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RESEARCH TYPE: **Production**

TITLE: **The Effect of Four Weed Management Systems on Soil Quality in Strawberry Production**

Principal Investigator:

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Dr. Gail R. Nonnecke
Professor

Department of Horticulture
106 Horticulture Hall
Iowa State University
Ames, IA 50011
Phone: 515-294-0037
Fax: 515-294-0730
Email: nonnecke@iastate.edu

Co-Principal Investigator:

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Craig A. Dilley
Graduate Research Assistant

Department of Horticulture
106 Horticulture Hall
Iowa State University
Ames, IA 50011
Phone: 515-294-6011
Fax: 515-294-0730
Email: cdilley@iastate.edu

Introduction and Background

Weed management. Few herbicides are registered for weed management in matted-row strawberry culture. This is especially important for weed control in the establishment year. The absence of such herbicides has produced much interest and research in alternative weed control strategies (Black *et al.*, 2002; Dilley *et al.*, 2000; Hancock *et al.*, 1997; Merwin *et al.*, 1994; Morse, 2001; Nonnecke and Christians, 1993, 2001; Pritts and Eames-Sheavly, 1988; Pritts and Kelley, 2001, 1993; Smeda and Putnam, 1988). Promising ideas resulting from this research include the use of various types of mulches, natural weed control products, living mulches, and strategies that combine these and other methods. It is possible that with the refinement of current alternative weed management strategies, the impact of weeds in strawberry fields can be controlled to economically viable levels similar to herbicide use (Pritts and Kelly, 1997).

Soil quality. Physical and chemical analyses of field soil have been proven useful for monitoring nutrient status in strawberry production. However, these analyses can be improved by measuring biological properties in addition to physical and chemical properties. Physical and chemical indicators of soil quality have been studied and are well known and characterized. Various indexes have been developed that loosely associate certain physical and/or chemical soil properties that estimate a soil's ability to produce crops (Dahnke and Olson, 1990). Biological indicators in soil are very sensitive to changes in their environment and can be an early indicator of soil quality trends (Rice *et* al., 1996). Thus biological properties such as microbial C and N have the potential to be good indicators of soil quality (Kennedy and Papendick, 1995).

Biological indicators of soil quality have not been well characterized due to the relative difficulty of their study in the past. Measurements of biological indicators of soil quality have been less consistent in the past, but due to improved techniques, more reliable information about soil microbe populations, communities, and interactions have made this an opportune time to investigate correlations among the physical, chemical, and biological indicators of soil quality (Doran and Jones, 1996) in strawberry production. For example, measuring nitrification and/or nitrogen mineralization is a way to monitor the availability of nitrogen to the strawberry plant. By measuring the effects of conventional and alternative strawberry weed management systems on physical, chemical, and biological soil properties, and by applying these measurements to a soil quality index, we will be able to quantify the relationships between soil properties, soil quality, and weed and disease pressure in strawberry fields.

There are an extensive number of measurements available to assess soil quality properties, but time and money preclude using all of them. One option that has been documented by Doran and Parkin (1996) is to collect data from a limited set of predetermined variables that will still provide accurate soil quality information. This idea has been called a minimum data set (MDS). The data gathered for the MDS can be quantified and used as a component of an overall soil quality analysis. Several mathematical formulas have been proposed for this purpose (Doran and Parkin, 1996; Gregorich *et al.*, 1994; Karlen *et al.*, 1997; Kennedy and Papendick, 1995; Parr *et al.*, 1992; Seybold *et al.*, 1997; Singh *et al.*, 1992) and we will base our model on these.

Research Project

The project investigates four different weed management strategies in a newly established strawberry planting and observes their effect on biological, physical, and chemical properties of soil. We will examine the relationships between all three properties and determine correlations. We will also measure the amount of specific soil-borne pathogens and determine if their presence is related to a weed management system. The effect of each weed management system on weed growth and development and strawberry plant growth and yield will also be important parts of this study.

This research project is distinctive in that we will attempt to measure soil quality of strawberry production systems using biological indicators in addition to other soil properties. Until recently, most soil quality indexes were based on the physical and chemical properties of soil alone. The combination of all three properties will increase the power of current soil quality measures and thereby benefit fruit growers. This research will also contribute to the development of useful alternative weed management strategies, an important aspect due to the lack of herbicides in small fruit production.

The experimental treatments include the four following weed and soil management systems.
Experimental treatments:

Treatment 1) Killed mulch: A cover crop mixture of hairy vetch (*Vicia villosa*) at 40 lb/acre, and cereal rye (*Secale cereale*) at 30 lb/acre, was planted on September 18, 2003 and was killed with a knife roller (stalk-chopper) May 10, 2004. A cover crop mixture of hairy vetch and rye was sown in the fall 2004 between the strawberry rows and will be killed with a heavy turf roller for use as a mulch in year two.

Treatment 2) Compost + CGM + Mulch: Composted, finished hog manure and corn gluten meal to obtain the equivalent of 50 lbs N/acre at planting (May 31, 2004) and 50 lbs N/acre on August 29, 2004 of year one. Straw was applied as a soil mulch within rows to a shallow depth (2 in, 5.2 cm) in year one; Composted, finished hog manure and corn gluten meal to obtain the equivalent of 50 lbs N/acre at renovation and 50 lbs N/acre in August (floral initiation application) of year two.

Treatment 3) Fumigation (and herbicide applications as needed): May14, 2004 - Preplant fumigation with methyl bromide, wick applications of glyphosate throughout season as needed. Spring 2005 (Year 2) – DCPA immediately after straw removal and repeat after renovation. Formula 40 (2, 4-D triisopropanolamine salt plus 2,4-D dimethylamine salt) @ 1.0 – 1.5 qt. in 25-50 gal of water/acre in early spring when plants are dormant (if needed) and at renovation. Poast EC (Sethoxydim 1.lb. a.i./gal @ 1.0 to 2.5 pt. plus 2 pt. of crop oil concentrate in 25 gal. water/acre) when grasses reach a few inches tall, wick applications of glyphosate throughout season as needed.

Treatment 4) Herbicides alone (no fumigation) Spring 2004 (year one) - Preplant, Preemergence Dacthal W-75 (DCPA 75% a.i.) sprayed at planting (June 2, 2004)

@ 9lbs/acre (8.4 kg/ha a.i.) (PM-1375). Repeated in July after hoeing. Wick applications of glyphosate throughout season as needed. Spring 2005 (year 2)– DCPA immediately after straw removal and repeat after renovation. Formula 40 (2, 4-D triisopropanolamine salt plus 2,4-D dimethylamine salt) @ 1.0 – 1.5 qt. in 25-50 gal of water/acre in early spring when plants are dormant (if needed) and at renovation. Poast EC (Sethoxydim 1.lb. a.i./gal @ 1.0 to 2.5 pt. plus 2 pt. of crop oil concentrate in 25 gal. water/acre) when grasses reach a few inches tall, wick applications of glyphosate throughout season as needed

Progress Toward Stated Objectives

Objective:
The overall objective is to examine the influence of four weed management systems in strawberry production on the physical, chemical, and biological indicators of soil quality.

Progress to date:
The research plots have been established as planned, treatments have been applied, and the first season's research data have been collected.

Sub-objectives:
1) Combine physical, chemical, and biological soil properties into a soil quality index for strawberry production.

2) To determine and correlate the impact of weed management systems and a proposed soil quality index on weed and strawberry plant growth and development.

Progress to date:
The framework of a soil quality index for Junebearing strawberry production has been created that combines data from physical, chemical, and biological characteristics of soil. As research data are collected and analyzed, the soil quality index will be further tested and developed.

Data presented in tables 1 and 2 of this report show that relationships between weed management and soil quality are evident and point to areas of further investigation and analysis.

Summary of Research

Fall 2003
The research field was established September 2003. Hairy vetch/cereal rye cover crop was established and initial soil samples were collected.

Spring 2004
Soil samples and bulk density measurements were collected from plots on May 9. Cover crop was knocked down with a Buffalo™ stalk-chopper (Fig. 1 & 2) and other treatment plots were tilled on May 10, 2004. The cover crop did not completely die from the stalk-chopper, so glyphosate was applied. We conducted one pass with the stalk chopper over the cover crop plots and it appears that more than one pass is needed for effective knock-down.

Fumigation treatment plots were treated with TERR-O-GAS® 98 (Methyl bromide 98%, chloropicrin 2%) on May 15 (Fig 3); tarp was removed after 48 hrs. Due to wet weather in spring 2004, strawberry planting was delayed until June 1st.

Summer 2004
All plots were irrigated (overhead) as needed during the summer based on tensiometer readings. Weed data (percent weed cover, weed number, and species) were collected on July 8 and August 20. The research plot was featured at the Iowa Fruit and Vegetable Grower Association's Annual Field day on July 8 at the Iowa State University Horticulture Research Station, Ames, IA (Fig. 4). The research project was explained to attendees and they were given the opportunity to ask questions and to walk around the plot. Strawberry leaf samples were collected for nutrition analysis on Aug. 9 and all treatment plots were fertilized on Aug. 29.

Fall 2004
Infiltration rates were measured on Oct. 3, earthworm samples were collected Oct. 10, and soil samples were collected Oct. 31. Analysis of soil samples for microbial biomass carbon content began, as well as for soil respiration, potentially mineralizable nitrogen, aggregate stability, and soil texture. Other measurements are ongoing and/or have been initiated and are awaiting analysis, e.g., foliar analysis and soil chemical analysis. Measurements that have been analyzed, to date, appear in tables 1 and 2.

Photographs from 2004 Field Research

lown.

Fig. 2. Cover crop after knock-down.

Fig. 3. Fumigation tarp on treatment plot.

Fig. 4. Iowa Fruit and Vegetable Grower Association field day at plot, July 12, 2004.

Summary of data presented in tables 1 and 2

There were no differences in percent weed cover between the four weed management treatments in July or August of year one (Table 1). The strawberry plant density (number of strawberry runners) was not different between treatments. Infiltration rate, soil bulk density, and total porosity were similar for all treatments (Table 2). The straw mulch treatment had higher volumetric water content and air-filled porosity than the other treatments. The straw mulch treatment had a similar amount of water-filled pore space compared to the fumigation treatment and had a higher amount compared to the herbicide and killed-cover crop treatment.

Table 1. Percent weed cover and 'Jewel' strawberry runner number for four weed management treatments in Junebearing strawberry soil quality experiment, 2004 growing season.

Treatment[z]	7/8/2004 Percent Weed cover[y]	8/20/2004 Percent Weed cover[y]	Strawberry Runner no.[x]
Herbicide	25.0	1.0	10.0
Fumigation	36.8	0.8	8.3
Killed cover crop	23.3	5.0	6.5
Straw mulch	29.0	7.0	7.0
Lsd[w]	NS	NS	NS

[z] Means of four replications.
[y] Means obtained from the avg. of three, 0.25^2m quadrats per plot.
[x] Means obtained from the avg. of three sample plants/plot.
[w] Least significant difference, $P < 0.05$.

Table 2. Five soil quality measurements taken from four weed management treatments in Junebearing strawberry soil quality experiment: infiltration rate, volumetric water content, bulk density, total porosity, air-filled porosity, and water-filled pore space, 2004 growing season.

Treat-ment[z]	Infiltration rate (in/hr)	Water content Volumetric(%)	Bulk density (g/cm^3)	Total porosity (%)	Air-filled Porosity (%)	Water-filled pore space (%)
Herbicide	7.5	27.7 b	1.42	0.46	27.2 b	60.9 b
Fumigation	5.9	27.5 b	1.47	0.45	27.0 b	62.5 a b
Killed Cover crop	15.3	25.5 b	1.37	0.49	25.0 b	52.9 b
Straw mulch	11.0	33.7 a	1.44	0.46	33.2 a	73.5 a
Lsd[y]	NS	2.2	NS	NS	2.3	11.7

[z] Means of four replications.
[y] Least significant difference, $P < 0.05$; NS = Not significant

Additional information.

We are pleased to report that a project related to the NASGA –funded grant was submitted to the North Central Region, Sustainable Agriculture Research and Education, Graduate Student Program and the project was selected for funding. The project is titled, "Transferring Information from Research Lab to Farm Field: Evaluation of On-Farm Quality Test Kits for Grower Use in Sustainable Strawberry Production." The $9988 grant will pay for the soil quality test kits for on-farm grower demonstration and research and student labor.

References cited:

Black, B.L., J.M. Enns, and S.C. Hokanson. 2002. A comparison of temperate-climate strawberry production systems using eastern genotypes. HortTechnology 12(4):670-675.

Blair, J.M., P.J. Bohlen, and D.W. Freckman. 1996. Soil invertebrates as indicators of soil quality. In: Doran, J.W. and A.J. Jones (eds.) 1996. Methods for assessing soil quality. SSSA Special Publication 49. SSSA, Inc. Madison, WI.

Dahnke, W.C. and R.A. Olson. 1990. Soil test correlation, calibration, and recommendation, p. 45-71. In: R.L. Westerman (ed.) Soil testing and plant analysis, 3rd ed. SSSA Book Series, no. 3. Madison, WI.

Dilley, C.A., G.R. Nonnecke, and N.E. Christians. 2002. Corn-based extracts to manage weeds and provide nitrogen in matted-row strawberry culture. HortScience 37(7):1053-1056.

Doran, J.W. and A.J. Jones (eds.) 1996. Methods for assessing soil quality. SSSA Special Publication 49. SSSA, Inc. Madison, WI.

Doran, J.W. and T.B. Parkin. 1996. Quantitative indicators of soil quality: a minimum data set. In: Doran, J.W. and A.J. Jones (eds.) Methods for assessing soil quality. SSSA Special Publication 49. SSSA, Inc. Madison, WI.

Gleason, M.L., D.R. Lewis, P.A. Domoto, and G.R. Nonnecke. 2003. Iowa commercial small fruit and grape spray guide. Iowa State Univ. Ext. Bul. PM-1375 (In press).

Gregorich, E.G., M.R. Carter, D.A. Angers, C.M. Monreal, and B.H. Ellert. 1994. Towards a minimum data set to assess soil organic matter quality in soils. Can. J. Soil Sci. 74(4):367-385.

Hancock, J.F., B.L. Goulart, J.J. Luby, and M.P. Pritts. 1997. The strawberry matted row: practical cropping system or dated anachronism. Adv. Strawberry Res. 16:1-4.

Karlen, D.L., M.J. Mausbach, J.W. Doran, R.G. Cline, R.F. Harris, and G.E. Schuman. 1997. Soil quality: a concept, definition, and framework for evaluation. Soil Sci. Soc. Am. J. 61(1).

Kennedy, A.C. and R.I. Papendick. 1995. Microbial characteristics of soil quality. J. Soil Water Cons. 50:243-248.

Merwin, I.A., W.C. Stiles, and H.M. van Es. 1994. Orchard groundcover management impacts on soil physical properties. J. Amer. Soc. Hort. Sci. 119(2):216-222.

Morse, R.D. 2001. No-herbicide, no-till summer broccoli-quantity of rye and hairy vetch mulch on weed suppression and crop yield. In: Stiegler, J.H. (ed.) Proc. 24th annual southern conservation tillage conference for sustainable agriculture, Oklahoma City, OK 9-11 July. OK State Univ. Agr. Expt. Sta. Misc. Publ. MP-151.

Nonnecke, G.R. and N.E. Christians. 1993. Evaluation of corn gluten meal as a natural weed control product in strawberry. Acta Hort. 348:315–320.

Nonnecke, G.R. and N.E. Christians. 2001. Effects of source, rate and particle size of corn gluten meal on weed and strawberry growth and development. Proc. Fifth North Amer. Strawberry Conf. Niagara Falls, Ont. Jan., 2001.
Parr, J.F., R.I. Papendick, S.B. Hornick, and R.E. Meyer. 1992. Soil quality: attributes and relationship to alternative and sustainable agriculture. Am. J. Altern. Agr. 7:5-11.
Pritts, M.P. and M. Eames-Sheavly. 1988. Effects of planting system and mulching with straw or sprayable latex on performance of a dayneutral and Junebearing cultivar. Adv. Strawberry Prod. 7:19-22.
Pritts, M. and D. Handley. 1998. Strawberry production guide for the northeast, midwest, and eastern Canada. N.E. Reg. Agr. Eng. Serv., Ithaca, N.Y.
Pritts, M.P. and M.J. Kelly. 2001. Early season weed competition reduces yield of newly planted matted-row strawberries. HortScience 36(4):729-731.
Pritts, M.P. and M.J. Kelly. 1997. Weed thresholds in strawberries. Acta Hort. 439:947–950.
Pritts, M.P. and M.J. Kelly. 1993. Alternative weed management strategies for strawberries. Acta Hort 348:321-327.
Rice, C.W., T.B. Moorman, and M. Beare. 1996. Role of microbial biomass carbon and nitrogen in soil quality. In: Doran, J.W. and A.J. Jones (eds.) Methods for assessing soil quality. SSSA Special Publication 49. SSSA, Inc. Madison, WI.
Seybold, C.A., M.J. Mausbach, D.L. Karlen, and H.H. Rogers. 1997. Quantification of soil quality. In: B.A. Stewart and R. Lals (eds.). Proceedings from an international symposium on carbon sequestration in soil. Adv. Agron. Lewis Publ.
Singh, K.K., T.S. Colvin, D.C. Erbach, and A.Q. Mughal. 1992. Tilth index: An approach to quantifying soil tilth. Trans. ASAE. 35(6):1777-1785.
Smeda, R.J. and A.R. Putnam. 1988. Cover crop suppression of weeds and influence on strawberry yields. HortScience 23:132-134.