# THE LONG-TERM VEGETABLE PRODUCTION EXPERIMENT: PLANT GROWTH AND SOIL FERTILITY COMPARISONS BETWEEN FERTILIZER AND COMPOST-AMENDED SOILS.

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A paired comparative study of compost versus conventionally-fertilized vegetable plots has been conducted for 11 years in a sandy loam soil near Truro, Nova Scotia; likely the longest study of its kind in Canada. The fertility treatments have been applied annually to six rotation plots planted with six to eight different vegetable crops. Compost and fertilizer applications have been based on the results of soil sampling and the Nova Scotia Soil Test Recommendations, and assuming 50 or 100% availability of the total N in the mature composts or fertilizers, respectively. The composts consist of animal manure, food waste, yard waste and straw or racetrack manure bedding. Marketable yields have been taken annually since 1990 and the plant tissue samples have been analysed for macro- and micronutrients, while soils have been sampled for pH, organic matter and Mehlich-3 extractable nutrients since 1994. This paper reports the results of the 1999 and 2000 cropping years.

Crop yield response was inconsistent between the two amendments; yields of tomatoes and broccoli varied from year to year. The fertilized plots, however, produced higher bean yields and numerically higher carrot and pepper yields, while the compost-amended plots produced higher onion yields in both years. There were few significant effects of treatments on plant tissue content; only Fe and B were higher in the organically-amended plant leaves in 1999. Of 19 soil parameters evaluated, the cation exchange capacity and the Mehlich-3 extractable Ca, Mn and Pb content of compost-amended soils were higher following the harvest in both study years. This six crop rotation study ended in 2001; in addition to the above parameters, emphasis is directed to soil biochemical changes which may have occurred from the continuous agronomic applications of the compost or fertilizer.

## *Introduction*

Numerous authors from various countries have examined different characteristics of vegetable crops whose soils were amended with compost and/or fertilizer. Ozores-Hampton and Obreza (2000) wrote an extensive review describing the use of composted waste on Florida vegetable crops. In Scotland, Purves and Mackenzie (1973) evaluated Cu, Zn and B uptake by garden vegetables from municipal compost applications in three successive years; as expected, the vegetables responded differently to the compost treatments. Vogtmann et al. (1993) described the effects of composts on the yield and quality of some vegetables in Germany. Compared with chemical fertilizers, compost treatments lowered vegetable yields the first two years, but yields did not differ after the third year of fertility applications. Generally, composts positively affected food quality and storage performance while reducing nitrates and improving the nitrate to vitamin C ratio.

The quality of conventionally and organically grown foods have been reviewed by Woese et al. (1997). They identified "some differences in quality between products" of the two fertilization systems. More recently, in their review of the literature, Brandt and Molgaard (2001) stated "organic plant foods may in fact benefit human health more than corresponding conventional ones". However, most previous studies were somewhat flawed since they were short-term and did not compare identical cultivars grown in the same soil type with similar soil and crop management practices. Also, many projects used high fertility soils or those with a history of fertilizer use or agronomically inappropriate rates of compost or fertilizer. Some studies have evaluated the differences in yield as well as quality, while others have examined differences in nutrient composition.

Past studies on peppers, cabbage, carrots, beans and broccoli, crops used in this study, have produced mixed results. Roe et al. (1997) grew peppers and cucumbers in a sandy soil supplemented with compost or fertilizers; yields were usually higher when compost was combined with fertilizer, while pepper leaf P, K, Ca and Mg increased and Cu levels decreased in plots amended with only compost. Reider et al. (2000) compared four composts with dairy manure and conventional fertilizer in a three-year rotation (which included peppers) and showed no significant yield differences among treatments for the three years; the authors used a 40% N availability factor for compost. In a three-crop vegetable rotation and a comparison of four organic amendments with chemical fertilizer, Blatt and McRae (1998) found equivalent marketable yields of cabbage and carrot from organic or fertilizer plots, but green bean yields were higher from 17-17-17 fertilizer. Treatment effects on soil and foliar nutrient contents varied with the element evaluated. Baziramakenga and Simard (2001) and Wen et al. (1997) compared compost fertilization with mineral fertilizers for snap bean and other crops, whereas, Buchanan and Gliesman (1990) evaluated broccoli production. These three studies emphasized P use efficiency or P uptake.

Warman and Havard (1996,1997,1998) conducted an extensive comparison of four vegetables grown organically and conventionally using non-rotational practices between 1990 and 1992. At the end of the first year of that study it was decided to maintain one set of six plots using compost and inorganic fertilizer treatments in a long-term (six year) vegetable crop rotation. The author has reported the experimental results for 1995 and 1996 (Warman, 1998) and for 1997 and 1998 (Warman, 2000). This paper reports on the 1999 and 2000 production years, with the objectives to compare the yield and nutrient content of different vegetables grown in a crop rotation system using either composted farmyard manure or commercial fertilizer, and evaluate the extractable nutrient content, pH, total C and N, and CEC of the treated soils.

## *Materials and Methods*

This field trial began in 1990 and has continued on the same site to this date. A Pugwash sandy loam (Humo-Ferric Podzol) in Lower Onslow, N.S. was selected because the site had no history of inorganic fertilizer or pesticide use. The site was used to grow cabbage and carrots in 1990 as part of the study documented in Warman and Havard (1996, 1997). Table 1 lists the crops grown in the plots for the last eight years. Each plot has an area of 11 $m^2$ and all the crops are planted into four rows/plot of 2.25 m long with a 1.2 m wide separation between plots. Each year an equal number of seeds or transplants were planted into each paired compost and fertilizer plot. Since the beginning of cropping, the six plots of each of the two treatments have been assigned to alternate plot areas.

Fertility amendments for each crop species were applied to the soil according to the Soil Test Recommendations of the Nova Scotia Department of Agriculture and Marketing (Table 2). Lime was applied to half the plots in 1998 to bring the soil pH of all plots to about 6.5; lime has not been applied since that time. The conventional method of growing the six types of vegetables followed the recommendations of the Vegetable Crops Guide to Cultivar Selection and Chemical Pest Control for the Atlantic Provinces (1989; Publication #1400A). Initially, organic vegetable production followed the Organic Crop Improvement Association guidelines; however, after 1992, only organic fertilization with compost was maintained and and insects were controlled using rotenone, pyrethrum or *Bacillus thuringensis* powder or liquid formulations. Plots were hand-weeded or rototilled; fungicides were not used.

TABLE 1.
Crop rotation (1993-2001) of the eleven crops among the six plots at the study site

| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | POT | CAR | SWC | BRO/ CAU | ONI | TOM | BEA | CAR | CAU/ B.SP |
| 2 | CAR | ONI | SWC | TOM | BEA | CAR | PEP | BRO/ B.SP | TOM |
| 3 | ONI | SWC | TOM | ONI | BRO/ B.SP | PEP | CAR | BEA | ONI |
| 4 | BEA | SWC | ONI | TOM/ PEP | CAR | BEA | TOM | ONI | PEP |
| 5 | BRO | SWC | CAR | BEA | TOM | ONI | BRO/ CAB | PEP | CAR |
| 6 | CAB | TOM | BEA | CAR | PEP | BRO/ CAU | ONI | TOM | BEA |

BEA: Beans
CAR: Carrots

BRO: Broccoli
CAU: Cauliflower
POT: Potatoes

B.SP: Brussels Sprouts
ONI: Onions
SWC: Sweet Corn

CAB: Cabbage
PEP: Peppers
TOM: Tomatoes

TABLE 2.
Quantities of Amendments Applied to the Plots in 1999 and 2000

| Crop | Moist YMFC | NPK Fertilizers (kg $ha^{-1}$) | | |
|---|---|---|---|---|
| | (Mg $ha^{-1}$) | N | $P_2O_5$ | $K_2O$ |
| Tomatoes | 25 | 60 | 85 - 225 | 30 - 60 |
| Carrots | 25 | 60 | 60 - 85 | 30 |
| Peppers | 34 | 80 | 60 - 85 | 30 - 50 |
| Beans | 13 | 30 | 50 | 0 - 30 |
| Onions | 50 | 120 | 150 - 225 | 30 - 50 |
| Broccoli/ Cabbage or Br. Sprouts | 63 | 150 | 150 - 225 | 30 - 50 |

The compost was made the year prior to its application using the aerated static pile method with a combination of chicken manure, food waste, grass clippings/weeds, and straw/racetrack manure bedding (designated YMFC). The mature compost was analysed for total N using a LECO CNS Analyzer and applied at rates appropriate to each crop assuming 50% availability of the N during the growing season. The analysis of the compost has varied slightly from year to year; the nitric acid procedure for compost digestion and ICP analysis is reported in Warman and Havard (1997). Based on the average values of the compost used in the two years, some chemical properties of the compost are shown in Table 3 (elemental analysis in g $kg^{-1}$ or mg $kg^{-1}$ on a dry weight basis); in addition, the YMF compost was 44% solid with a pH of 6.84.

TABLE 3.
Mean Elemental Analysis of the YMFC Compost used in the Study (dry weight basis)

| | YMFC g $kg^{-1}$ | | YMFC g $kg^{-1}$ | | YMFC mg $kg^{-1}$ |
|---|---|---|---|---|---|
| C | 318 | Mg | 1.22 | Cu | 77 |
| N | 25.3 | S | 4.26 | Zn | 107 |
| P | 13.6 | Na | 5.83 | B | 39 |
| K | 13.4 | Fe | 6.03 | | |
| Ca | 36.1 | Mn | 1.32 | | |

Marketable fresh weight yields were taken annually from each plot at maturity, while leaf/petiole tissue samples were taken at flowering, fruit-set or root elongation. Five mature plant leaves from each row (20 in total) were sampled from each vegetable plot each year. Tomatoes, peppers and snap beans were harvested 6-10 times until the frost in the fall. Soil samples were taken in September of both years at the 0-15 cm depth. Plant tissue samples were washed with water, air dried for 48 hours, oven dried at 65C for 48 hrs and ground in a Wiley Mill to pass through a 1.0 mm stainless steel sieve. Tissue was digested in nitric acid and analysed by ICP for macro-, micro-, and trace elements, except N, which was analysed using a CNS analyzer (Warman and Havard 1997, 1998). After harvest, soil samples were taken from each plot from the 0 to 15 cm layer using a stainless steel probe. The soil was extracted with Mehlich-3 solution and analysed by ICP. Soil samples were also evaluated for pH, total C and N, and cation exchange capacity (CEC) using the calcium acetate saturation procedure.

Treatment results for crop yields, tissue content and extractable soil elements were statistically analyzed using a paired, two-tailed t-test or ANOVA at p  0.05.

*Results and Discussion*

Crop yield response was inconsistent between the two amendments; yields of tomatoes and broccoli varied from year to year (Table 4). The fertilized plots, however, produced higher bean yields and numerically higher carrot and pepper yields, while the compost-amended plots produced higher onion yields in both years. I noted that the % of Class A carrots, which had shown a higher % for organic carrots in 1997 – 1999, changed in 2000. Onion yields, however, were greater in the organic plots, as they had been in 1997 and 1998 (Warman, 2000).

TABLE 4.
Fresh Crop Yields (kg) from the Six Paired Rotation Plots

| | 1999 | | | 2000 | | |
|---|---|---|---|---|---|---|
| Plot # | | NPK | Compost | | NPK | Compost |
| 1 | Beans* | 15 | 14 | Carrots | 13 | 13 |
| | | | | % Class A | 87 | 83 |
| 2 | Peppers | 17 | 15 | Broccoli | 1.7 | 1.0 |
| 3 | Carrots | 25 | 22 | Beans* | 11 | 9 |
| | % Class A | 70 | 86 | | | |
| 4 | Tomatoes | 33 | 42 | Onions** | 12 | 14 |
| 5. | Broccoli | 3 | 4 | Peppers | 7 | 6 |
| | Cabbage | 10 | 9 | | | |
| 6 | Onions** | 16 | 21 | Tomatoes | 13 | 11 |

* Yields significantly higher with the NPK treatment

**Yields significantly higher with the compost treatment

There were few significant effects of treatments on plant tissue content (Tables 5 and 6); of the essential plant nutrients, only Fe and B were higher in the organically-amended plant leaves in one year (1999). Although the edible portion of the crops were not evaluated the last few years of the study, we have found a positive correlation between leaf tissue and edible portions of carrots (Warman and Havard, 1997) and other crops. Therefore, based on mineral analysis, our results do not support the belief that compost-grown vegetables are more nutritious.

Of 19 soil parameters evaluated, the CEC and the Mehlich-3 extractable Ca, Mn and Pb content of compost-amended soils were higher following the harvest in both study years (Tables 7 and 8). I noted that the compost-amended plots also had higher levels of Mehlich-3 Cu, Zn, and B in 2000, and this was the first year since 1996 that C was not significantly higher in the compost-amended plots. The 11 years of continual compost or fertilizer applications have significantly reduced the original differences in soil fertility between the plots so there are fewer differences between the treated soils in N-P-K but more differences between the soils in extractable micronurients. Furthermore, compared to the composts produced and used in 1990-1992 (Warman and Havard, 1997), the compost we are now making and using is of higher nutrient quality, probably due to the higher nutrient feedstocks we are using (more weeds and food wastes), and the improvement in our ability to make a better quality compost.

TABLE 5.
Leaf tissue analysis of macronutrient ($g\ kg^{-1}$), micronutrient and trace elements ($mg\ kg^{-1}$) of the NPK fertilizer and YMFC compost plots from 1999

| | C | N | P | K | Ca | Mg | S |
|---|---|---|---|---|---|---|---|
| Carrot-NPK | 420 | 27.0 | 2.00 | 1.85 | 4.9 | 3.13 | 4.67 |
| Carrot-YMFC | 406 | 22.2 | 2.01 | 1.09 | 8.9 | 3.32 | 6.17 |
| Broccoli-NPK | 391 | 35.3 | 2.25 | 7.05 | 10.6 | 2.95 | 6.48 |
| Broccoli-YMFC | 411 | 27.4 | 3.11 | 8.95 | 11.1 | 2.70 | 5.54 |
| Pepper-NPK | 408 | 49.3 | 3.19 | 1.88 | 13.7 | 6.40 | 4.70 |
| Pepper-YMFC | 395 | 53.5 | 2.55 | 1.86 | 15.2 | 6.55 | 5.09 |
| Bean-NPK | 406 | 32.9 | 1.71 | 1.17 | 11.0 | 4.75 | 3.26 |
| Bean-YMFC | 415 | 31.5 | 1.81 | 1.19 | 11.6 | 5.02 | 3.11 |
| Tomato-NPK | 414 | 29.6 | 1.86 | 0.95 | 13.0 | 5.72 | 6.41 |
| Tomato-YMFC | 412 | 31.8 | 2.52 | 1.16 | 13.8 | 5.30 | 5.90 |
| Onion-NPK | 411 | 36.3 | 2.63 | 7.63 | 7.4 | 4.25 | 6.43 |
| Onion-YMFC | 414 | 32.3 | 2.37 | 9.45 | 6.8 | 4.82 | 6.77 |
| p-value | 0.929 | 0.341 | 0.618 | 0.286 | 0.141 | 0.589 | 0.775 |

| | Fe | Mn | Cu | Zn | B | Cr | Na | Pb |
|---|---|---|---|---|---|---|---|---|
| Carrot-NPK | 140 | 60 | 8.4 | 40 | 27.7 | 1.3 | 1835 | 1.5 |
| Carrot-YMFC | 160 | 64 | 7.1 | 32 | 30.6 | 1.7 | 2626 | 9.0 |
| Broccoli-NPK | 60 | 42 | 8.1 | 31 | 11.6 | 1.0 | 2084 | 4.6 |
| Broccoli-YMFC | 70 | 45 | 9.9 | 27 | 25.9 | 2.4 | 1332 | 11.3 |
| Pepper-NPK | 70 | 48 | 4.9 | 49 | 18.2 | 1.7 | 54 | 11.9 |
| Pepper-YMFC | 90 | 36 | 8.9 | 25 | 19.1 | 1.7 | 42 | 2.5 |
| Bean-NPK | 60 | 43 | 6.5 | 38 | 13.7 | 1.0 | 57 | 1.2 |
| Bean-YMFC | 90 | 42 | 7.1 | 25 | 16.2 | 1.0 | 45 | 2.1 |
| Tomato-NPK | 40 | 36 | 4.7 | 25 | 9.6 | 1.2 | 2065 | 1.5 |
| Tomato-YMFC | 70 | 40 | 9.3 | 37 | 17.1 | 1.6 | 1967 | 3.1 |
| Onion-NPK | 90 | 27 | 5.6 | 18 | 8.7 | 1.3 | 515 | 0.9 |
| Onion-YMFC | 140 | 28 | 9.0 | 31 | 16.6 | 1.2 | 1024 | 0.9 |
| p-value | 0.005 | 0.886 | 0.066 | 0.537 | 0.031 | 0.201 | 0.758 | 0.654 |

TABLE 6.
Leaf tissue analysis of macronutrient(g $kg^{-1}$), micronutrient and trace elements(mg $kg^{-1}$) of the NPK fertilizer and YMFC compost plots from 2000

| | C | N | P | K | Ca | Mg | S |
|---|---|---|---|---|---|---|---|
| Carrot-NPK | 414 | 27.4 | 2.03 | 12.7 | 10.2 | 2.95 | 4.42 |
| Carrot-YMFC | 426 | 25.7 | 1.45 | 10.4 | 7.7 | 2.97 | 3.59 |
| Broccoli-NPK | 401 | 35.7 | 1.05 | 13.0 | 14.0 | 27.0 | 1.17 |
| BroccoliYMFC | 414 | 37.4 | 1.43 | 15.0 | 19.0 | 34.0 | 1.35 |
| Br.Sprout-NPK | 414 | 49.5 | 1.28 | 3.3 | 8.0 | 1.39 | 3.27 |
| Br.SproutYMFC | 399 | 51.5 | 2.02 | 3.9 | 8.5 | 1.38 | 5.59 |
| Pepper-NPK | 408 | 32.1 | 1.23 | 14.1 | 16.0 | 6.17 | 5.29 |
| Pepper-YMFC | 413 | 31.7 | 1.50 | 14.7 | 15.6 | 5.83 | 6.75 |
| Bean-NPK | 417 | 29.9 | 1.41 | 7.0 | 9.8 | 3.16 | 1.77 |
| Bean-YMFC | 414 | 31.7 | 2.20 | 7.3 | 10.5 | 3.06 | 3.33 |
| Tomato-NPK | 419 | 36.8 | 1.50 | 10.0 | 16.2 | 5.85 | 6.01 |
| Tomato-YMFC | 412 | 35.2 | 1.50 | 10.4 | 17.3 | 5.08 | 6.93 |
| Onion-NPK | 426 | 34.8 | 1.24 | 6.3 | 5.6 | 1.47 | 2.58 |
| Onion-YMFC | 431 | 32.6 | 1.87 | 6.8 | 5.3 | 1.54 | 2.18 |
| p-value | 0.725 | 0.938 | 0.133 | 0.559 | 0.521 | 0.727 | 0.135 |

| | Fe | Mn | Cu | Zn | B | Cr | Na | Pb |
|---|---|---|---|---|---|---|---|---|
| Carrot-NPK | 78 | 22 | 7.5 | 17 | 20.0 | 0.5 | 2398 | 4.8 |
| Carrot-YMFC | 69 | 20 | 5.1 | 12 | 12.8 | 0.5 | 1242 | 3.1 |
| Broccoli-NPK | 178 | 32 | 13 | 40 | 15 | 1.3 | 640 | 6.5 |
| BroccoliYMFC | 167 | 31 | 18 | 38 | 38 | 1.7 | 2010 | 3.1 |
| Br.Sprout-NPK | 30 | 13 | 2.4 | 10 | 7.4 | 0.3 | 973 | 4.3 |
| Br.SproutYMFC | 33 | 10 | 2.8 | 11 | 9.7 | 0.4 | 837 | 4.0 |
| Pepper-NPK | 153 | 30 | 6.0 | 21 | 11.5 | 0.7 | 61 | 2.6 |
| Pepper-YMFC | 182 | 27 | 5.2 | 21 | 17.6 | 0.6 | 123 | 2.6 |
| Bean-NPK | 179 | 33 | 5.0 | 8 | 8.8 | 0.4 | 48 | 1.9 |
| Bean-YMFC | 154 | 35 | 7.9 | 14 | 9.0 | 0.6 | 81 | 2.7 |
| Tomato-NPK | 180 | 37 | 7.6 | 10 | 17.8 | 0.6 | 431 | 2.6 |
| Tomato-YMFC | 192 | 37 | 8.2 | 13 | 20.3 | 0.7 | 290 | 3.4 |
| Onion-NPK | 119 | 16 | 1.4 | 2 | 2.5 | 0.2 | 191 | 1.7 |
| Onion-YMFC | 122 | 17 | 3.8 | 8 | 8.5 | 0.4 | 384 | 2.0 |
| p-value | 0.967 | 0.289 | 0.262 | 0.435 | 0.226 | 0.078 | 0.912 | 0.422 |

TABLE 7.
Soil pH, CEC [cmol+]kg$^{-1}$, C and N (g kg$^{-1}$) and Mehlich-3 extractable nutrients (mg kg$^{-1}$) from the 1999 plots.

| | pH | CEC | C | N | P | K | Ca | Mg | S | Fe |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Fertilizer Treatment | | | | | |
| Bean | 6.09 | 11.3 | 27.0 | 2.27 | 65 | 83 | 1070 | 292 | 50 | 67 |
| Broccoli | 6.76 | 11.2 | 17.0 | 1.52 | 58 | 105 | 1350 | 384 | 49 | 76 |
| Carrot | 6.14 | 10.5 | 23.4 | 2.13 | 44 | 83 | 1240 | 333 | 52 | 87 |
| Onion | 6.92 | 11.7 | 16.3 | 1.28 | 62 | 65 | 1150 | 254 | 50 | 81 |
| Pepper | 6.75 | 10.4 | 28.2 | 2.28 | 43 | 75 | 1690 | 314 | 68 | 80 |
| Tomato | 6.52 | 10.1 | 16.7 | 1.37 | 54 | 92 | 1130 | 218 | 62 | 76 |
| **mean** | 6.53 | 10.9 | 21.4 | 1.81 | 54 | 84 | 1270 | 299 | 55 | 78 |
| ±s.d. | ±0.35 | ±0.6 | ±5.5 | ±0.47 | ±9 | ±14 | ±230 | ±59 | ±8 | ±7 |
| | | | | | Compost Treatment | | | | | |
| Bean | 6.31 | 13.4 | 29.2 | 2.56 | 44 | 77 | 1460 | 343 | 56 | 75 |
| Broccoli | 6.66 | 11.6 | 23.4 | 1.83 | 52 | 100 | 1540 | 403 | 50 | 88 |
| Carrot | 7.01 | 11.4 | 27.5 | 2.34 | 41 | 78 | 1470 | 346 | 55 | 84 |
| Onion | 6.94 | 12.5 | 29.6 | 2.34 | 41 | 63 | 1270 | 237 | 66 | 83 |
| Pepper | 6.56 | 12.0 | 27.0 | 1.69 | 40 | 62 | 1730 | 320 | 56 | 84 |
| Tomato | 6.84 | 11.4 | 29.0 | 2.04 | 42 | 84 | 1320 | 263 | 83 | 68 |
| **mean** | 6.72 | 12.1 | 27.6 | 2.13 | 43 | 77 | 1470 | 318 | 61 | 80 |
| ±s.d. | ±0.26 | ±0.8 | ±2.3 | ±0.34 | ±5 | ±14 | ±160 | ±60 | ±12 | ±7 |
| p-value | 0.280 | 0.005 | 0.045 | 0.025 | 0.005 | 0.010 | 0.010 | 0.118 | 0.281 | 0.423 |

| | Mn | Cu | Zn | B | Cd | Cr | Na | Ni | Pb |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Fertilizer Treatment | | | | |
| Bean | 21 | 1.19 | 3.21 | 0.56 | 0.03 | 0.18 | 24.5 | 0.85 | 1.33 |
| Broccoli | 19 | 1.23 | 2.96 | 0.68 | 0.06 | 0.24 | 36.5 | 0.98 | 0.78 |
| Carrot | 25 | 0.90 | 4.93 | 0.51 | 0.07 | 0.19 | 20.5 | 0.75 | 0.53 |
| Onion | 24 | 1.36 | 3.52 | 0.56 | 0.05 | 0.25 | 23.1 | 0.99 | 0.82 |
| Pepper | 15 | 1.41 | 3.53 | 0.82 | 0.04 | 0.23 | 36.5 | 0.91 | 1.01 |
| Tomato | 15 | 1.37 | 3.84 | 0.72 | 0.07 | 0.34 | 38.5 | 0.82 | 0.75 |
| **mean** | 20 | 1.24 | 3.67 | 0.64 | 0.05 | 0.24 | 29.9 | 0.88 | 0.87 |
| ±s.d. | ±4 | ±0.19 | ±0.69 | ±0.12 | ±0.02 | ±0.06 | ±8.1 | ±0.09 | ±0.27 |
| | | | | | Compost Treatment | | | | |
| Bean | 28 | 1.49 | 4.50 | 0.99 | 0.10 | 0.32 | 25.9 | 0.81 | 1.69 |
| Broccoli | 23 | 1.39 | 2.93 | 0.89 | 0.07 | 0.19 | 21.2 | 0.73 | 0.87 |
| Carrot | 29 | 1.42 | 4.90 | 0.98 | 0.14 | 0.18 | 34.2 | 0.91 | 1.48 |
| Onion | 29 | 1.36 | 3.42 | 0.97 | 0.05 | 0.28 | 28.8 | 0.80 | 1.40 |
| Pepper | 19 | 1.25 | 3.05 | 0.78 | 0.05 | 0.15 | 25.2 | 0.80 | 1.09 |
| Tomato | 22 | 1.36 | 3.69 | 0.66 | 0.07 | 0.40 | 27.2 | 0.89 | 1.24 |
| **mean** | 25 | 1.38 | 3.75 | 0.88 | 0.08 | 0.25 | 27.1 | 0.82 | 1.30 |
| ±s.d. | ±4 | ±0.08 | ±0.79 | ±0.13 | ±0.03 | ±0.10 | ±4.3 | ±0.07 | ±0.29 |
| p-value | 0.000 | 0.236 | 0.753 | 0.060 | 0.112 | 0.664 | 0.571 | 0.389 | 0.025 |

TABLE 8.
Soil pH, CEC[cmol+]kg$^{-1}$, C and N (g kg$^{-1}$) and Mehlich-3 extractable nutrients (mg kg$^{-1}$) from the 2000 plots

| | pH | CEC | C | N | P | K | Ca | Mg | S | Fe |
|---|---|---|---|---|---|---|---|---|---|---|
| | Fertilizer Treatment | | | | | | | | | |
| Bean | 6.92 | 11.4 | 27.9 | 2.34 | 89 | 45 | 1560 | 131 | 83 | 209 |
| Broccoli | 6.09 | 11.1 | 22.9 | 1.75 | 124 | 65 | 1200 | 211 | 110 | 178 |
| Carrot | 6.75 | 10.7 | 23.1 | 2.24 | 131 | 161 | 1400 | 158 | 92 | 227 |
| Onion | 6.25 | 11.3 | 26.5 | 2.45 | 99 | 47 | 1260 | 192 | 81 | 181 |
| Pepper | 6.52 | 10.2 | 26.2 | 2.05 | 125 | 66 | 1120 | 214 | 96 | 116 |
| Tomato | 6.76 | 10.4 | 26.7 | 2.07 | 231 | 104 | 2140 | 252 | 107 | 183 |
| **mean** | 6.55 | 10.9 | 25.5 | 2.24 | 133 | 81 | 1450 | 193 | 95 | 182 |
| ±s.d. | ±0.32 | ±0.49 | ±2.06 | ±0.25 | ±51 | ±44 | ±370 | ±43 | ±12 | ±38 |
| | Compost Treatment | | | | | | | | | |
| Bean | 6.94 | 13.9 | 29.1 | 2.41 | 95 | 41 | 1700 | 171 | 91 | 180 |
| Broccoli | 6.31 | 11.7 | 23.2 | 1.72 | 138 | 66 | 1970 | 243 | 85 | 248 |
| Carrot | 6.56 | 11.9 | 24.5 | 2.31 | 143 | 184 | 1620 | 176 | 97 | 173 |
| Onion | 6.34 | 12.8 | 27.4 | 2.37 | 105 | 52 | 1570 | 180 | 87 | 210 |
| Pepper | 6.84 | 12.4 | 25.8 | 2.17 | 132 | 63 | 1640 | 201 | 87 | 195 |
| Tomato | 6.66 | 11.7 | 27.0 | 2.11 | 208 | 95 | 2210 | 239 | 80 | 190 |
| **mean** | 6.61 | 12.4 | 26.2 | 2.18 | 137 | 84 | 1790 | 202 | 88 | 199 |
| ±s.d. | ±0.26 | ±0.85 | ±2.12 | ±0.25 | ±40 | ±52 | ±250 | ±32 | ±6 | ±27 |
| p-value | 0.478 | 0.003 | 0.075 | 0.340 | 0.535 | 0.657 | 0.025 | 0.424 | 0.334 | 0.468 |

| | Mn | Cu | Zn | B | Cd | Cr | Na | Ni | Pb |
|---|---|---|---|---|---|---|---|---|---|
| | Fertilizer Treatment | | | | | | | | |
| Bean | 19 | 1.48 | 2.08 | 0.68 | 0.01 | 0.20 | 100 | 0.91 | 0.52 |
| Broccoli | 30 | 1.18 | 3.95 | 0.76 | 0.03 | 0.22 | 188 | 0.81 | 0.91 |
| Carrot | 28 | 1.72 | 2.84 | 0.71 | 0.01 | 0.19 | 110 | 0.78 | 1.17 |
| Onion | 28 | 1.80 | 2.37 | 0.78 | 0.04 | 0.21 | 99 | 0.41 | 0.55 |
| Pepper | 22 | 1.83 | 2.71 | 0.86 | 0.03 | 0.25 | 114 | 0.57 | 0.27 |
| Tomato | 34 | 1.27 | 3.07 | 1.17 | 0.06 | 0.30 | 157 | 0.72 | 2.07 |
| **mean** | 27 | 1.55 | 2.84 | 0.83 | 0.03 | 0.23 | 128 | 0.70 | 0.92 |
| ±s.d. | ±6 | ±0.28 | ±0.65 | ±0.18 | ±0.02 | ±0.04 | ±36 | ±0.18 | ±0.65 |
| | Compost Treatment | | | | | | | | |
| Bean | 47 | 1.94 | 2.78 | 1.10 | 0.05 | 0.22 | 98 | 0.75 | 1.47 |
| Broccoli | 35 | 1.68 | 4.50 | 1.15 | 0.01 | 0.22 | 107 | 0.62 | 2.47 |
| Carrot | 41 | 2.67 | 3.00 | 1.18 | 0.05 | 0.20 | 122 | 0.71 | 3.15 |
| Onion | 35 | 1.87 | 3.17 | 0.98 | 0.02 | 0.19 | 102 | 0.56 | 1.15 |
| Pepper | 37 | 1.91 | 3.17 | 1.12 | 0.03 | 0.19 | 87 | 0.54 | 1.82 |
| Tomato | 43 | 2.01 | 3.15 | 1.35 | 0.04 | 0.19 | 88 | 0.44 | 2.27 |
| **mean** | 40 | 2.01 | 3.30 | 1.15 | 0.03 | 0.20 | 100 | 0.60 | 2.06 |
| ±s.d. | ±5 | ±0.34 | ±0.61 | ±0.12 | ±0.02 | ±0.01 | ±13 | ±0.11 | ±0.73 |
| p-value | 0.012 | 0.023 | 0.011 | 0.001 | 0.793 | 0.246 | 0.149 | 0.175 | 0.009 |

In conclusion, mineralization of recently added and previously applied compost influence plant response in a particular crop year, especially for the high nutrient-demanding crops (brassica species). Seasonal variation in soil moisture and temperature seem to have a greater influence on plant production, through mineralization, than the source and amount of mature compost applied. In some years, compost is providing a higher level of available nutrients than the literature would predict, probably because the soil environment has more biological activity and is more conducive to mineralization from long-term organic applications


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