PRODUCING VEGETABLES IN CONSERVATION TILLAGE SYSTEMS IN NORTH CAROLINA

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ABSTRACT

Vegetable growers in the Southeast US have tillage alternatives to successfully produce vegetables and provide soil erosion control, water conservation, and improve soil quality. Conservation tillage -primarily no-till and strip-till are being used by growers to produce sweet corn, cabbage, pumpkins, and tomatoes successfully across the state. Available conservation-tillage equipment, weed control, and experience has been the key requirements for this success. We established long term conservation tillage systems ten years ago in an effort to develop a field site that could be used for answering questions related to vegetable production planted with conservation tillage and the resulting soil biological, chemical, and physical property changes that have evolved over the years. Objectives for this experiment were to evaluate whole systems of current technology that growers use in their operation. These include conventional tillage systems with chemicals (what growers are currently using), conventional systems with organic production methods, conservation tillage systems with chemicals, and conservation tillage systems with organic production methods. Tomato production for the past seven years has seen a continuous down trend for most treatments - the plowed systems with either chemical or organic production methods, and the conservation tillage treatment with chemical production methods. The exception to this downward trend was with the conservation tillage treatment with organic production methods. This treatment initially had low yields, but once established (first three years) has seen increased yields over the last four years. Nutrient cycling and nutrient removal by tomato fruit showed similar results for the various treatments, but showed a different path flow for nutrients. Fruit nitrogen and potassium were exported off the field in large quantities, up to 90 lbs N and 130 lbs K/per acre. Phosphorus, calcium and magnesium were exported at a lower removal rate, in the order of 5, 7, and 15 lbs P, Ca, and Mg per acre, respectively. Tomato roots recycled very low amounts of any nutrient, with 5 lbs N and K/acre the highest amount of nutrients measured. A control treatment with no fertilizer input has seen about 25 lbs N, 51 lbs K, and 10 lbs P available from the soil.

INTRODUCTION

Conservation tillage has become a common practice for many row crops in North Carolina and the Southeast. This tillage practice has become successful due to the availability and improvement of surface herbicides and equipment modifications. Horticultural crops are currently being trialed for their use with conservation tillage (Hoyt, 1999).

No-till experiments with vegetables have resulted in various degrees of success. The introduction of a no-till transplanter has provided a means for planting bare rooted or containerized cabbage or broccoli (Hoyt, 1999; Morse, 1993) transplants in undisturbed soil. Sweet corn, dry and field beans, and squash (Cucurbita spp.) can be easily planted by current no-till seeders designed for agronomic row crops. Other vegetable crops have been successfully planted with some form of conservation tillage - popcorn, tomatoes, peppers, potatoes (Hoyt and Monks, 1996; Mundy et al., 1999). Conversely, lower yields with conservation tillage have been obtained with cucumber and carrot.

The benefit of surface residues or mulch in conserving soil moisture in horticultural crops has been known for many years with materials such as black plastic emulating the benefits of crop residues (Estes et al., 1985). Growing winter cover crops for surface residues in conservation tillage provides mulch that may decrease soil temperature and influence vegetable yields, depending on cover residue selection (Hoyt and Konsler, 1988). Legume residues have increased vegetable yields when compared to grass residues (Hoyt and Hargrove, 1986). Both legume and grass winter cover crops increased nitrogen (legumes through biological nitrogen fixation), potassium, and phosphorus recycling within the soil horizon (Johnson and Hoyt, 1999). Winter cover grass residues can produce similar yields as legume cover residues with conservation tillage if fertilizer nitrogen is adequately supplied (Hoyt, 1984; Ranells and Wagger, 1997).

The following experiment compares conventional tillage with black plastic to strip-tillage and the use of winter cover residues as mulch. Each tillage system also has two production methods, a chemical production system using current labeled materials and an organic production system that uses only materials permitted by the Organic Materials Review Institute. This experiment was conducted at the Mountain Horticultural Crops Research Station, Fletcher, North Carolina, in the Mountain region of the Southeastern United States.

METHODS AND MATERIALS

Five production systems were established in 1995 to determine how tillage and management can affect the whole farming system. These systems include: 1.Conventional tillage/chemical management; 2. Conventional tillage/organic management; 3. Conservation-tillage/chemical management; 4. Conservation-tillage/organic management; and 5. Control-conventional tillage (no management). Chemical management methods include the use of synthetic chemicals common to production agriculture. Herbicides, insecticides, fungicides, and chemical fertilizers (P and K at recommended rates and nitrogen at 180 lbs/acre for tomatoes) are used in this treatment. Fumigation was used in the plow/plastic chemical management treatment (Treatment 1). Organic production methods include the use of materials allowable by the Organic Materials Review Institute (OMRI). Although the organic treatments (Treatments 2 and 4) use only allowable materials by OMRI, these plots have not been certified. Soybean meal was used as the nitrogen source, with the same N rate as the chemical treatments. All fertilizer materials were hand broadcast in-row before plastic was established (putting the fertilizer under the plastic) or after strip-tilling. The control treatment had no winter cover crop, no fertilizer or pesticides applied and was plowed similar to the conventional treatments. Irrigation was applied to all production treatments as needed, except for the control treatment which had no irrigation.

All production systems had a winter cover crop of wheat (50 lbs/acre) and crimson clover (20 lbs/acre). Plots that were conventional tillage-chemical were plowed in late April each year and the conventional tillage-organic in early May. Conservation tillage used strip-tillage for the tomatoes, using a Bush Hog Ro-till one week after herbiciding (conservation tillage-chemical) or flail chopping (conservation tillage-organic) and one week before transplanting. All plots were transplanted the third or fourth week of May. Each system had a 3 year rotation of vegetables on one half the plots, and the other half with continuous tomatoes. Only data from the continuous tomato treatments will be discussed in this publication.

RESULTS AND DISCUSSION

Tomatoes were grown each year on the continuous tomato section of each plot. The first few years all treatments steadily had lower tomato yields, with both tillage treatments with chemical management having greater yields (Figure 1). The last 4 years both plowed treatments (chemical and organic management) continued this pattern. The strip-till chemical tomato yields have maintained good yields, while the strip-till organic have increased each year. This contradicts the tomato vine weights 45 days after transplanting, where both plowed/black plastic production systems (both chemical and organic management) have greater growth early in the season compared to the strip-till systems (Figure 2). Conservation tilled vegetable crops with long growing seasons have similar yields to plowed conventional systems because plant (vine or stalk) growth generally is comparable by harvest time (Hoyt, 1999). Vegetable crops that are short season or have multiple harvests will start to produce fruit earlier in the conventional system due to warmer soil conditions compared to the mulch covered soil produced by conservation tilled systems (Hoyt and Konsler, 1988).

Each year we measured end of the season tomato vine, root, and weed biomass, and total fruit removed from the plot treatments. Figures 3 and 4 represent the nutrients removed (fruit) or recycled (vines, roots, weeds) back into the soil for each treatment. Each year variations did occur, but these data do represent similar data for each year. Vine biomass carbon averages around 1000 lbs C/acre, an amount similar to early winter cover crop plowdown. Weeds represent a considerable amount of organic matter going back into the soil for the two organic tillage treatments, the strip-till chemical, and the control treatments (these measurements are at the end of the tomato growing season, when fall weeds were allowed to grow due to the lack of fruit harvested towards the end of the season). The control treatment has nearly all plant components as weed organic C.

Fertilizer nutrients (N,P,K) moved both off the field (fruit) and recycled back into the soil. Fruit nitrogen removed 25 to 85 lbs N/acre from the field (depending on treatment), but recycled 30 to 90 lbs N/acre in the vine. Total N recycled back into the soil by weeds and plant ranged from 95 to 130 lbs N/acre (not counting the control treatment). Potassium was the plant nutrient taken up in the greatest quantity by these plant systems. Potassium too was exported from the field, and in greater amounts than nitrogen. Fruit potassium ranged from 50 to 130 lbs K/acre, compared to vine K of 50 to 85 lbs K/acre. Total recycled potassium to the soil ranged from 150 to 190 lbs K/acre. Roots add less than 5 lbs N or K/acre. The control treatment measures the amount of nutrients available from the soil only, thus the 30 lbs N/acre and 50 lbs K/acre taken up by the plant, fruit, and weeds (mostly weeds) would be the minimum amount these soils provide for any of the treatments. Nitrogen and potassium represent the major fertilizer nutrients needed by the plant (if we consider calcium being supplied by limestone).

Tomato fruit removed only about 15 lbs P/acre from a field, with another 15 lbs P/acre recycled back into the soil (Figure 4). Less than 1 lb of P/acre was measured in the roots for any treatment. Calcium and magnesium movement in plants and fruit were quite different than the potassium and nitrogen. Most of both Ca and Mg taken up by the plants (weeds and tomato) were measured in the vine and weed biomass. Less than 5 lbs Ca/acre and 7 lbs Mg/acre were removed in the fruit, yet the system (tomato and weeds) took up as much as 200 lbs Ca/acre and 80 lbs Mg/acre. Three lbs of Ca and less than one lb of Mg per acre were measured in the roots.

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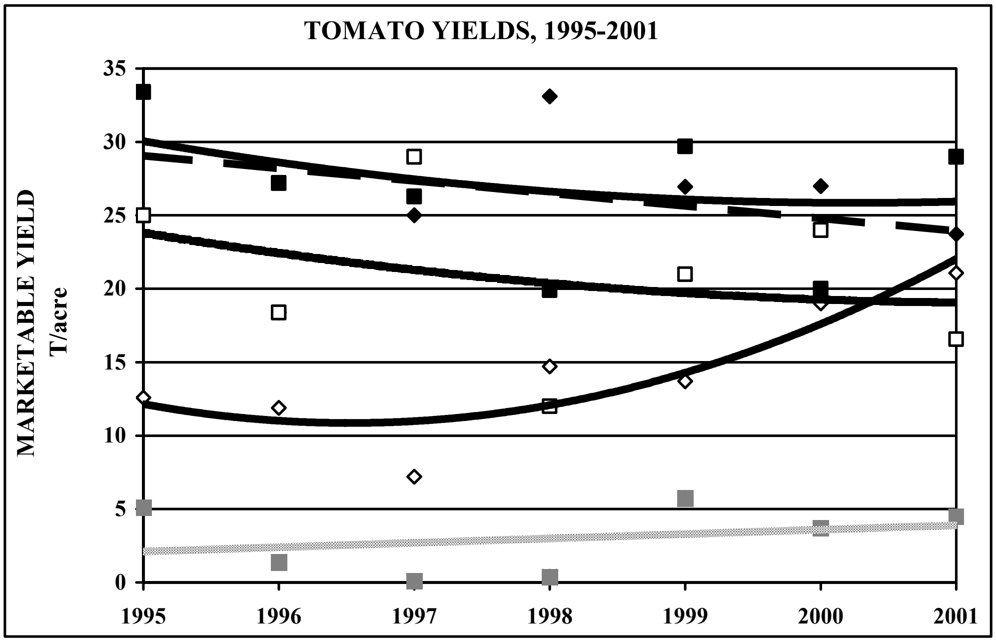

Figure 1. The effect of tillage and production methods on tomato yields from 1995 to 200

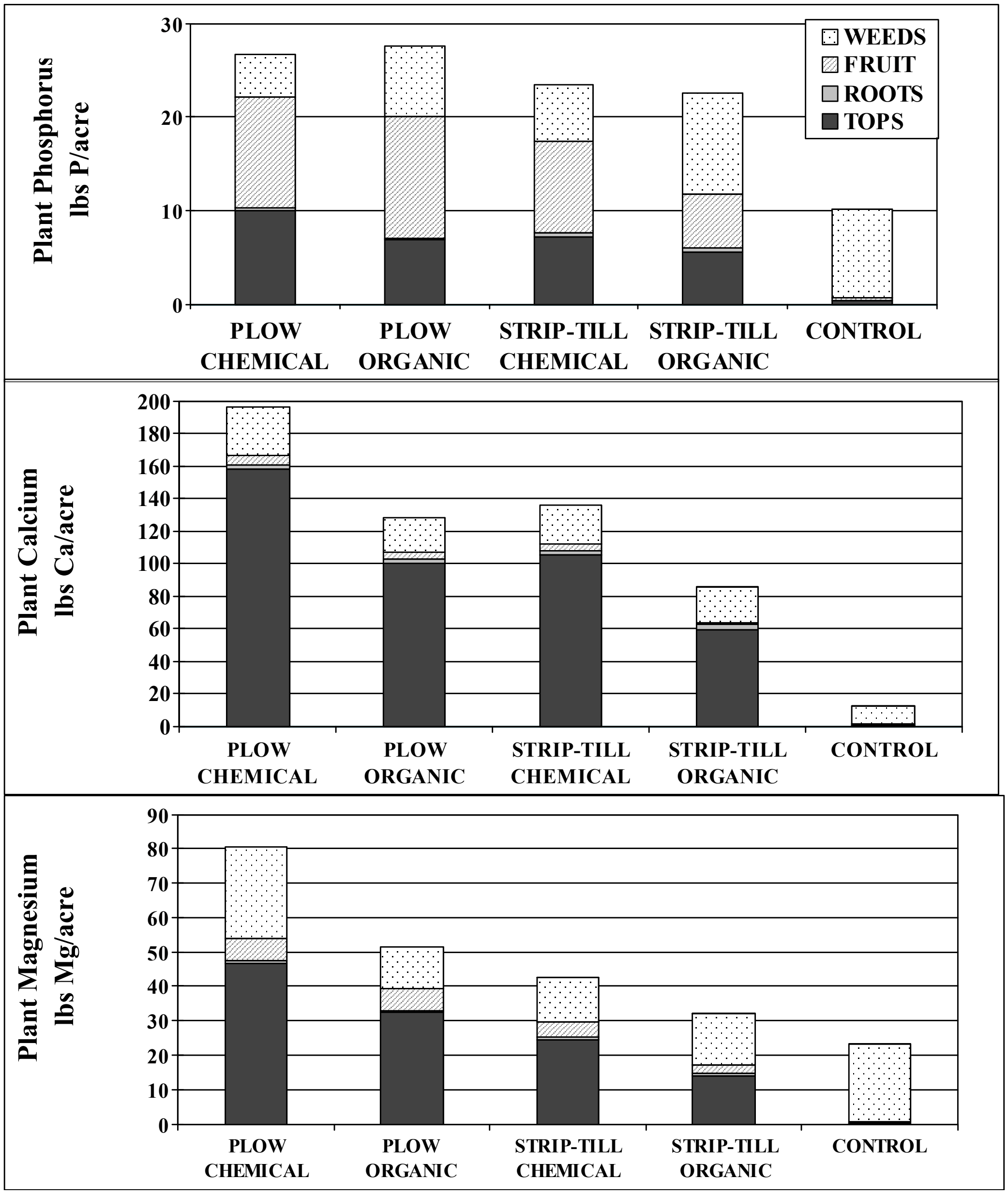

Figure 2. The effect of tillage and production methods on tomato vine growth 45 days after transplanting

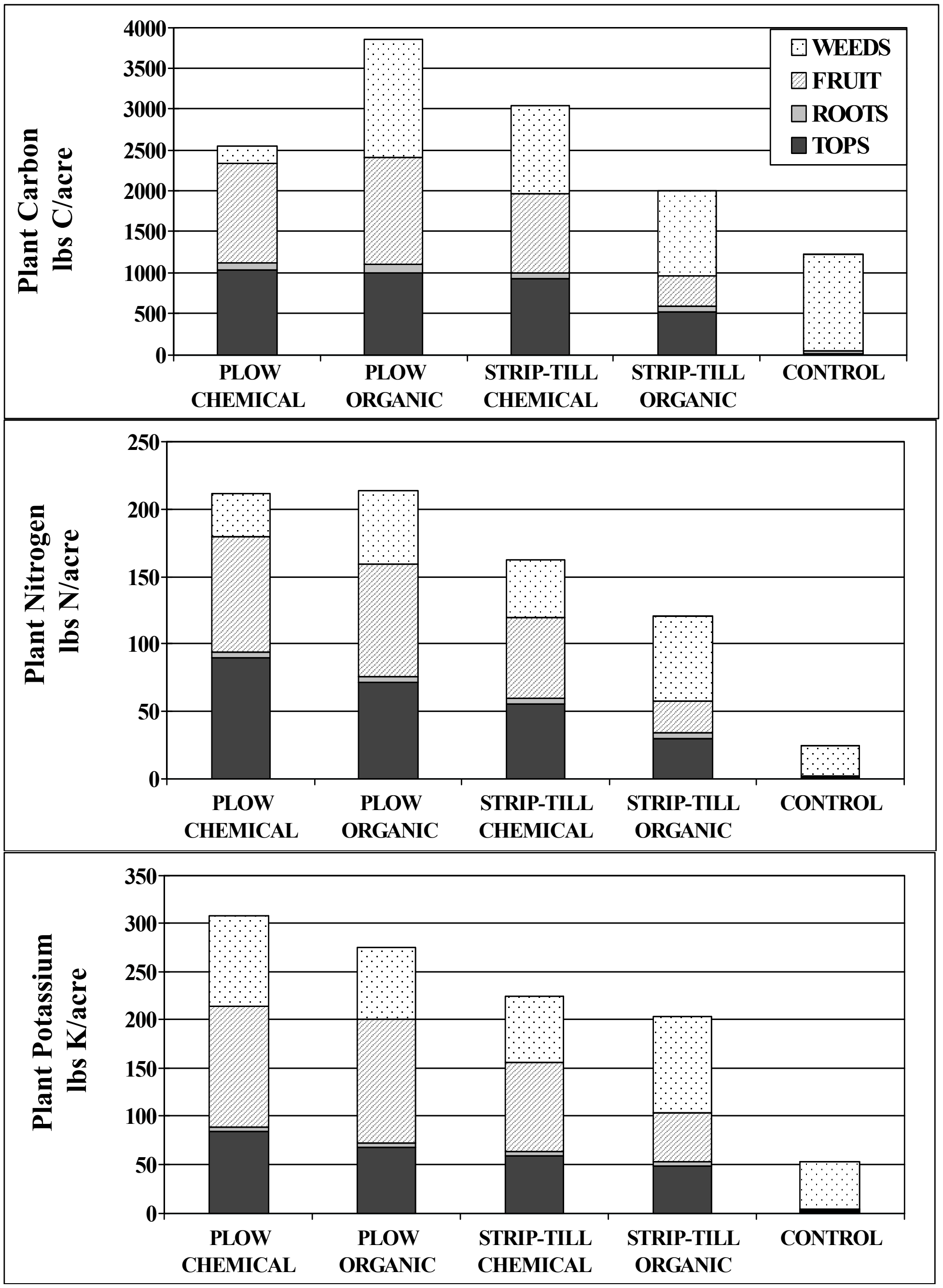

Figure 3. Tomato top (vine), root, fruit, and weed carbon, nitrogen, and potassium uptake measured at final harvest.

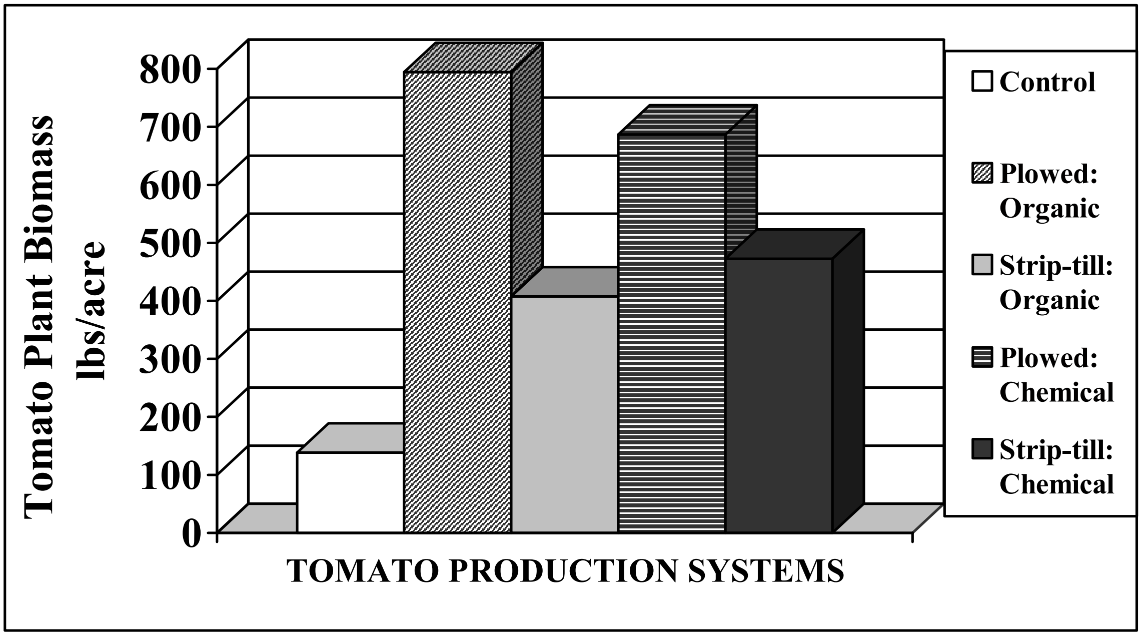

Figure 4. Tomato top (vine), root, fruit, and weed phosphorus, calcium, and magnesium uptake measured at final harvest