2007 NYS IPM Program
Research and Development Report

Title: Vegetable Management Systems: Soil Health Assessment and the Effect on Snap Bean Yield and Soil Fungal Pathogen Community

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Abstract:

At the Vegetable Research Farm in Geneva, NY, the soils from four long-term systems management blocks were assessed for their soil health status using the 2007 Cornell Soil Health Test. Snap beans were planted in four strips within each block with half of the rows overlapping where beans had been planted in 2006 (2-year beans) and half which had not been previously planted to beans (1-year beans) to relate yield to the observed differences in the soil health status between the blocks. Snap bean yield was significantly higher in the IPM-future block (managed using season-long soil-building crops in addition to cover crops and IPM strategies). Due to the dry conditions during the growing season and frequent cultivation, yields were lowest in the organically managed block. Observed differences in root health as a result of differing soilborne fungal pathogen populations were further explored to determine if there were species composition and/or population density differences between the four management systems. ITS sequence primers were identified for specific soilborne fungal pathogens of interest and the methodologies fine-tuned for the sonication and centrifugation of rhizosphere soil from bean plants harvested from the field. However, the limited total amount of DNA extracted from the soil sampled prohibited the use of real-time PCR to further identify and quantify the soilborne fungal pathogen population in these differing soils. Thus, additional work is needed in order to assess the mechanism(s) involved in the observed differences in root health among the four production systems.

Background and Justification:

The IPM systems research site established in 1995 provides an excellent opportunity to assess the impact of these four management systems on the health status of the soil. The four systems (conventional, IPM present, IPM future, and organic) were defined and compared on the basis of yield and quality, economics and environmental impact. The four fields, each two acres in size, were managed using the four systems for 13 years. The focus crops initially were fresh market sweet corn and then four cucurbit crops in the more recent years. Cover crops and rotation crops varied among the four systems so that each field had a unique cropping pattern over this 10-year

period. In addition to using IPM strategies and cover crops used in the IPM present block, the IPM future block also had season-long soil building crops in the rotation.

Previous results have shown that the different management systems practiced over time have resulted in different soil health levels especially with regard to the pressure from soilborne fungal pathogens (Petzoldt et al., 2007). In 2007, we were interested in exploring more closely these observed differences in soil health and relating them to snap bean yield in addition to beginning to look at more specific differences in the species composition and the density of soilborne plant-pathogenic fungal populations between these four systems. Our specific project objectives were to:

1. Assess the soil health of the four systems plots using the 2007 Cornell Soil Health Test.
2. Compare yield between plots that have been planted with either one or two consecutive years of snap bean in one of four IPM systems comparison plots (conventional, organic, IPM present, IPM future).
3. Compare the soil fungal community as well as soilborne fungal pathogen populations between the four systems using real-time PCR.

Procedures:

Objective 1: From each 2-acre IPM systems block (conventional, organic, IPM present, IPM future), four composite soil samples consisting of 10 to 12 sub-samples each were collected for a total of 16 soil samples on 8 May prior to land preparation for planting. Soil penetrometer measurements were taken and recorded at the 0-6 and 6-18 in. depths on 9 May. However, the soil was very dry and cracked (last rain was 29 April) thus, penetrometer readings were taken again on 13 May following 0.89 in. of rainfall accumulation on 10 May. The soil samples were processed for soil health assessment using the Cornell Soil Health Test (http://soilhealth.cals.cornell.edu) at a centralized lab facility in Ithaca, NY. The raw data for the individual soil health measurements was analyzed using an analysis of variance and the means separated using Fisher's least significant difference test ($P \leq 0.05$) (SAS 9.1, SAS Institute, Inc., Cary, NC).

Objective 2: In order to collect additional information about the impact of soil health in four plots managed under different IPM systems on bean yield after either one or two consecutive years of snap bean production, snap bean cv. 'Caprice' was planted in 4, 12-row strips in each of four two-acre fields. Six of the snap bean rows overlapped where snap beans had been planted in strips in 2006 (2-yr bean) and six rows were planted adjacent to the 2006 snap beans (1-year bean). The snap beans were maintained using practices congruent with each of the IPM systems (conventional, organic, IPM present and IPM future). The four plots were plowed and fitted on 14-15 May and the strips of snap bean cv. 'Caprice' were planted on 7-8 June. Emergence counts were taken on 6 July. Yield assessments were made on 24 Aug. Total plant weight was measured in four 10ft sections in each of four replicate 2-year and 1-year bean plots per system block. Total pod weight was determined from an 8 lb sub-sample taken from the combined 40ft of plant collected per plot. The harvested pods were graded using a FMC snipper and grader. The emergence counts and yield data cross system blocks within 2-year and 1-year bean plantings was analyzed using an analysis of variance and the means separated using Fisher's least

significant difference test ($P \leq 0.05$). Comparisons within system blocks between 2-year and 1-year bean plots were analyzed using a t-test ($P \leq 0.05$) (SAS 9.1, SAS Institute, Inc., Cary, NC). *Objective 3:* Initial soil microbial analyses focused on soilborne fungal pathogens and the development of the methodology to identify and quantify *Fusarium solani*, *Pythium ultimum*, *Rhizoctonia solani* and *Thielaviopsis basicola* from the rhizosphere soil. At flowering, 20 snap bean plants were dug from each plot (1 and 2 yr beans x 4 nested reps) in the conventional and IPM future blocks (16 samples total). The majority of the soil was shaken off in the field. The rhizosphere soil was sonicated from the roots of the bean plants in sterile water and then centrifuged. Total DNA was extracted from the rhizosphere soil pellet using the UltraClean Soil DNA Kit (Mo Bio Laboratories, Inc., Carlsbad, CA). ITS sequence primers specific for the target fungal pathogens as well as universal fungal sequence primers were identified. It was anticipated that an iQ5 Multicolor Real-Time PCR Detection System from Bio-Rad was going to be used to identify and quantify the targeted soilborne fungal pathogens. The results from the molecular identification and quantification were going to be compared to the results of the visual greenhouse root health bioassay.

Results and Discussion:

Objective 1: Four nested soil samples were collected per management system and assessed for their soil health status using the 2007 Cornell Soil Health Test. Several of the soil health indicators measured have been slow to be impacted by the production practices but they do show a trend. For example, root health ratings is lowest (most healthy) in the IPM future block indicating the least pressure from soilborne fungal pathogens compared to the conventionally managed block (Table 1). Potentially mineralizable nitrogen is also highest in the IPM future block indicating a higher level of microbial activity among the population of microbes involved in nitrogen mineralization. The level of extractable phosphorus was also the lowest in the IPM future block but still an adequate level for sustaining crop growth.

Objective 2: Within each of the IPM systems blocks (conventional, organic, IPM present and IPM future) total snap bean plant weight (mean of four 10ft sections per plot) and total pod weight (harvested from an 8 lb sub-sample from the 40ft of row harvested per plot) between plots planted with snap bean one year and those planted with snap bean two consecutive years were not significantly different so the data was pooled to compare yield between the different system blocks (Table 2). Similar to the results in 2006, both total plant weight and pod weight were significantly higher in the block managed using soil-building rotational crops in addition to cover crops and IPM practices for pest management (IPM future) compared to the organically managed block. Due to the dry weather and frequent use of cultivation for weed management in the organically managed block, seedling establishment and stand were significantly lower than the other three management systems which may in part explain the significantly lower yields from this block. However, there was no significant difference in pod sieve size between the systems.

Objective 3: The ITS primers sequences necessary for identifying and quantifying *Fusarium solani* (5_GGTATGTTCACAGGTTGATG3_), *Rhizoctonia solani* (5_AGTGTTATGCTTGGTTCCACT3_) and *Pythium ultimum* (5_TGTATGGAGACGCTGCATT3_) were identified from the literature (Lievens et al., 2006).

Protocols were fine-tuned for the sonication and centrifugation of the rhizosphere soil from sub-samples of the field grown bean root systems as was the extraction of DNA from the rhizosphere pellet using the UltraClean Soil DNA Kit. However even after manipulating the protocol several times, the extraction of DNA from the soil never yielded enough DNA (>100ng/10_l) necessary to run the real-time PCR reaction thus this portion of the project has been halted for the time being. It is our hope to be able to continue this objective as a part of a future project.

References:

Lievens, B., Brouwer, M., Vanachter, A.C.R.C., Cammue, B.P.A., and Thomma, B.P.H.J. 2006. Real-time PCR for detection and quantification of fungal and oomycete tomato pathogens in plant and soil samples. Plant Science 171: 155-165.

Petzoldt, C., Gugino, B., Abawi, G., and Seaman, A. 2007. Growing snap beans in fields with different soil health: yield, root disease, and soil health indicators. In 2006 New York State Vegetable IPM Project Reports, NYS IPM Publication #131. p. 129.

Project Location (s): The Vegetable Research Farm, NYSAES, Geneva, NY and in applicable in the Northeast.

Table 1. Differences between management system blocks in the select soil health indicator measurements included in the 2007 Cornell Soil Health Test.

Indicator	Conventional [a]	Organic [a]	IPM present [a]	IPM future [a]
Aggregate stability (%)	24.4 a	18.8 a	14.9 a	23.9 a
Available water capacity (m/m)	0.15 a	0.18 a	0.14 a	0.17 a
Surface hardness (psi)	127.1 a	197.9 b	232.3 b	209.4 b
Subsurface hardness (psi)	345.8 a	389.6 b	334.4 a	350.0 a
Organic matter (%)	2.57 a	2.82 a	2.07 a	2.82 a
Active carbon (ppm)	544.7 a	622.4 a	491.5 a	498.8 a
Potentially mineralizable nitrogen (ugN/gdwsoil/week)	2.3 b	5.0 a	2.6 b	5.1 a
Root health assessment (scale 1-9)	5.9 c	4.6 ab	4.9 b	4.1 a
pH	7.3 b	7.8 a	7.4 ab	7.3 b
Extractable phosphorus	9.1 ab	6.4 bc	11.5 a	4.7 c
Extractable potassium	43.7 b	36.2 c	53.1 a	45.6 b
Minor elements				

[a] Means within rows followed by the same letter are not significantly different according to Fisher's LSD ($P \leq 0.05$).

Table 2. Snap bean stand count and yield comparisons between plots that have been managed using four different management systems in 2007.

Systems treatment	Stand count per 10ft row [a]	Mean plant weight (lb) per 10ft row [a]	Mean pod weight (lb) per 8 lb of plant [a]	Mean sieve size per 8 lb of pods [a]
IPM Future	54 b	6.68 a	4.05 a	3.97 a
IPM Present	58 ab	5.33 b	3.98 ab	3.91 a
Conventional	62 a	4.43 bc	3.67 bc	4.33 a
Organic	39 c	4.04 c	3.41 c	4.51 a

[a] There was no significant difference between plots that had been planted to 1- or 2-years of consecutive beans so the data were pooled prior to analysis. Means within columns followed by the same letter are not significantly different according to Fisher's LSD ($P \leq 0.05$).