Effect of Organic Soil Amendments on Broccoli Production

Jan Libbey (One Step at a Time Farm) On-Farm Trial, Kanawha, IA

Introduction

This project was initiated as an on-farm trial in 1998 at the Jan Libbey and Tim Landgraf One Step at a Time Farm near Kanawha, IA. The farm is organic and produce is marketed as a Community Supported Agriculture (CSA) farm and at local farmers' markets. Prior to this experiment, the farmer had not employed any methods of fertilization or composting on the land used for this study.

Experimental Design

The experimental design consisted of two treatments with four replications. Treatments consisted of an application of composted turkey litter (Ultra-Gro®, Ellsworth, IA) with a chemical analysis of 2.2-2.8-1.5 (N-P-K) and other minor nutrients and an untreated control.

Materials and Methods

A new site was selected within the farm each year in order to prevent pest and disease build-up resulting from continuous cropping and to avoid excessive compost applications. In 1998, the experimental area was roto-tilled by the cooperator on 7 May 1998. Broccoli seedlings (Orion cultivar from Johnny's Selected Seeds, Albion, ME) were started in a greenhouse on 3 April and were transplanted on May 11. A total of 156 plants were planted in a randomized complete block design with three replications of 52 broccoli plants each. Compost was applied at a rate of 100 lb N/acre (112 kg N ha^{-1}) on May 11 to half the plots in the experiment. Factors quantified were plant height, number of leaves, and number of pest and beneficial insects on each plant. Data collection was initiated on May 27 and continued weekly until June 19 (5/27, 6/4, 6/10, 6/19). Harvesting was initiated on July 1 (45 days after transplanting-DAT) and on July 5 (49 DAT). This produce was harvested at the peak of quality and was delivered immediately to CSA customers. All data for each year was subjected to analysis of variance and differences were determined with Fisher's PLSD test (SAS Institute, 1988), with the exception of yields, where mean weight and number of harvested heads per treatment are presented.

In 1999, the experimental area was roto-tilled by the cooperator on May 3. Broccoli seedlings ('Genji,' Johnny's Selected Seeds, Albion, ME) were started in a greenhouse on April 2 and transplanted on May 11. Forty plants were planted in each of the three replicated rows, for a total of 120 plants in the experiment. Compost was applied as described above on May 11. Monitoring occurred on 15 plants per treatment in each replicate. Data collection was initiated on June 11 and continued weekly until July 21 (6/11, 6/16, 6/24, 6/30, 7/8, 7/14, 7/21). Plants were sprayed with *Bacillus thuringiensis* subsp. *kurstaki* (Dipel® DF, Abbott Laboratories, North Chicago, IL) on July 13 for the control of lepidopterous pests such as cabbage worm and cabbage butterfly. Harvesting was initiated on July 8 (58 DAT) with nine additional harvests on

July 12, 15, 18, 19, 22, 29, and on August 9, 11, and 17 (98 DAT). Harvested broccoli heads were handled in a similar method as in 1998.

Plant bed preparation followed that described in 1998 and 1999 on 8 May 2000. Broccoli seedlings ('Genji,' Johnny's Selected Seeds, Albion, ME) were started in the greenhouse on April 1. A total of 177 plants were transplanted on April 29 and 177 additional plants were transplanted on June 10 as a result of inadequate populations. Three replicate plots, each with 118 plants, were transplanted for a total of 354 plants in the experiment. Compost was applied as previously described on May 25. A representative number of soil samples were taken from each plot and analyzed to determine soil fertility levels on 25 May 2000 (Table 1). Data was collected on 15 plants per treatment in each plot. Data collection was initiated on June 1 and continued weekly until August 17 (6/1, 6/8, 6/16, 6/29, 7/6, 7/20, 7/27, 8/3, 8/10, 8/17). Plants were sprayed with Dipel® on July 1, July 28 and July 31. The first harvest was initiated on June 28 (60 DAT) and continued until July 18 (80 DAT). The second harvest was initiated on August 3 (54 DAT) and continued until August 17 (68 DAT). All data for each year were subjected to analysis of variance and differences were determined with Fisher's PLSD test (SAS Institute, 1988).

Results and Discussion

Results of the first year of the trial in1998 showed a significant increase in broccoli plant height and number of leaves where compost was applied (Figures 1 and 2). There were also greater numbers of heads harvested and greater fresh weight in plots receiving compost (Figures 3 and 4). There were significantly more beneficial insects (ladybeetle, lacewings, spiders) found in the compost plots 39 DAT (Figure 5). Significantly more cabbage butterfly larvae (Figure 6) were found 30 DAT in the control plots.

Figure: 1 Broccoli plant height with and without compost 1998

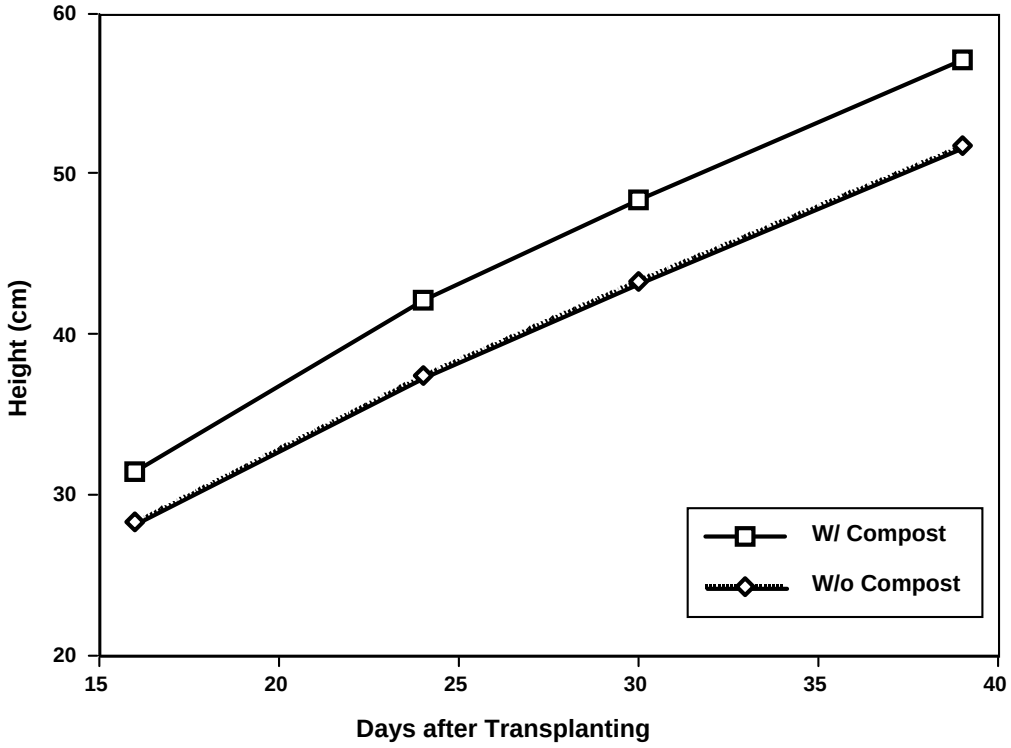


Figure: 2 Broccoli leaf number per plant with and without compost 1998

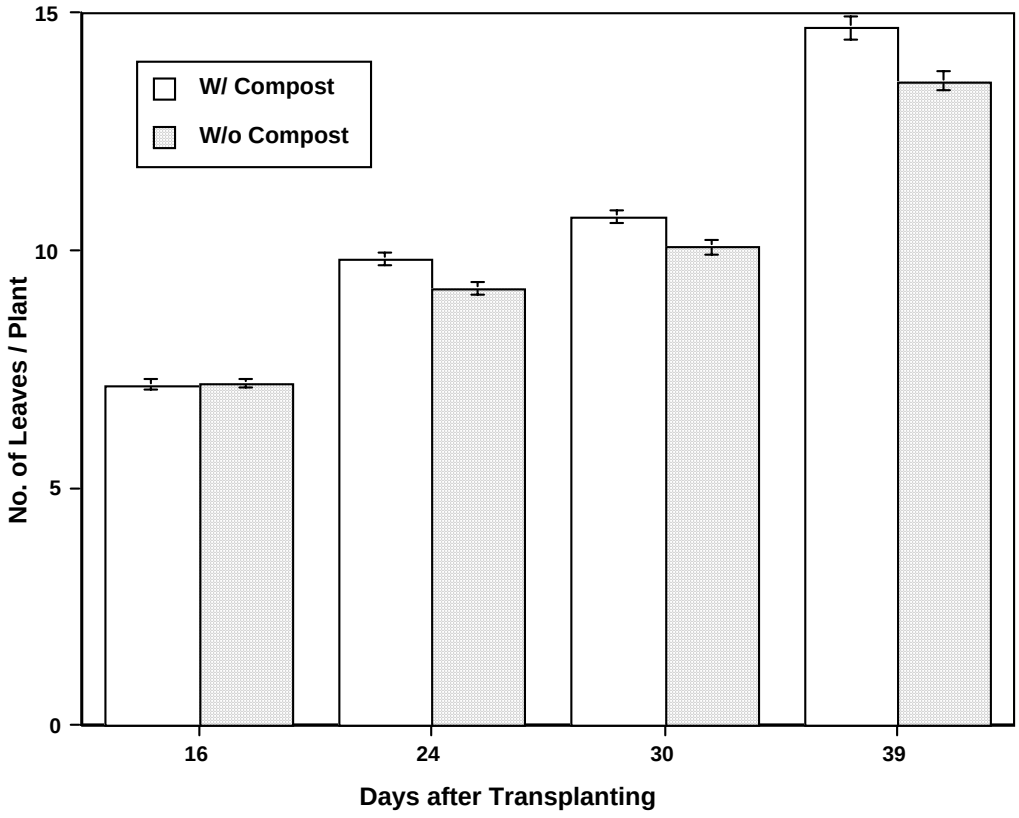


Figure: 3 Number of broccoli heads with and without compost 1998

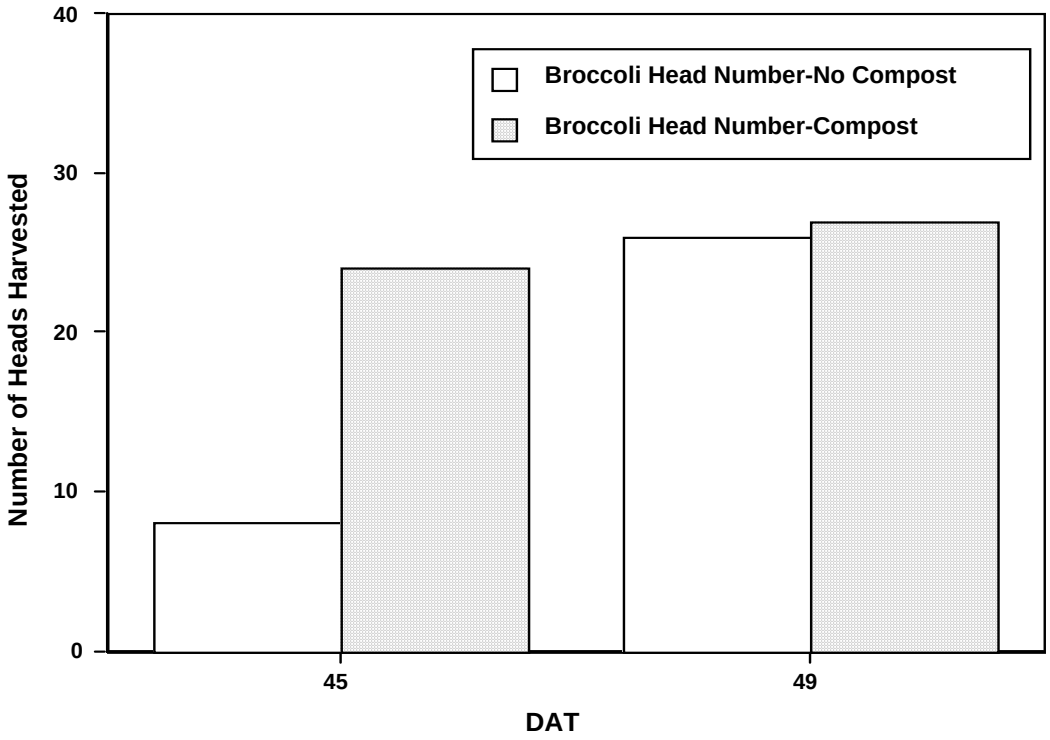


Figure: 4 Total broccoli weight with and without compost 1998

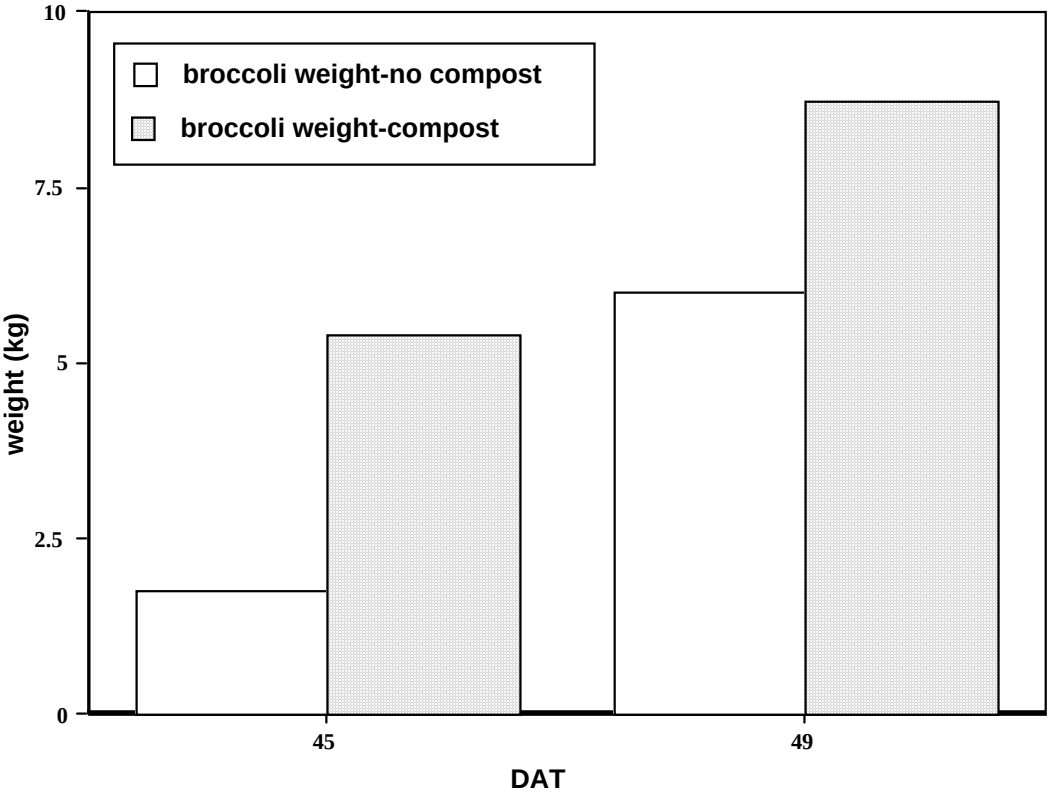


Figure: 5 Beneficial Insects, Kanawha Compost Trial, 1998.

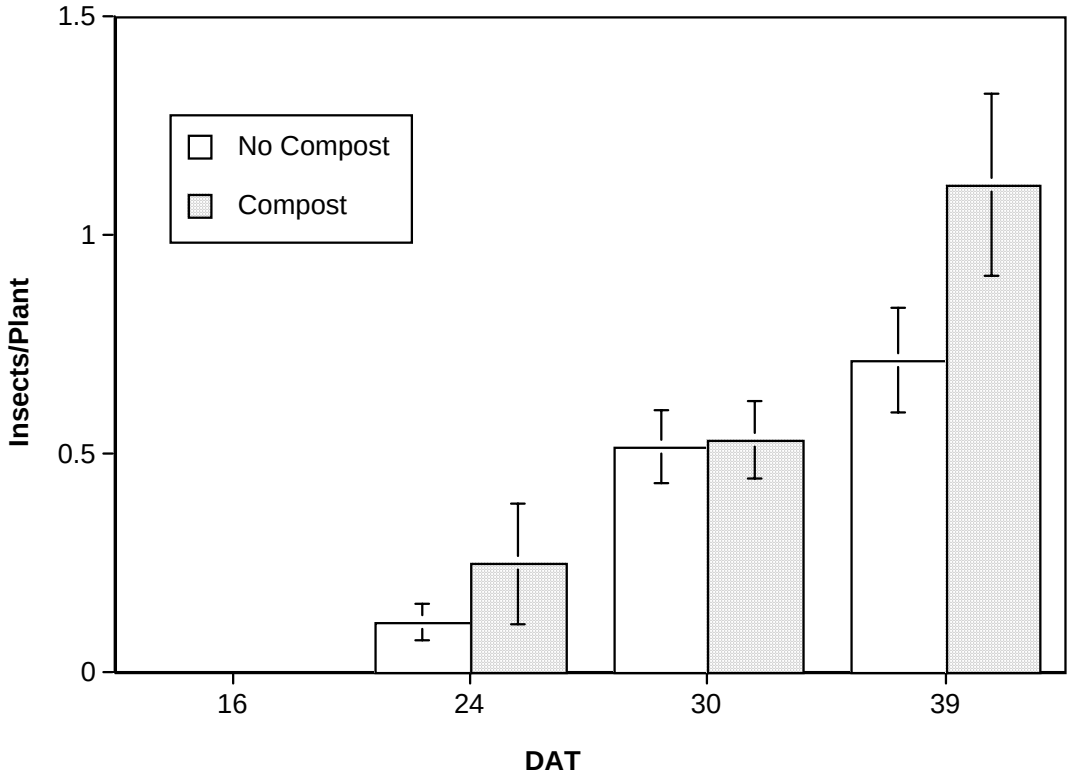
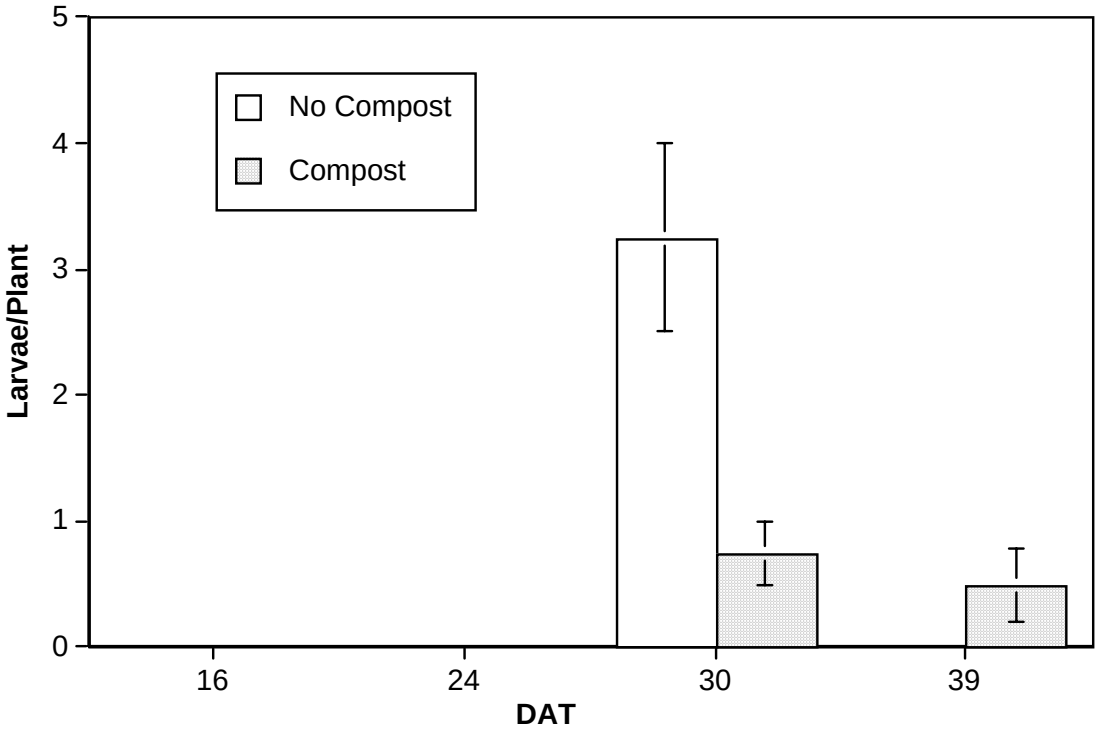


Figure: 6 Cabbage butterfly larvae, Kanawha compost trial, 1998



In 1999, a significant increase in broccoli plant height was observed on the final two sampling dates (July 14 and 21) where compost was applied (Figure 7). No significant differences were found in leaf number, number of heads harvested and fresh weight at harvest (Figures 8, 9 and 10). Significantly greater numbers of beneficial insects (ladybeetle, lacewings and spiders) were found 60 DAT in the compost plots (Figure 11) but significantly more cabbage butterfly larvae were found in the compost plots 74 DAT (Figure 12).

Figure: 7 Broccoli plant height with and without compost 1999

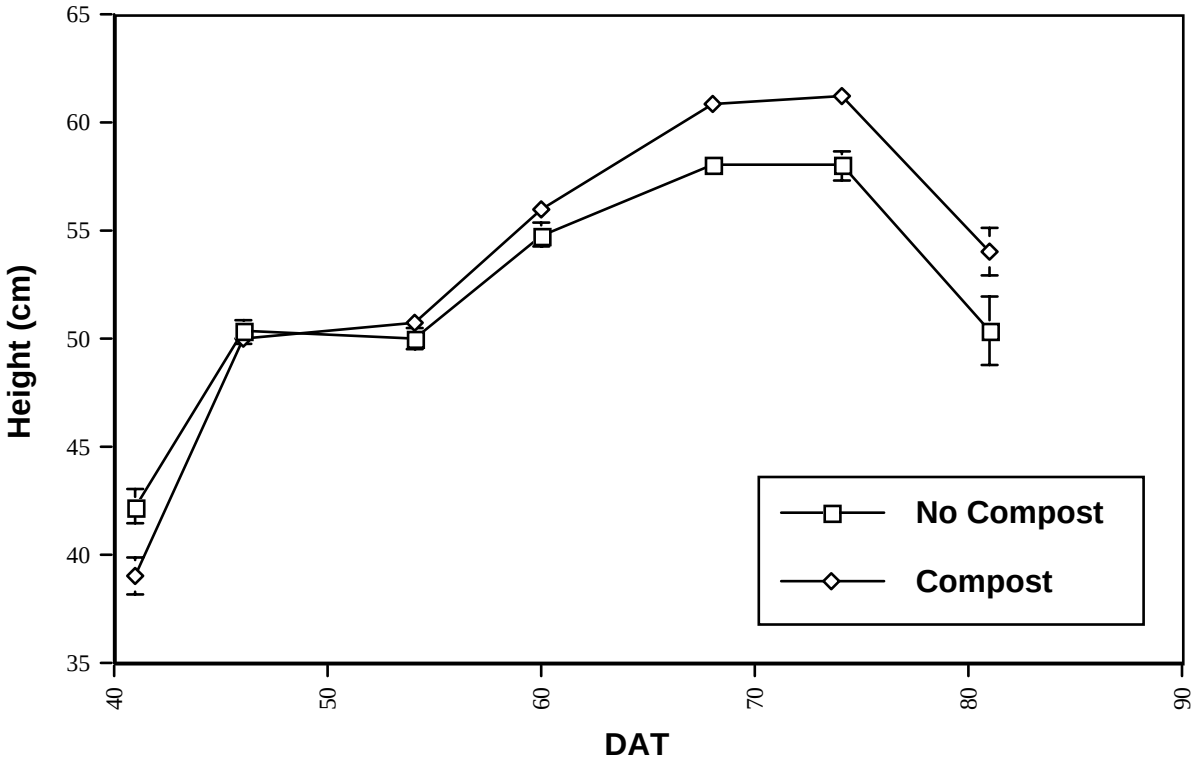


Figure: 8 Broccoli leaf number with and without compost, 1999

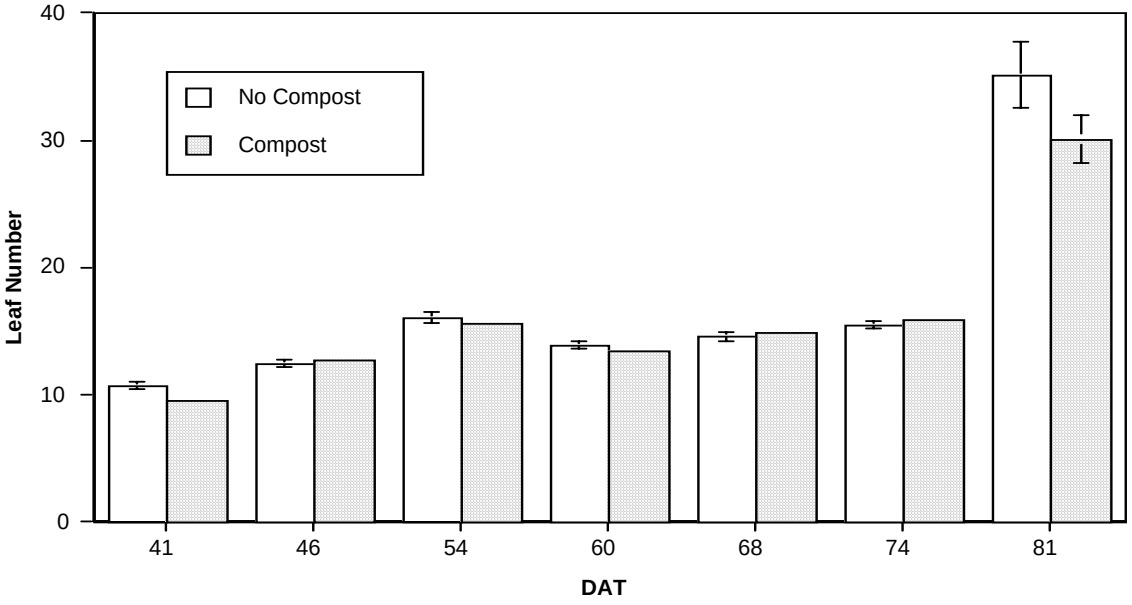


Figure: 9 Number of broccoli heads harvested, Kanawha compost trial, 1999

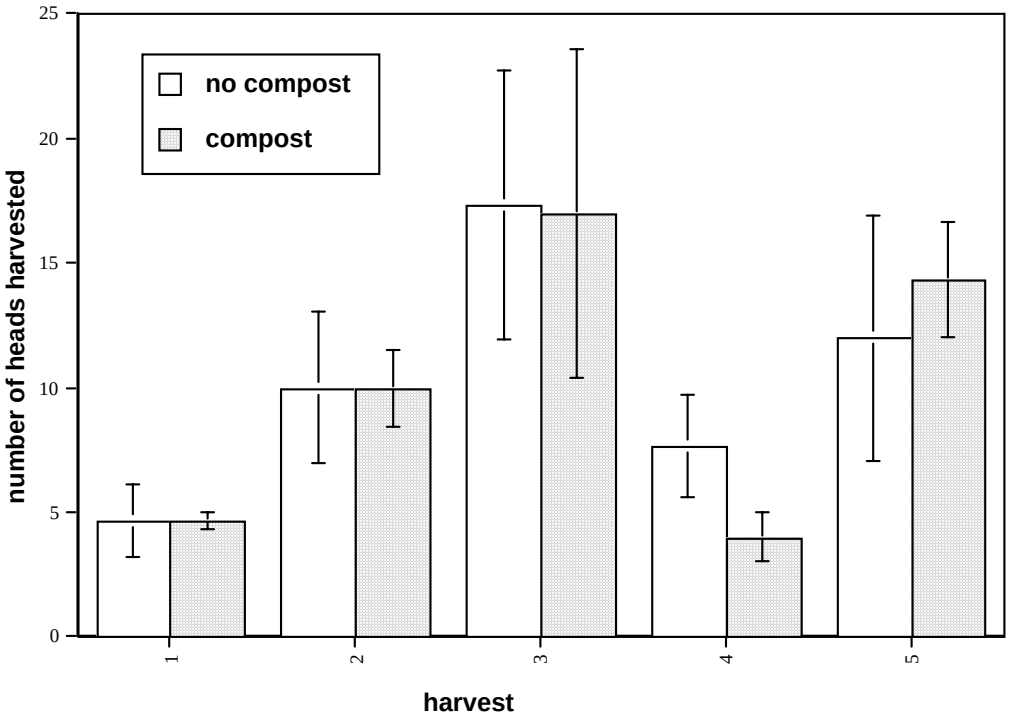


Figure: 10 Broccoli harvest weight with and without compost, 1999

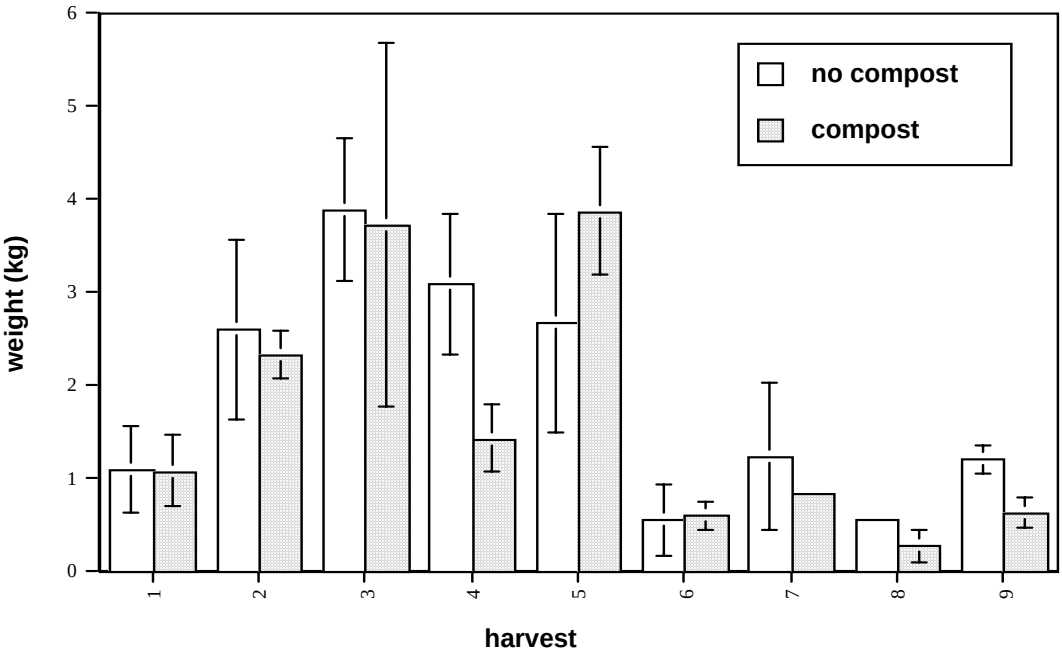


Figure: 11Beneficial Insects, Kanawha Compost Trial, 1999 .

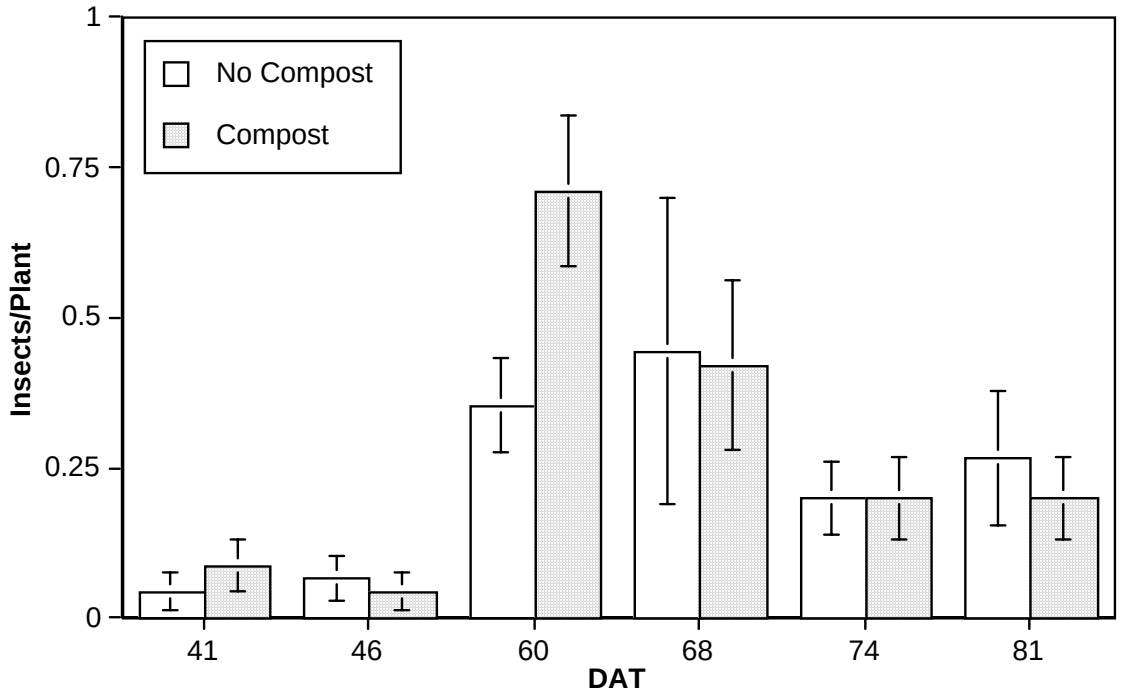
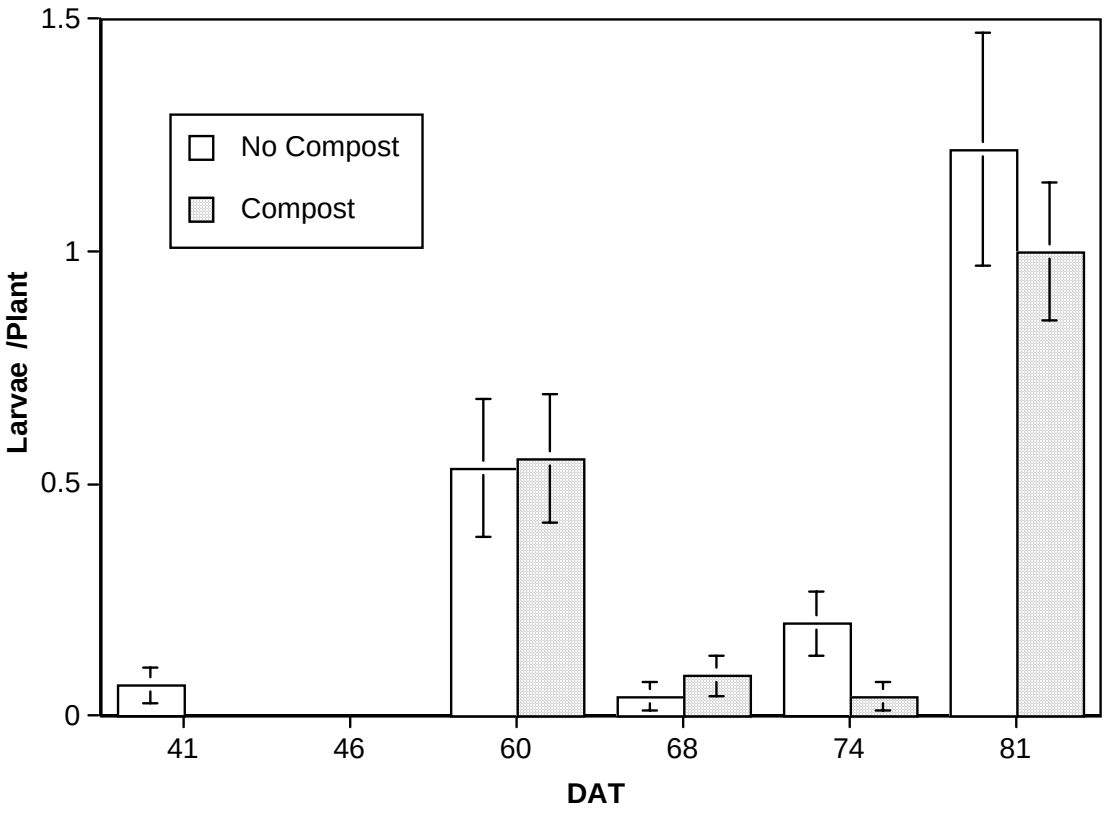


Figure: 12 Cabbage butterfly larvae, Kanawha Compost Trial, 1999



In 2000, there were no significant differences found in plant height or leaf number between compost and control plots (Figures 13 and 14). Although composted plots produced greater broccoli weight at harvest, significant differences were not obtained. The lack of a significant difference is surprising since the soil nutrient levels (Table 1) in the compost plots are much greater than those of the control. As was suggested in 1999, soil moisture may have limited productivity in the control plots in 1998 resulting in the statistically significant difference in that year. In seasons where moisture is limited, the compost plot may be less sensitive to deficiency as a result of enhanced soil moisture retention brought about by compost addition.

Table1. Soil Characteristics following compost applications, 2000.

	% moist	pH	E.C.	tot. C ug/g	NO_3-N	NH_4+NO_3	P	K	Na
control	12.0	5.9	185.1	21270	8.7	11.3	42.9	144.4	21.8
compost	11.5	5.9	292.2	24557	31.6	34.9	125.2	267.6	49.3

Since the broccoli cultivar was changed at the suggestion of the farmer-cooperator from 1998 to 1999-2000, it is possible that yield improvements arising through the compost addition were masked by overall improved yields in the 'Genji' cultivar. Each cultivar will vary in response to environmental conditions. In 1998, there were significantly greater numbers of heads harvested and fresh weight at harvest in 'Orion' broccoli. In 1999, greater average head weight at harvest was obtained in 'Genji' broccoli plants receiving compost, but differences were only statistically significant on one harvest date. In 2000, the same effect was observed (Figure 15).

The value of compost as a soil amendment and the effect on organic broccoli production will not be consistent for every cultivar. From these experiments, it appears the lower yielding cultivar 'Orion' benefited significantly from the compost addition, whereas for the higher yielding 'Genji,' compost addition resulted in a less significant increase in yield.

Figure: 13 Broccoli Plant Height with and without compost, 2000

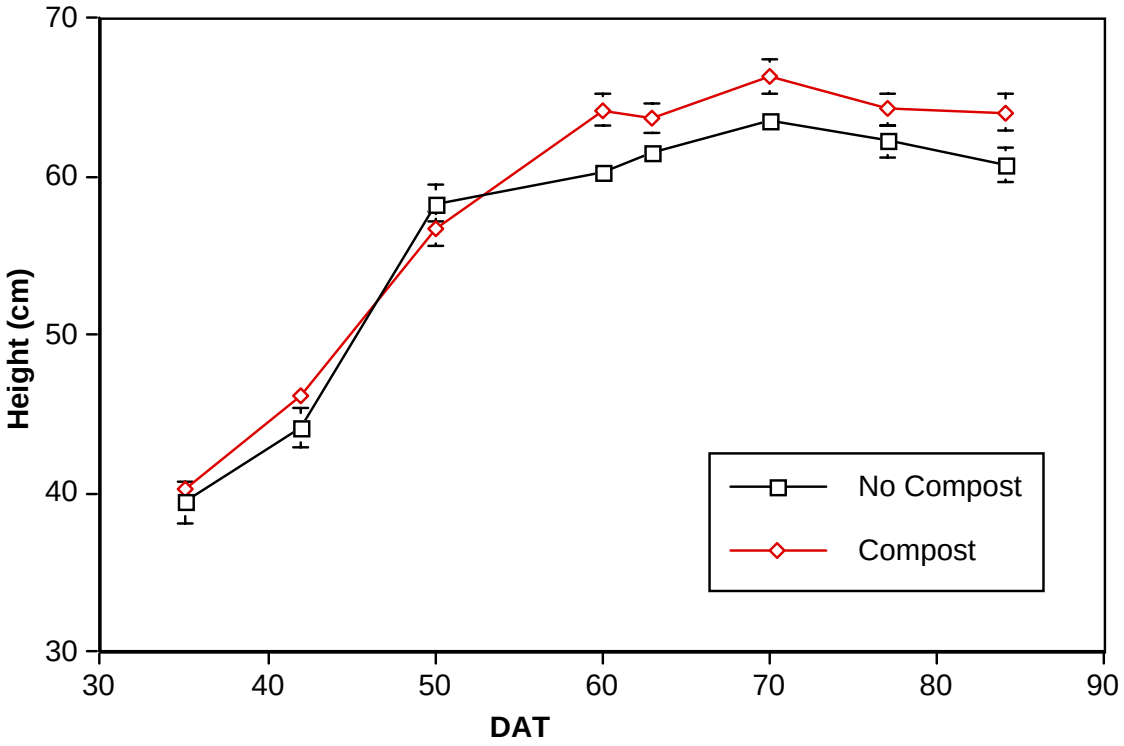


Figure: 14 Broccoli Leaf Number with and without compost 2000

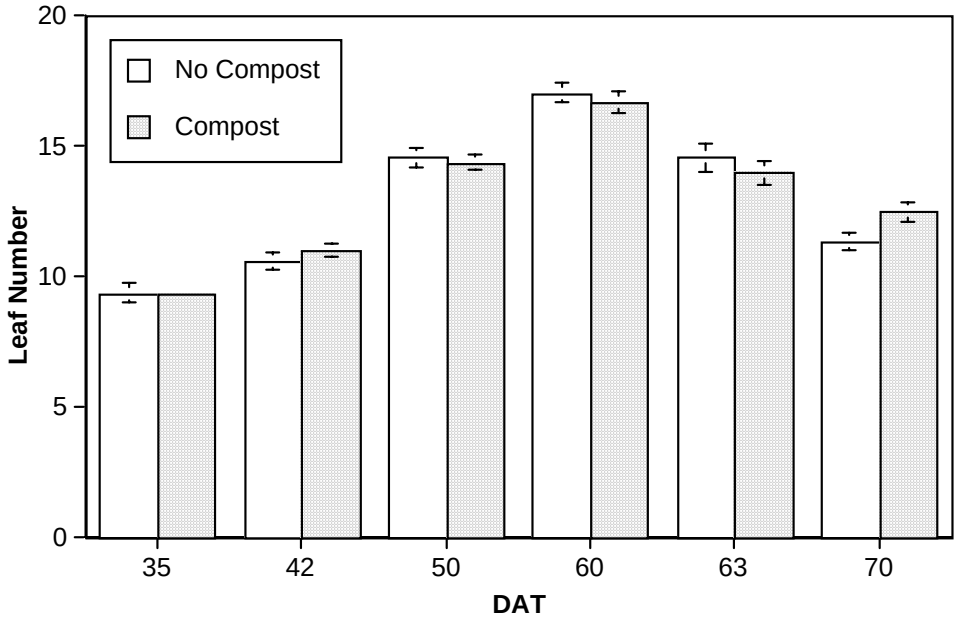
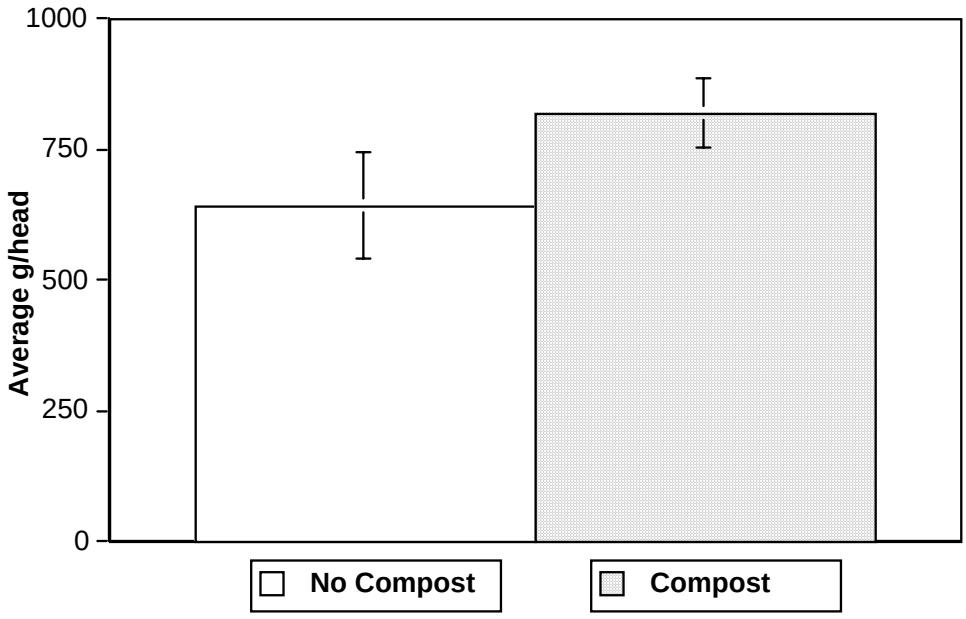


Figure: 15 Average Broccoli Head Weight with and without compost, 2000.



Significant differences in the number of beneficial insects were found on three out of eight sample dates in 2000 (Figure 17). Differences were not significant over the entire sampling period, however. Harmful insect numbers were significantly greater in the compost plots. This significance was apparent for the entire sampling period (Figure 18).

Figure: 17 Beneficial Insects, Kanawha Compost Trial, 2000.

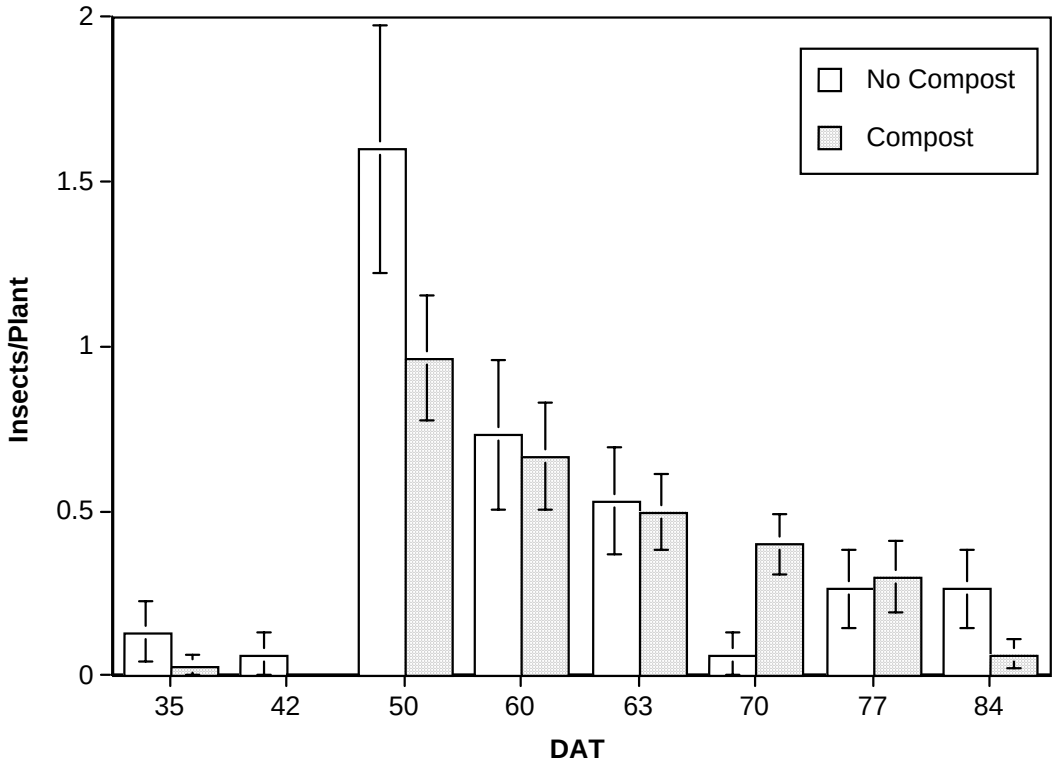
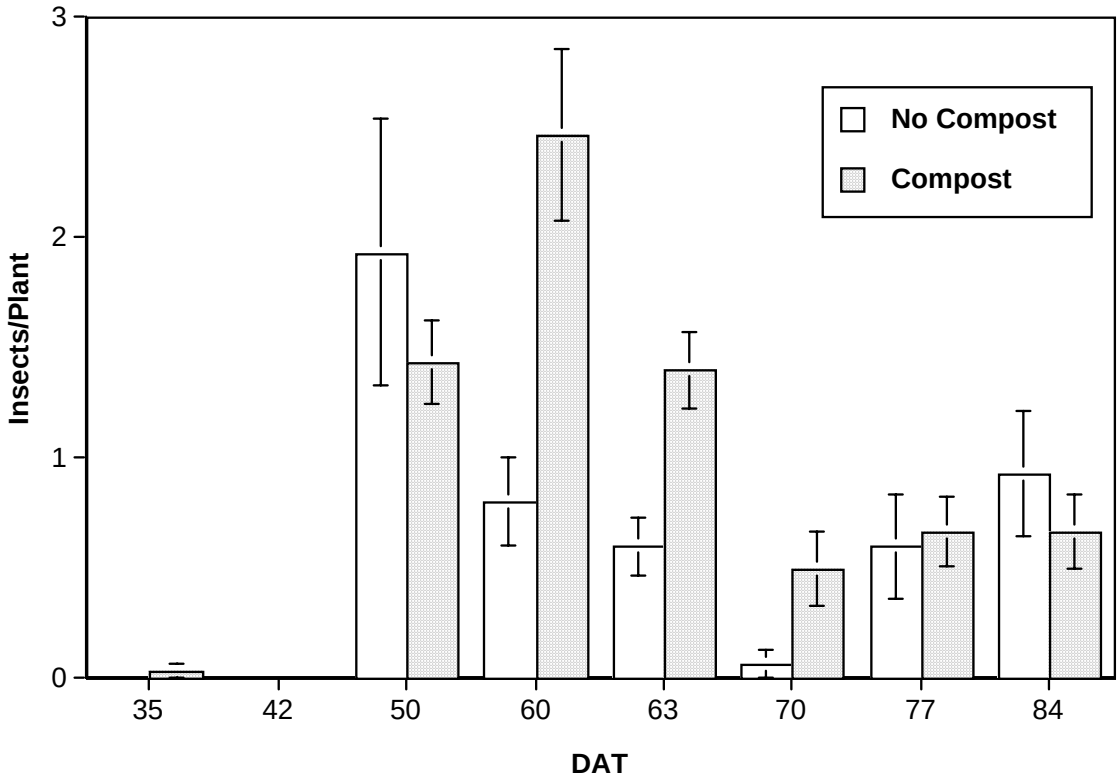


Figure: 18 Harmful Insects, Kanawha Compost Trial, 2000.



Conclusions

The addition of compost as a soil amendment should not be confused with a synthetic fertilizer addition. The long-term benefits of compost to the soil-plant system in terms of improving soil structure through the addition of organic matter, soil moisture retention, and soil microbial activity may exceed benefits derived from the supply of plant nutrients alone. A study of the long term effects of compost addition and varying rates and types of compost would prove beneficial to organic farmers and gardeners in choosing the optimum conditions for organic vegetable and herb production. In addition, the interaction between cultivar and response to compost appears to be significant and warrants further investigation.

Impact of the Results

It is difficult to separate the impacts of all LCSA projects from each other. Overall impacts are outlined below. Specific impacts to the ***Soil Amendments*** project include that approximately 7,000 people were made aware at Field Days and presentations about the benefits of compost and other sustainable and organic agricultural practices. The farmers involved in these trials have adopted sustainable practices of soil testing and applying compost when needed.

I. Output Indicators

Generating Basic Information

- Number of research/demonstration plots established to develop sustainable/organic systems: 13
- Number of research/extension publications in sustainable/organic horticulture/agronomy: 15
- Number of grants to supplement research and demonstration efforts: 12

Engagement/Application

- Number of producers utilizing sustainable/organic practices: 353
- Number of acres in certified organic production: 150,000
- Number of Community Supported Agriculture projects (CSAs) active: 35
- Number of diversified or alternative community marketing systems or alliances established: 5
- Number of trained or updated key agricultural professionals in sustainable agriculture: 35
- Number of educational meetings, field days, workshops, one-on-one contacts, phone contacts: 268
- Number of mass media dissemination and direct teaching events: 7

II. Outcome Indicators:

- Percentage improvement in soil quality as a result of sustainable/organic practices: 10%
- Percentage reduction of harmful contaminants (excess nutrients and toxic chemicals) in Iowa waterways and groundwater: 44%
- Percentage new products (out of total market) for the value-added market: 2%
- Percentage income increase for family farmers from adoption of sustainable/organic practices:
  (Long-range determination underway in 2000)

Publications with Information from this Project:
(* represents availability on the Web)

Delate, K. 2001. Using an agroecological approach to farming systems research. Accepted for HortTechnology (#1413)

*Rossiter, C. and K. Delate. 2001.Effect of Organic Treatments on Tomato Yield. Iowa State University Allee Research and Demonstration Farm Progress Report, College of Agriculture, Iowa State University, Ames, IA..

*Delate, K. 2000. Organic Agriculture. Submitted as PM publication to Extension Communications. Expected release date: 8/2001

*Delate, K. 2000. Soil Management for Organic Farmers. Submitted as PM publication to Extension Communications. Expected release date: 8/2001

*Delate, K. and D. Muenchrath. 2000. Organic Farming Systems. Cropping Systems Management and Crop Ecology-Agronomy 531. Department of Agronomy, Iowa State University, Ames, IA.

Delate, K.M. 2000. Organic Agriculture. Encyclopedia of Pest Management , Professor David Pimentel (ed.), Cornell University, Marcel Dekker Press, New York (In press: publication date1/01)

Delate, K.M. 2000. The Sustainability of Organic Production: A Model for Rural Development. World Bank Sustainable Agriculture Conference, April 10, 2000, Iowa State University, Ames, IA.

Delate, K.M. and J. Boes. 2000. Managing Your Organic Crops for Optimum Returns. Integrated Crop Management Conference Proceedings, November 29, 2000, Iowa State University, Ames, IA.

* Delate, K. and V. Lawson. 2000. Evaluation of Soil Amendments and Cover Crops for Certified Organic Pepper Production. Horticulture Research Report, Dept. of Horticulture, ISU, Ames, IA.

*Delate, K., V. Lawson and C. Cambardella. 2000. Evaluation of Organic Soil Amendments for Certified Organic Vegetable and Herb Production. Annual Report for the Leopold Center for Sustainable Agriculture, LCSA, ISU, Ames, IA.

* Delate, K. 1999. Targeting the Premium Market: Organic Crops for Iowa. Integrated Crop Management Conference Proceedings, November 17, 1999, Iowa State University, Ames, IA.

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Rossiter, C. and K. Delate. 2000. Organic Gardening Trial. Iowa State University Allee Research and Demonstration Farm Progress Report, College of Agriculture, Iowa State University, Ames, IA.

Education and Outreach:

K. Delate made 197 presentations on organic production, agroecological research, and organic marketing to an audience of approximately 10,000 people from 1998-2000. This included the development of 17 slide shows and 4 publications to use at such meetings. The fact sheets have been submitted to become permanent numbered Extension publications. Twenty-five Field Days, where this project was discussed, were held from 1998 to 2000 to an audience of approximately 1,650 Iowa and Midwest producers/Extension staff. Included in these Field Days were the development of full-color fact sheets and media packages. Field Days were held at the Heenah Mahyah Farm herb trial in 1998 and 1999; the Muscatine Island Farm in 1998, 1999 and 2000; and at the One Step at a Time Farm in 1998, 1999 and 2000, where a total of 240 people participated in a discussion of trial results with K. Delate and cooperators. Other Extension activities around this research are discussed below.

Producer/Extension Workshops

Composting for Organic Producers Workshop

At the invitation of the Planning Committee of the Upper Midwest Organic Farming Conference, I organized a 6-hour composting workshop on March 18, 2000, that consisted of faculty from the University of Wisconsin and Iowa State University and growers engaged in compost operations. Over 400 people

attended these sessions and gained valuable information on compost composition and utilization.

TOOLBOX TRAINING FOR ORGANIC AGRICULTURE
On August 22-23, 2000, a tri-state training on organic agriculture was held in Greenfield and Orient, Iowa. This training focussed on organic principles and practices for 35 Extension specialists in Iowa, Missouri, and Wisconsin. Efforts in this activity included contacting appropriate administrators in other states, securing arrangements for speakers (including seven Iowa State University professors and seven farmers), arranging hotel and meeting rooms, meal orders/ delivery, and conducting a pre- and post-test to measure course effectiveness.

ORGANIC CROP PRODUCTION IOWA COMMUNICATION NETWORK (ICN) COURSE
In the fall of 1999, I developed the first Organic Crop Production ICN course for Extension and ISU university credit (AGRON/HORT 494X) for Spring semester 2000. The total attendance for the course was 168 participants, including 24 ISU students. Efforts for the course included the following:

- Arranging speakers (ten Iowa State University professors and eleven farmers);
- Developing a resource manual (700 pages);
- Arranging an all-Iowa organic meal for the final session;
- Developing a corresponding web page where PowerPoint presentations were translated for the web;
- Developing testing materials, student project development and grading; and
- Evaluation of the course.

This course will be repeated in 2002, based on the amount of requests from producers and Extension staff. From this course, eight videotapes have been produced and have been distributed to more than fifty recipients. An Organic Agriculture Gateway webpage was created with assistance from the Brenton Center. Completion of the webpage is anticipated in January 2002.

Upper Midwest Organic Farming Intensive Workshop
Based on request from organic farmers and agricultural professionals in the Midwest, a six-hour workshop was organized for March 23, 2001, in La Crosse, Wisconsin. I was responsible for a course on “Resources for Organic Farmers” that included publications, video tapes, farmer contacts, and organizations supporting organic producers in terms of funding and research initiatives. My course involved Extension personnel from the Universities of Minnesota and Wisconsin, along with agricultural professionals from lending agencies. Regional attendance was estimated at 400 participants.

Iowa Fruit and Vegetable Growers Association Organic Workshop
On February 11, 1999, over 100 people attended the first Organic Fruit and Vegetable Workshop I organized for the IFGVA annual conference in Cedar

Rapids. In addition to arranging for seven professor- and producer-speakers, an all-organic meal was organized for the event, which allowed involvement of farmers with the conference participants. Since this event, I have spoken at all IFGVA annual conferences, and organized an Organic Workshop for the February 24, 2000, meeting.

Cooperative Efforts:

We gratefully acknowledge the help of Jan Libbey and Tim Landgraf of One Step at A Time CSA, and the staff at the Muscatine Island Research Farm, USDA National Soil Tilth Lab (Cindy Cambardella and lab); the diagnostic labs. in Agronomy, and Horticulture; George Kraus (Chemistry) and Frontier Herbs (Norway, IA) for their efforts, advice and support. .

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