central American regional meeting in San Pedro Sula, Honduras on March 19, 1999 will also include data from this study. An abstract has been submitted to the American Society for Horticultural Sciences Annual Meeting in Minneapolis, MN July 28-31, 1999 at which this data will be presented as a poster paper or as part of the colloquium on Organic Horticulture. Other opportunities will no doubt arise to share these results with interested growers.

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Finally, we appreciate the financial support of the Organic Farm Research Foundation who funded this study.

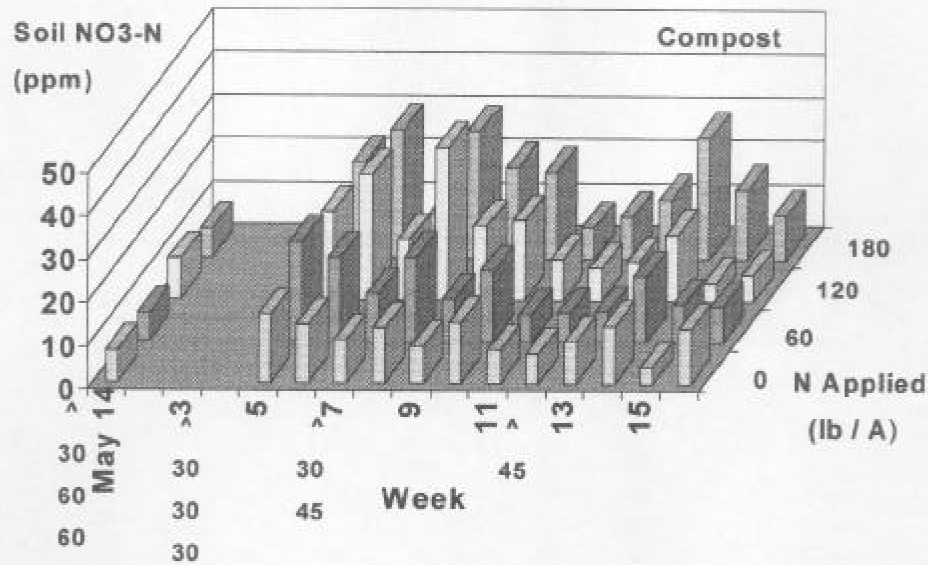


Figure 1. Weekly soil nitrate nitrogen following application of three rates of compost. Values are means of four replicates.

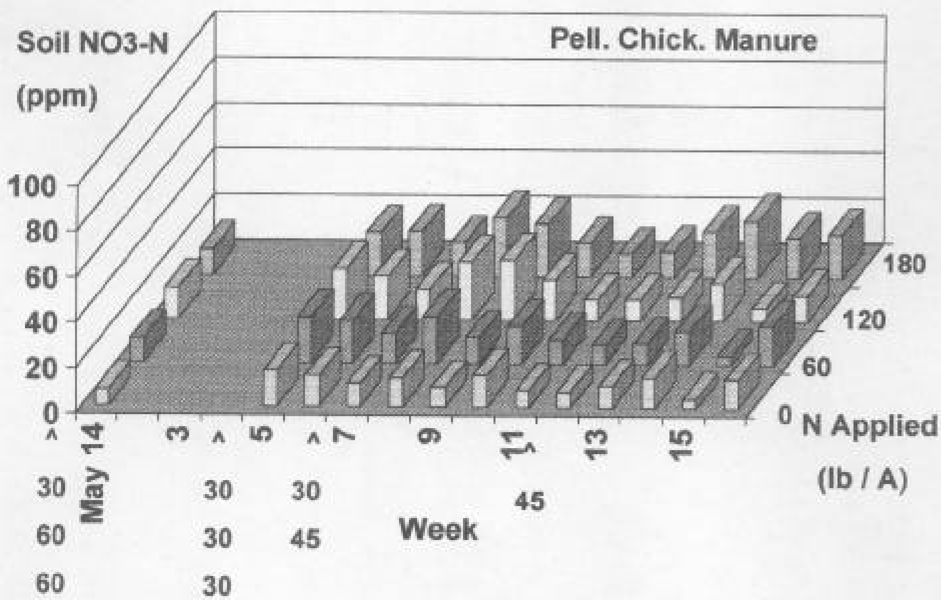


Figure 2. Weekly soil nitrate nitrogen following application of three rates of pelleted chicken manure. Values are means of four replicates.

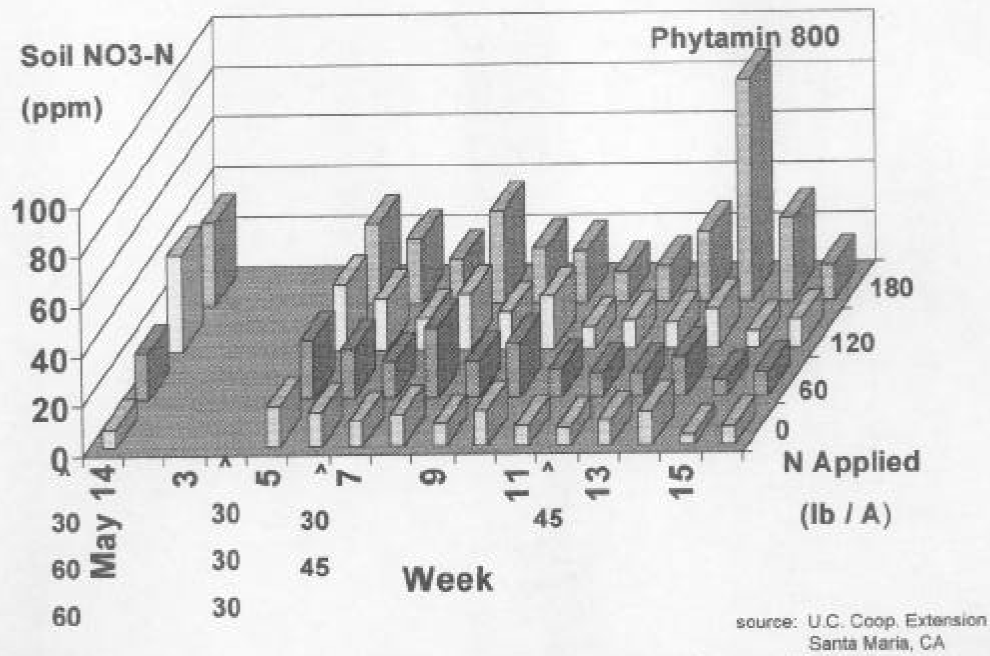


Figure 3. Weekly soil nitrate nitrogen following application of three rates of liquid soybean meal (Phytamin 800). Values are means of four replicates.

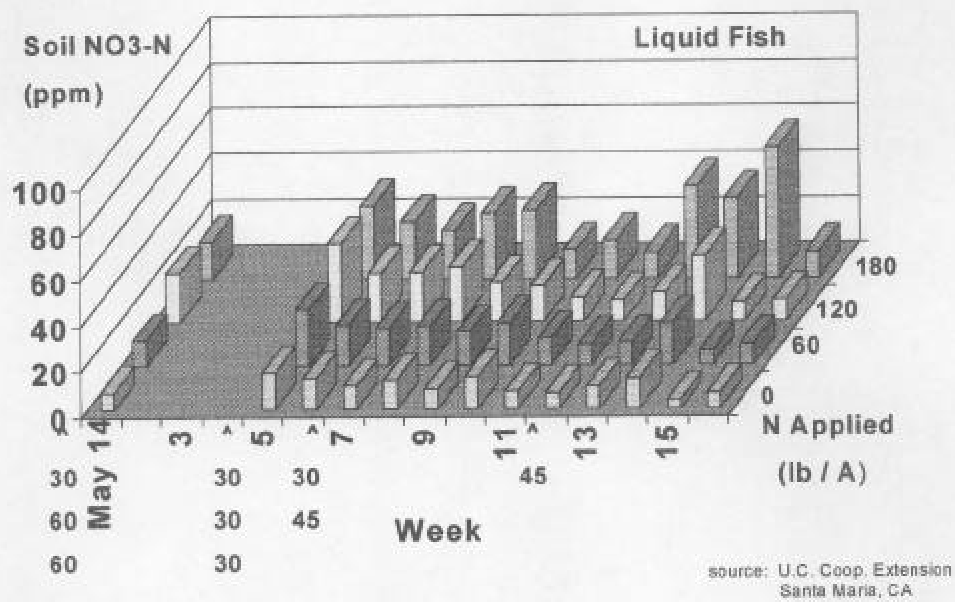


Figure 4. Weekly soil nitrate nitrogen following application of three rates of liquid fish fertilizer. Values are means of four replicates.

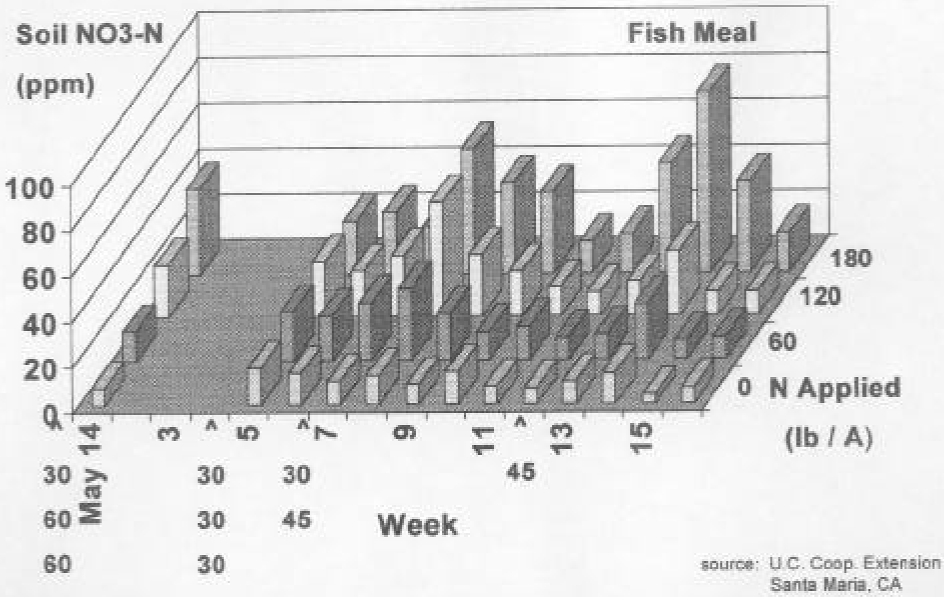


Figure 5. Weekly soil nitrate nitrogen following application of three rates of fish meal fertilizer. Values are means of four replicates.

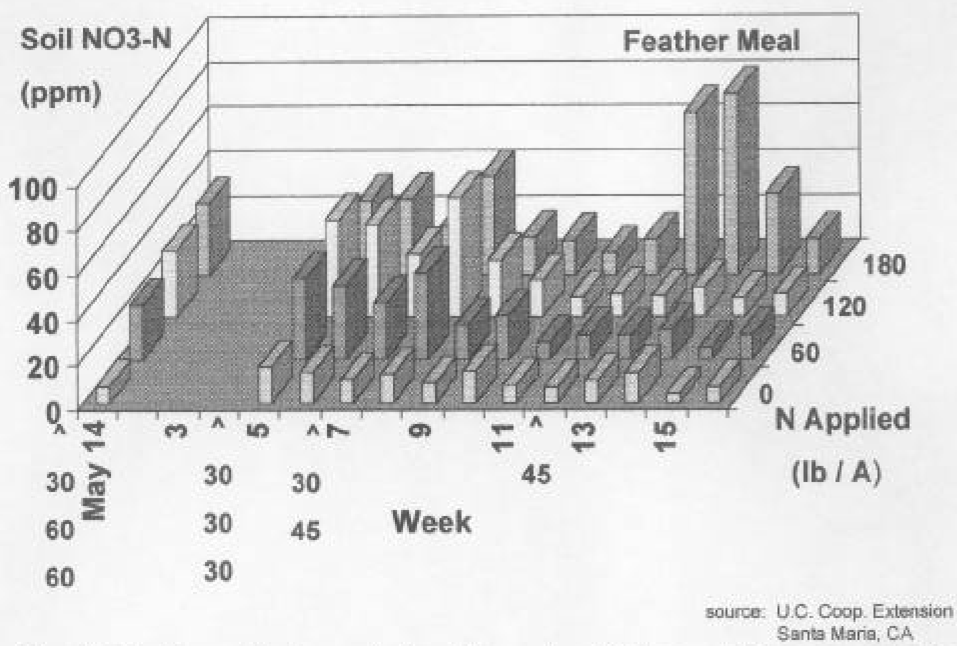


Figure 6. Weekly soil nitrate nitrogen following application of three rates of feather meal. Values are means of four replicates.

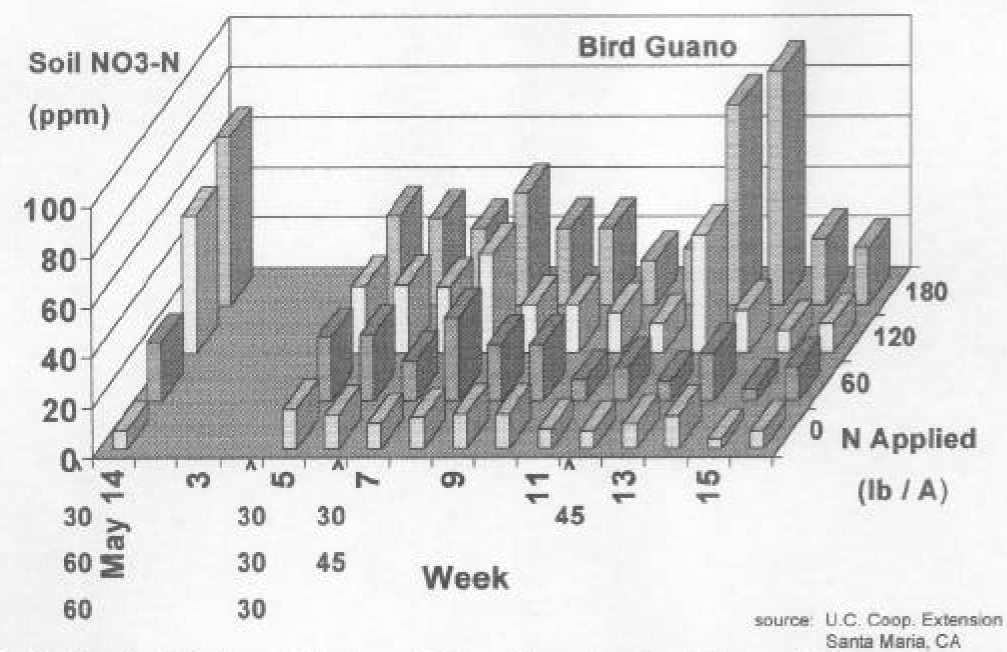


Figure 7. Weekly soil nitrate nitrogen following application of three rates of seabird guano fertilizer. Values are means of four replicates.

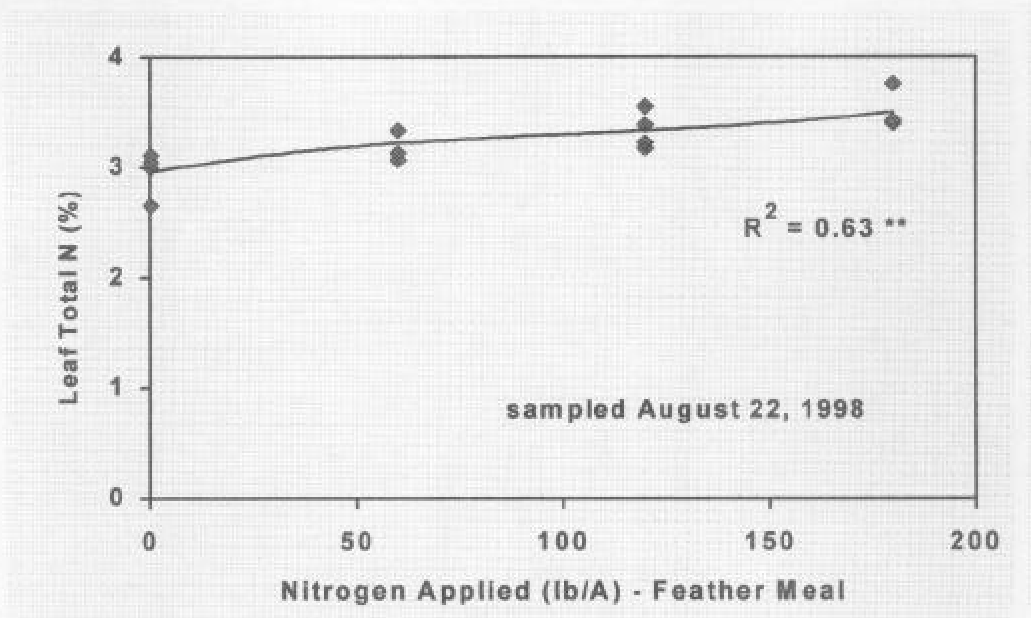


Figure 8. Linear regression line of leaf tissue nitrogen (%N) following application of three rates of feather meal fertilizer.

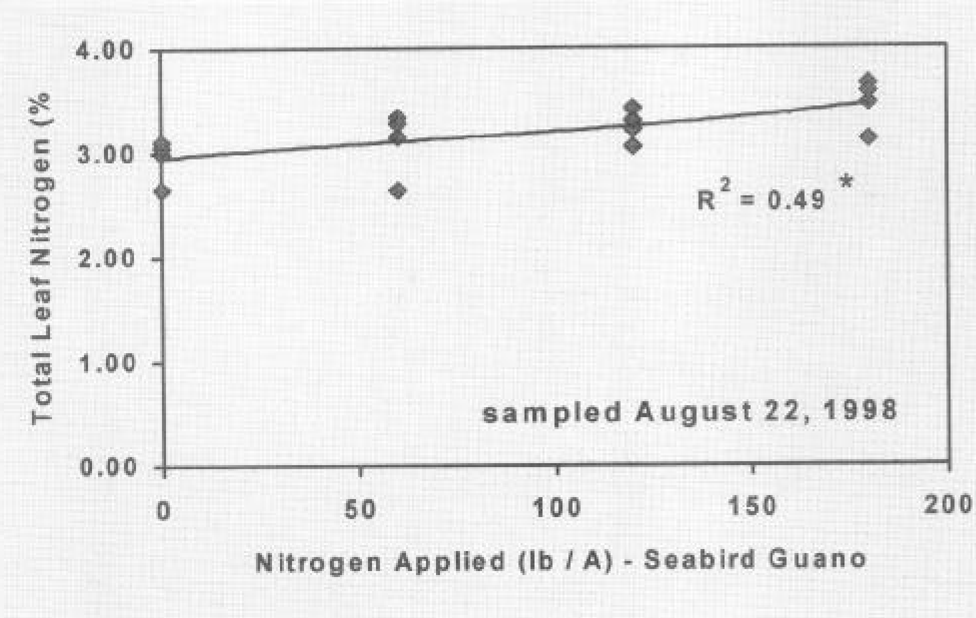


Figure 9. Simple linear regression line of leaf tissue nitrogen (%N) following application of three rates of seabird guano fertilizer.

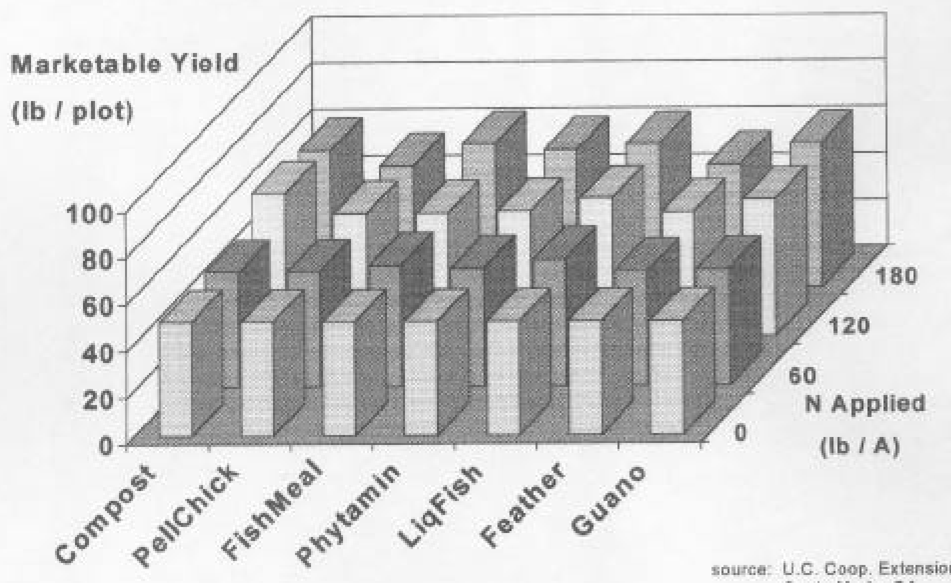


Figure 10. Total marketable bell pepper yield (lb. per plot) from plots fertilized with three rates of varying types of organic fertilizer materials. Values are means of four replicates. Values are means of four replicates differences between materials not significantly different (> 0.5).

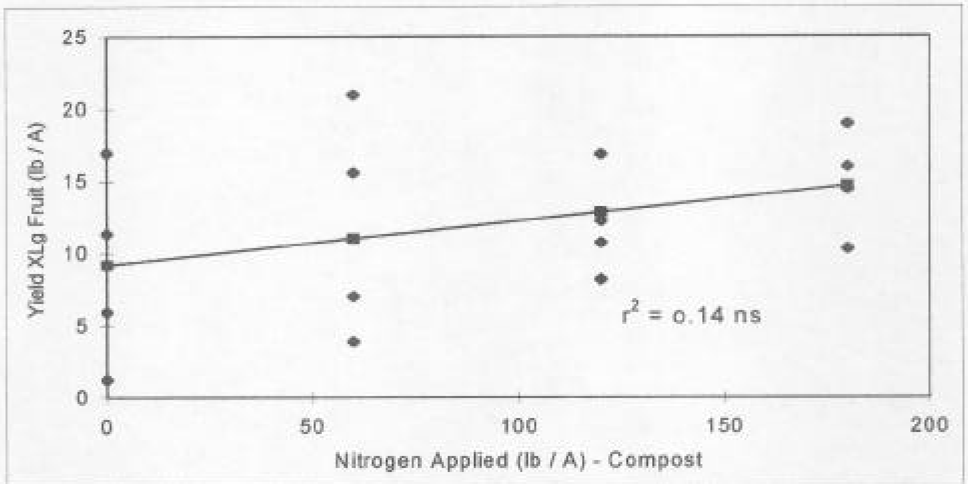


Figure 11. Relationship between yield of extra large peppers and rates of applied compost (lb N per acre.

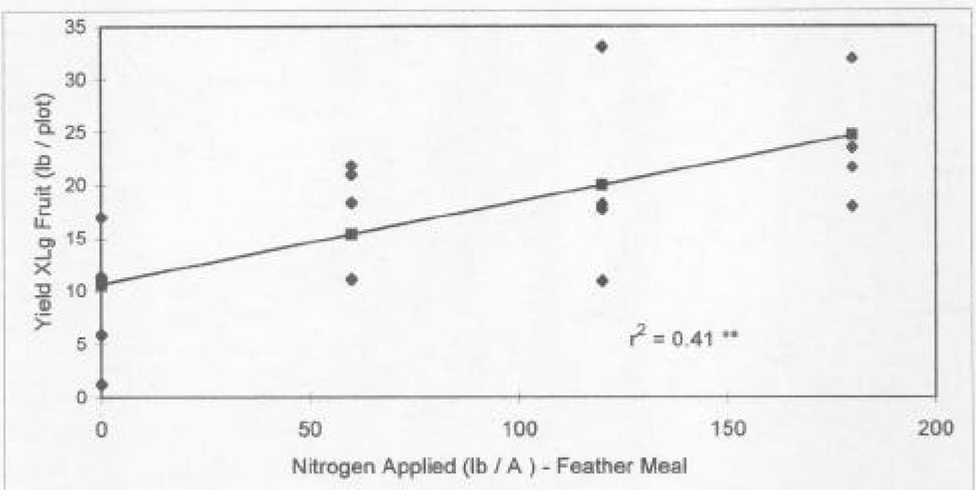


Figure 12. Relationship between yield of extra large peppers and rates of applied feather meal (lb N per acre.

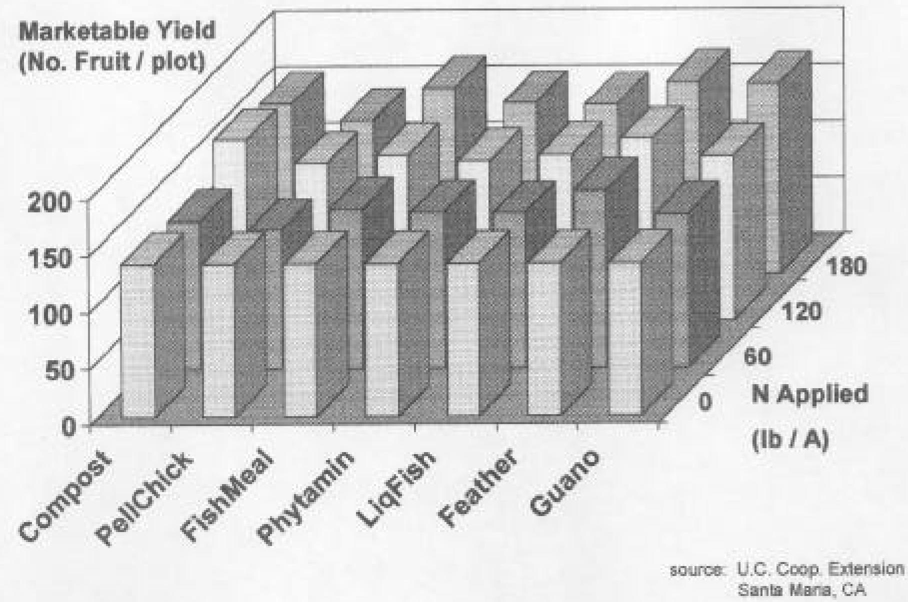


Figure 13. Total marketable bell pepper fruit number (per plot) from plots fertilized with three rates of varying types of organic fertilizer materials. Values are means of four replicates differences between materials not significantly different (> 0.5).

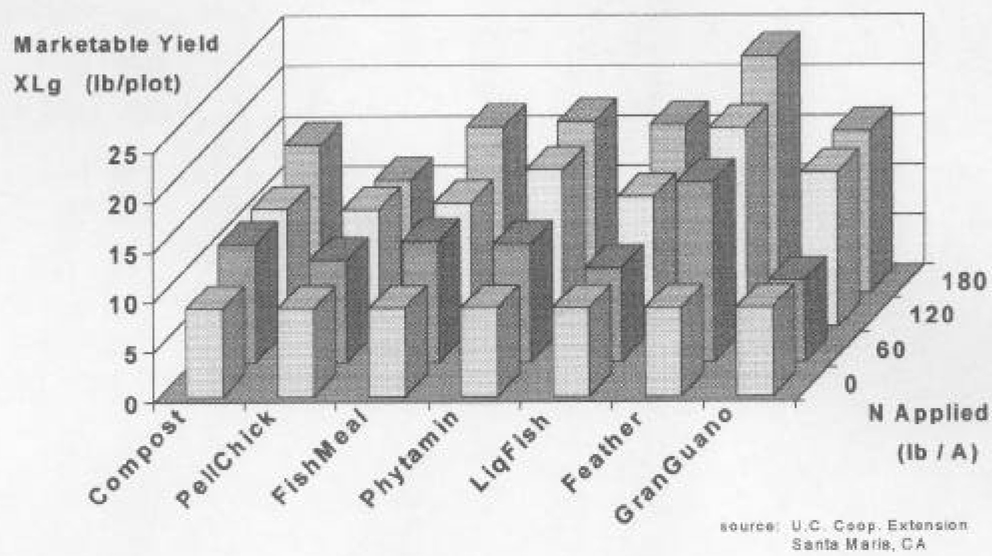
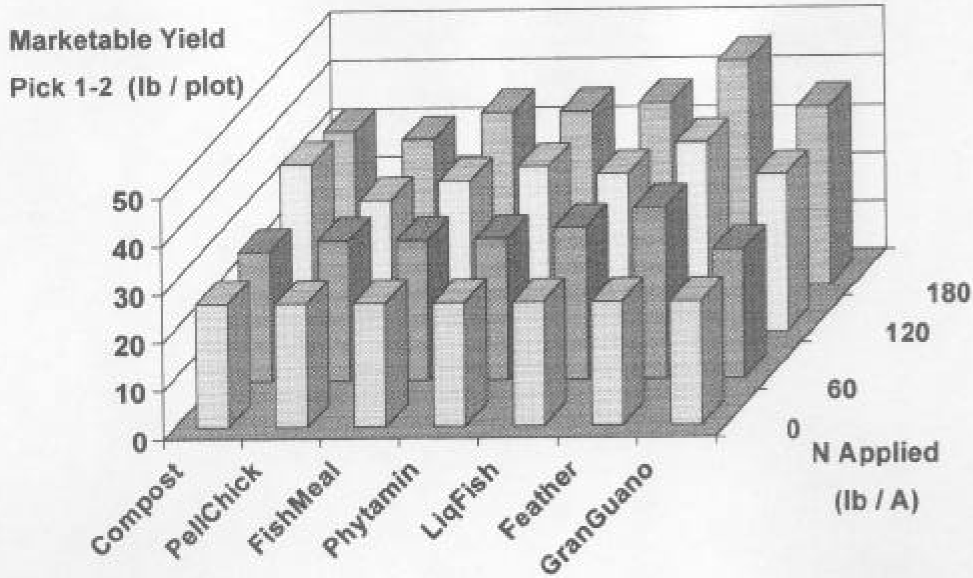


Figure 14. Total marketable yield of extra large bell peppers (lb, per plot) from plots fertilized with three rates of varying types of organic fertilizer materials. Values are means of four replicates.



source: U.C. Coop. Extension
Santa Maria, CA

Figure 15. Total marketable early yield (first and second pick) of bell peppers from plots fertilized with three rates of varying types of organic fertilizer materials. Values are means of four replicates.

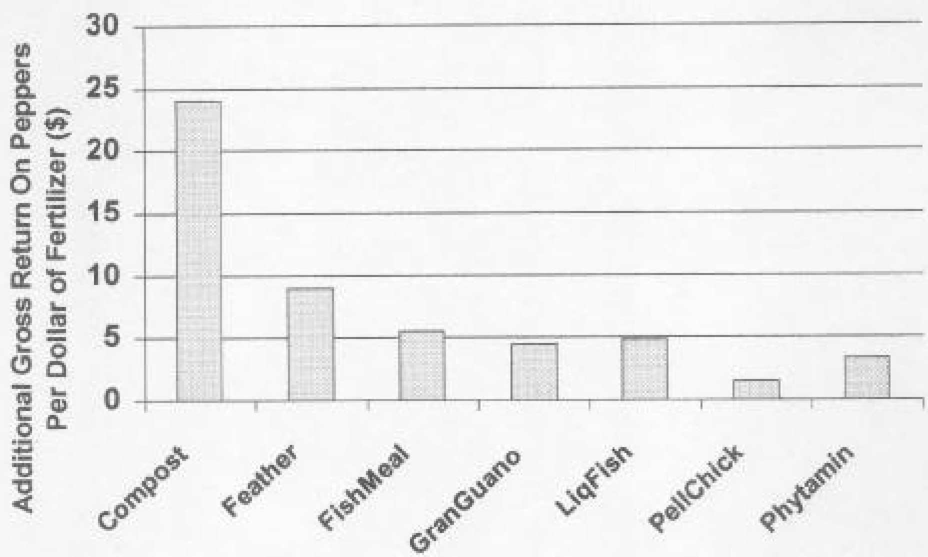


Figure 16. Total marketable early yield (first and second pick) of bell peppers from plots fertilized with three rates of varying types of organic fertilizer materials. Values are means of four replicates.

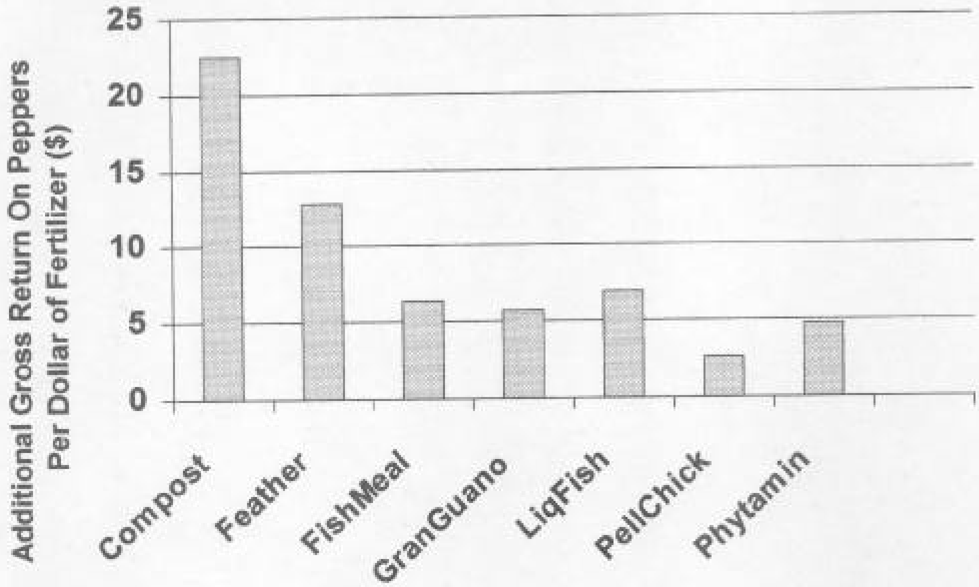


Figure 17. Additional return on early harvested (pick 1-2) bell peppers following application of varying types of organic fertilizers at 180 lb. N per acre. Assume $0.75 per lb. peppers.