Evaluation of Limited Tillage and Cover Crop Systems to Reduce N Use and Disease Population in Small Acreage Vegetable Farms Mirror Image Projects in Uruguay and North Carolina, USA

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Abstract

N management is a primary determinant of vegetable crops production in the United States and in Uruguay. We evaluated 7 rotational systems for vegetable crops in both countries. These rotational systems influence N fate in the environment in different ways and impact both cost of production and the environment. We used rotational systems that include both winter and summer cover crops and vegetable crops. Insects, diseases and weed infestations differed with the systems. All activities were closely coordinated via email and annual visits to ensure an integrated approach to crop and pest management. Crop growth, yield, quality, nutrient cycling and soil microbial activity measured. N status of cover crops, cash crop and soil were determined at 6 depths to establish an N balance for each system. Market price data are being combined with normalized treatment data to determine gross revenues, operating costs, and net revenue per acre. Input and production data from all production systems is used to evaluate economic feasibility for both traditional and more sustainable vegetable production systems. In addition to production benefit/cost determination, we will determine environmental benefit/cost relationships as a result of the various production systems.

INTRODUCTION

Conservation tillage has been used by farmers for over 30 years. Conservation tillage systems have found favor for grain crops all over the world, but are used very limitedly in vegetable crops. Further adoption is most common in locations where conservation tillage (CT) equipment is available and for vegetable crops that can be planted with grain crop equipment (sweet corn, squash, etc) (Hoyt, 1999), (Rutledge, 1999). Soil tillage has great effect on nitrogen cycling, soil biota, pests, diseases and weed infestation. Also on the organic matter content and nutrient availability (Lamarca 1996). Erosion is often a big problem in intensive vegetable production areas.

In North Carolina, hot and warm summers, cold winters make it difficult to accumulate organic matter in the soil. Heavy rains (1250 mm/yr) contribute to increased erosion problems and predominant sandy soils increase the risk of nitrogen leaching. In Uruguay, erosion has degraded the fertility and physical conditions. Many years of mono-cropping practices have increased pest and diseases problems. CT practices are not common among the vegetable growers. Growers have limited acreage making the possibility for long term rotation cycles difficult. In order to get information to help overcome this situation we installed a minimum tillage study in both countries to evaluate

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its effect on nitrogen leaching, pest, diseases, soil health, yield and benefit/cost relations.

MATERIALS AND METHODS

The study begun in spring 1999 in Uruguay and spring 2000 in North Carolina . In Uruguay the study was conducted at INIA "Las Brujas" Expt. Estation (Lat 34.55 S. Long.056.10 W). The rainfall average is about 1000 mm/year. Soil was a Brunosol Eutrico típico, Clay loam (Table 1). Topography is rolling In North Carolina the study is conducted by North Carolina State University, Horticultural Crops Research Station in Clinton, NC, USA. The Uruguay soil analysis is in Table 1.

Seven rotational systems for vegetable crops were evaluated in both countries (Table 2). We used rotational systems that include both winter and summer cover crops and vegetable crops. Predominant diseases, insects and weed were scouted and information was recorded during each cycle of crop. Among the major diseases Sclerotium rolfsii Sacc.(in garlic and sweetpotato) and Plenodomus destruens Harter. (in sweetpotato) were found. The live sclerotia counting were done using the Backman et. al. method (1980). Crop growth yield, quality, nutrient cycling and soil microbial activity were measured. Cultivars and plant density used in the study is presented in Table 3.

Mineral nutrient status of cover crops, cash crops and soil were determined, Soil ammonia and nitrates were determined to a one meter depth, to determine the nitrogen leaching from the various systems.

Experimental design was a randomized complete block with four replications. The plots were 10m x 10m and boarders were 3m wide in Uruguay and 10 m wide in North Carolina. Crops were planted in beds and rows according the general management recommendations (see Table 3). Crops were irrigated when it was necessary. Disease, pest and weed control was done following the management recommendations for these crops. In minimum tillage treatments was used a rototiller before the passes of the conventional machine for the crop. No tillage treatments were planted by hand.

RESULTS

The results presented correspond to the Uruguay study, during the period 1999/2000. In Table 4 crop yields for 1999-2000 are presented, during this cropping cycle some of the plots were with different crops. Yields obtained were good when compared to the national average in most of the cases. For sweet potato the average yield is o 7 t/ha and for garlic 3.5 t/ha. The lower yields on minimum tillage and no tillage treatments were caused by the lack in nitrogen. Foliar analysis is being conducted to confirm this hypothesis. Equivalent levels nitrogen were applied for all the systems at garlic crop (see Table 6). Soil nitrate information for the period 1999-2000 is presented in Table 5.

In September 99 nitrate values were about 7 ppm in the first 30 cm, after fertilization those values increased up to 14 ppm, after summer crops in March 2000 nitrate values descended for the most of the treatments. In the chicken manure treatment (Treat 4) nitrates values increased during the summer due to the natural mineralization and mechanical weed control. Less values are in treatment one with sweet potato and those with sorghum.

In August 2000 before garlic fertilization a soil nitrate was sampled. The highest values were found in treatments where organic residue is decomposing actively, like sweet potato and sorghum. (Treat 1 and 3), and in the treatment where chicken manure was added as fertilizer. The lower nitrate values in the soil profile were in minimum tillage or no tillage treatments (Treat 6 and 7) . After the garlic crop the nitrate values obtained were lower in all the treatments, been the lowest those treatments with minimum tillage and no tillage. Usually in Uruguay farmers apply heavy amounts of chicken manure (> 30 ton/ha), in view of these results it is possible to reduce the amounts used for fertilizing the most of the crops.

Crop residues are also an important source of nutrients as well as nitrates for the succeeding crop. There was less garlic total yield in no tillage and minimum tillage treatments and this was more related to a lack of nitrogen than a soil physical impediment.

Soil Macrofauna

In March 2002, soil macro fauna was sampled, two soil samples per plot were taken and soil macro fauna was classified and counted. In Fig. 1 the total worm number by m^2 for continuing cropping (Treat 2), green manure (Treat 3), chicken manure (Treat 4) and minimum tillage (Treat 6) are presented. The most relevant result was for treatment 6 where was counted 70 worms /m^2 compared to 4.2 in continuing tillage.

Soil Biomass

In Fig. 2 is presented the total soil biomass data for the year 2000, using the fumigation-extraction methodology (Brookes, 1985). Samplings were done on treatments of continuous cropping, animal manure and no tillage. There were four sampling times: 13/04/200 (S1), 26/05/2000 (S2), 17/08/2000 (S3) and 08/11/2000 (S4).

The no tillage system had greater soil biomass during the period of observation than the continuous cropping or chicken manure systems. We observed a seasonal change through the year with higher values in fall and spring for the no tillage. More exhaustive sampling is being done in order to reflect the different management on those treatments.

Evaluation of Southern Blight (*Sclerotium rolfsii* Sacc.)

In Fig. 3 is presented the information obtained during the period 2000-2002. During this period four samplings of 500g soil each were done the 5/09/2000 (S1), 22/12/2000 (S2), 5/12/2001 (S3) and 12/04/2002 (S4).

CONCLUSIONS

Strip Tillage and No Tillage treatments had lower nitrate levels in the soil than those in other tested treatments. Application of reduced fresh chicken manure (4 t/ha) as fertilizer was enough for the grow of garlic. Strip Tillage increased worms/m^2 to 70 compared to 4.2 in continuing tillage. Soil biomass was greater in No Tillage treatment had greater soil biomass than those in continuous cropping or chicken manure treatments. Strip Tillage, No tillage and chicken Manure systems had less sclerotia than continuous cropping and multi vegetable systems.

To determine the benefit/cost effective production, a market price data will be combined with normalized treatment data to determine gross revenues, operating cost and net revenue per hectare. Input and production data from all production systems will be used to evaluated economic feasibility.

ACKNOWLEDGMENT

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Tables

Table 1. Soil type characteristics in Uruguay.

Type of Soil	pH H2O	O.M. %	N-NO3 ppm	P ppm	K meq/100g
Clay loam	5.47	3.49	13.7	12.2	0.63

Table 2. Crop Sequences.

	Treat 1	Treat 2	Treat 3	Treat 4	Treat 5	Treat 6	Treat 7
1999-2000							
Summer	Sp	Sq	SCC	CMAN	FAL	Sq+SCC	Sq+SCC
Winter	Ga	Ga	Ga	Ga	Ga	Ga	Ga*
2000-2001							
Summer	Sp	SC+Cab	SC+Cab	CMAN SC	SC	SC+SCC	SC+SCC
Winter	Ga	WCC	Cab	CMAN Cab	FAL	WCC	WCC
2001-2002							
Summer	Sp	Sp	Sp	CMAN Sp	Sp	Sp	Sp
Winter	Ga	Ga	WCC	CMAN	FAL	WCC	WCC
2002-2003							
Summer	Sp	Sq+SCC	Sq	Sq	Sq	Sq+SCC	Sq+SCC
Winter	Carr	Carr	Carr	CMAN Carr	FAL Carr	Carr	Carr

Treatments: Continuous Cropping system(Treat 1); Multiple Vegetable system (Treat 2); Green Manure system (Treat 3); Chicken Manure system (Treat 4); Fallow system (Treat 5); Strip Tillage System (Treat 6); No Tillage System (Treat 7).
Crops:Sp_ Sweetpotato, Sq_ Squash, WCC_ Winter Cover Crop (oat, triticale),SCC_ Summer Cover Crop (sorghum Sudan Grass), SC_ Sweet Corn, Ga*_ Garlic, CMAN_Chicken Manure, FAL_ Fallow, Carr_ Carrot

Table 3. Cultivars and plant density.

Crop	Plant density Plants/ ha	Rows per plot	Cultivar
Garlic	200.000	7 beds	M50 (Urug. Selec)
S.potato	40.000	9 rows	Arapey (Urug. Selec)
Squash	20.000	9 rows	Any Plus
Sorghum	25kg		Sudex

Table 4. Total yield of Garlic and Sweet Potato after Cover crops in t/ha.

	Treat 1	Treat 2	Treat 3	Treat 4	Treat 5	Treat 6	Treat 7
1999-2000							
Summer							
Squash		57				55	53
S. Potato	34						
Sorghum (D.M.)			8.6			8.8	6.1
Winter							
Garlic	6.7	6.9	6.7	6.9	6.5	5.7	5.6

Table 5. Soil Nitrate Information from September 99 to December 2000 in Uruguay.

Treatments	Depth cm	Sept 99	Oct. 99	March 2000	Aug. 2000	Dec. 2000
1	0-30	7.5*	13.25	6.32	8.65	4.15
1	30-60			4.5		3.34
1	60-90			5.99		3.91
2	0-30	6.25	11.25	13.04	5.82	5.7
2	30-60			5.56		3.99
2	60-90			8.9		5.62
3	0-30	7	17.75	7.36	9.15	4.76
3	30-60			4.42		3.49
3	60-90			6.12		3.72
4	0-30	7		13.61	16.12	3.55
4	30-60			5.79		4.22
4	60-90			9.77		5.04
5	0-30	7			3.9	5.84
5	30-60					4.62
5	60-90					5.24
6	0-30	7.75	15.75	6.15	3.7	3.59
6	30-60			6.32		3.1
6	60-90			8.07		2.62
7	0-30	7	10.5	6.31	2.85	3.19
7	30-60			6.57		2.69
7	60-90			9.24		2.56

* Soil Nitrate information for the first 20 cm depth

Table 6. Fertilizer applied on the crops kg/ha.

Crop	N	P_2O_5
Squash	90	230
S. Potato	100	115
Garlic	100*	
Sorghum	50	

* Treatment 4 (Chicken Manure) was fertilized by 4000 kg/ha fresh chicken manure to reach the nitrogen requirements.

Figures

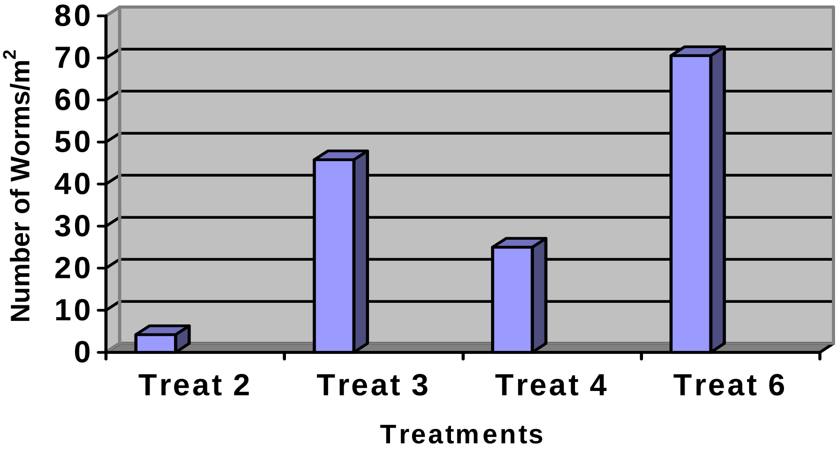

Fig. 1. Total number of worms by m^2.

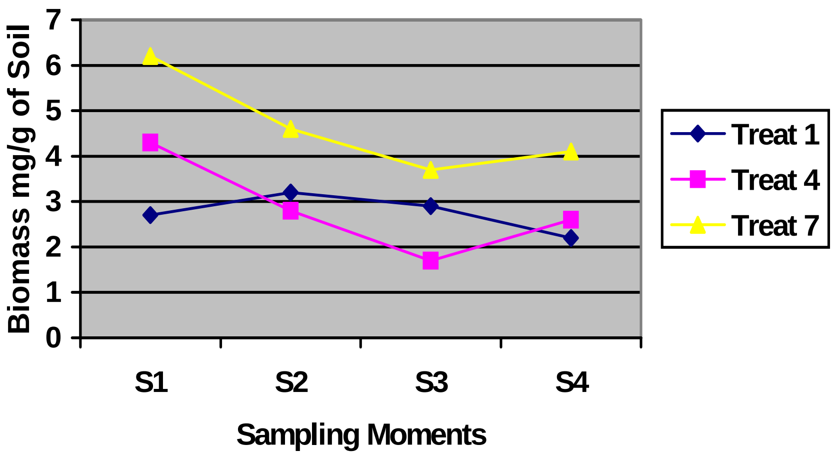

Fig. 2. Seasonal Evolution of Soil Biomass mg/g of Soil.

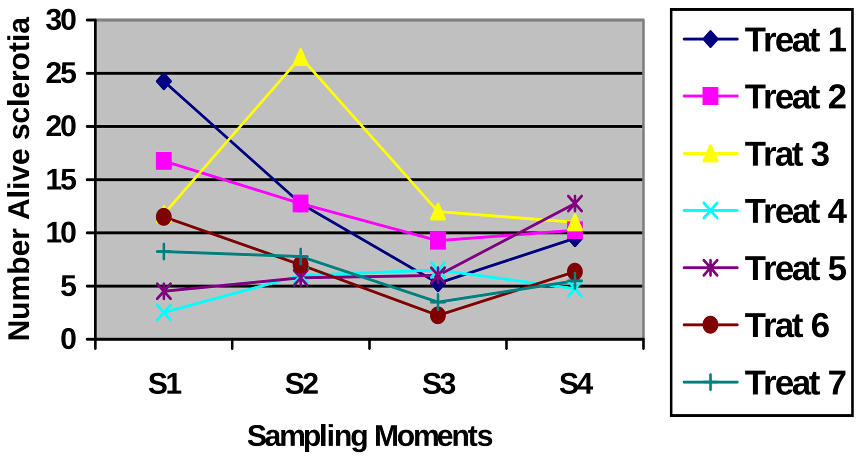

Fig. 3. Number of alive sclerotia / 500 g of soil.