Effects of Farm Management on Soil Quality

*E.E. Huntley, M.E. Collins, and M.E. Swisher

ABSTRACT

The objectives of the study were: 1)to determine the effects of different farm management systems on soil quality and to 2)relate the ratio of product output and energy input to the efficiency and viability of the management systems. Soil quality of two farm management systems, conventional and organic, were compared in terms of productivity and sustainability. Farming systems were also compared to native control and pasture plots to determine potential levels of soil quality of the studied soils. Soil properties measured included bulk density, moisture content at field capacity, percent organic C, and microbial biomass C. Results showed statistical differences in soil properties over time and depth of sampling. The product output and energy input ratio for organically farmed watermelon *(Citrullus lanatus)* plots was higher than the ratio for conventionally farmed watermelon plots. The productivity ratio was lower for organically farmed peanut *(Arachis hypogaea)* plots than for conventionally farmed peanut plots.

INTRODUCTION

Soil quality of a specific managed area may indicate sustainability of that managed area. Smith (1993) stated that soil quality is the most important factor for sustaining the global biosphere. Too often however, soils have been overlooked when measuring the "health" of a farming system (Rapport, 1996). This is especially critical for the fragile soil ecosystems in Florida, where management recommendations from studies of other regions cannot be applied The quality and quantity of inputs used to sustain many Florida agricultural soils are worth investigating to determine the environmental, social, and economic cost effects of farm management.

MATERIALS AND METHODS

Physical, chemical, and biological properties were used to quantfy soil quality. These properties were represented by bulk density (BD), moisture content at field capacity (%MC), percent organic C, and microbial biomass C (MBC). Samples were taken from six different sites including a control plot under natural vegetation, pasture of bahiagrass *(Paspalum notatum* Flugge.) (P), organic watermelon *(Citrullus lanatus* [Thumbs.] Mansf.) plot (OW), conventional watermelon plot (CW), organic peanut *(Arachis hypogaea* L.) plot (OP), and conventional peanut plot (CP). Samples were taken from each plot four times within a growing season of each crop. Control and pasture plots were sampled twice, at the beginning and end of the *study.*

Energy analysis was completed for representative areas of watermelon and peanut production in the organic and conventional fanning system. Information concerning all inputs used were gathered from farmer interviews. Energy analysis was used to measure energy efficiency and productivity by calculating the following ratio (Fluck, 1996):

$$\text{Energy Productivity} = \frac{\text{Total Outuut (lb/a)}}{\text{Total Energy (million Btu)}} = \text{lb/million Btu/a}$$

RESULTS AND DISCUSSION

Results were interpreted by investigating how properties changed over individual times within each farmed plot. Soil morphological properties confirmed that studied soils were uniform in characteristics and could be compared in reference to management effects. Bulk density showed least change among soil properties measured. Percent moisture content, % OC, and MBC showed most variability over time.

Soil Properties

Percent Moisture Content. Increases in %MC were greater in the OP and CP plots than in OW and CW plots. Hudson (1994) suggested that as organic matter increased, volume of water held by soil at field capacity also increased. However the design of this study did not confirm that %MC was affected by %OC. Samples for %MC were taken from undisturbed cores. Percent OC did not necessarily represent the %OC within those cores

[1]E.E. Huntley, [1]M.E. Collins, and [2]M.E. Swisher. [1]Soil and Water Science Dept., and [2]Family, Youth and Community Sciences Dept., University of Florida, IFAS, Gainesville, FL. Manuscript received 18 April 1997. *Corresponding author.

Percent Organic Carbon. Changes in %OC at 0 to 15 cm soil depth are recorded in Figures 1 and 2. Increase in %OC at the second sampling time in OW most likely reflected the addition of 4 ton/a of chicken manure. The %OC in CW was lower than that in OW at all sampling times. This was attributed to both inherent soil conditions and effect of black plastic mulch on decomposition rate of % OC. At the final sampling time, in both OP and CP plots, an increase in %OC was recorded. Having been cultivated for 2-yr, this result was unexpected. The increase may have been due to decomposition of bahiagass lignin root system and peanut plant residue after harvest. Decomposition of ryegrass (Lolium spp.) in the OP plot also may have contributed to the increase in %OC.

Microbial Biomass Carbon. Three flushes of growth were observed in MBC (Figure **3).** These were recorded at March sampling time for the OW plot and March and May sampling times for the CW plot. The increase in growth was typical of MBC *after* addition of organic amendments. The addition of manure provided a C substrate which contributed to MBC for the OW plot at March sampling time. Data of MBC recorded at March and May sampling times for the CW plot were attributed to the use of black plastic mulch and fertigation which created good conditions, including C, energy, and moisture sources, and heat. The fresh bahiagrass most likely provided a C source. Fertigation provided energy and moisture sources. The plastic helped to heat the soil.

Statistical Analysis. The means of soil properties, over time and depth of sampling, were compared to see if differences in soil properties occurred due to farm management Statistical differences were not shown between BD. Statistical differences were shown between %OC means and between %MC means. The mean % OC, through time and depth, of the OW plot was recorded at 0.88% while the mean %OC for CW was 0.49%. The % MC mean, through time and depth, at 1.0 bar of the OW plot was 11.6% and the % MC mean of the CW plot was 8.6%. These results confirmed that management did effect soil properties over the short term. The higher means %OC and %MC of OW and OP plots gave evidence that the organic systems more positively influenced these factors that contribute to soil quality.

Energy Analysis

As expected, the lower energy input systems (OW and OP) were the lower yielding systems (Table 1). The total energy used in OW was 65% less than in CW. Yield in OW was 56% lower than yield of CW. Total energy used in OP was 49% less than in CP production. Yield in OP was 71% less than in CP. In terms of energy efficiency, OW energy productivity was 83% higher than energy productivity in CW. Energy productivity of CP system was 77% greater than energy productivity in the OP system.

Quantities of individual inputs were ranked in order of greatest to least amounts of energy used (Table 2). In the OW and CW plots, the highest energy inputs directly effected crop and soil properties. Nitrogen, applied to the soil through manure, contributed to the largest amount of energy used in OW. Plastic mulch and drip irrigation most greatly effected soil properties in CW. Microbial flush and decline in organic C reflected the influence of black plastic mulch. In the OP and CP plots, diesel, an input which does not directly effect crop and soil conditions, was reported as the highest energy input. This difference in direct and indirect inputs reflects the particular requirements for the two different crops, watermelon and peanut. Furthermore, diesel was used most in OP and CP during land preparation and production and reflected use of equipment for cultivation in OP production and application of amendments and pesticides in CP production.

CONCLUSIONS

The organic and conventional farm management practices studies affected soil properties. For example, organic materials in manure, bahiagrass, and ryegrass, improved %OC. Soil quality seemed to be most affected by the practice of bahiagrass rotation that was shared by both systems. Crop yield was more effected by other practices used in the conventional system than measured soil properties were effected. Continued emphasis on balancing the most efficient inputs used to enhance soil quality is needed on sandy soils.

Agriculture makes a demand on an ecosystem to produce energy in the form of food. Management is needed to replace that amount of energy taken away in crop yield. Cassman and Harwood (1995) stated that as soil quality decreases, greater inputs and management skills are necessary to counter the reduction in nutrients the crop obtains fiom soil resources. In systems with limiting environmental conditions, such as sandy, low-fertility soils, significant gains in efficiency in input use are needed to maintain or increase productivity and yields. One way to determine effects of energy on soil quality and effects of input changes on yield may be to calculate a ratio between a measured soil property and energyinput. Given the results that lower input systems were lower yielding systems but not necessarily less energy efficient systems, further investigations of the relationship between yield, soil quality, and energy efficiency are needed.

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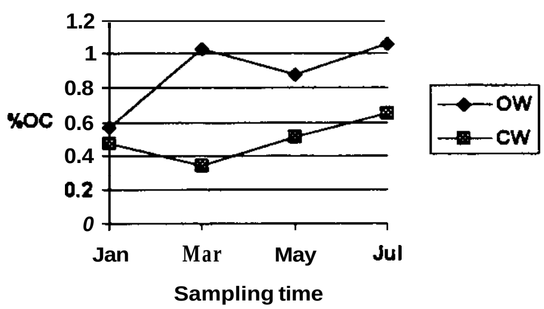

Figure 1. Percent organic carbon (%OC) of OW and CW plots at four sampling times at 0 to 15 cm.

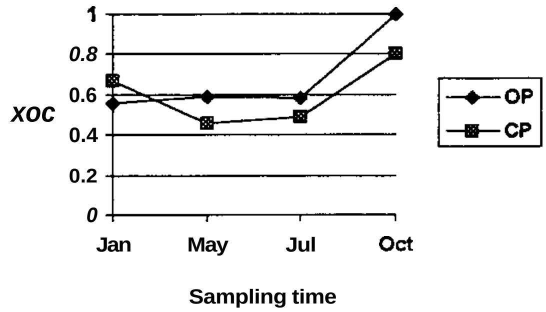

Figure 2. Percent organic carbon (%OC) of OP and CP plots at four sampling times at 0 to 15 cm.

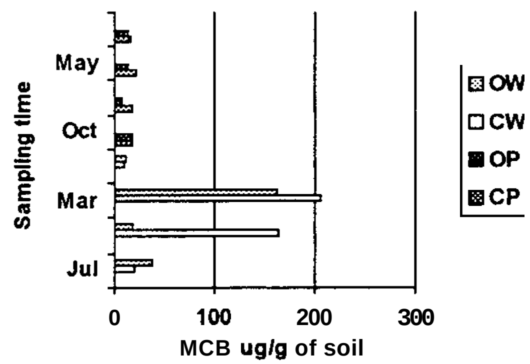

Figure 3. Microbial biomass carbon (MBC) of OW and CW at four sampling times at 0 to 15 cm.

Table 1. Energy inputs, total energy, yield and energy productivity in OW, CW, OP, CP fields[1].

	OW	CW	OP[2]	CP
Land preparation inputs (million Btu/a)	9.91	34.22	2.81	6.19
Planting inputs (million Btu/a)	0.88	9.73	1.93	2.97
Production inputs (million Btu/a)	**2.06**	7.76	1.44	3.52
Harvest (million Btu/a)	5.53	2.46	1.41	2.04
Other costs (million Btu/a)	1.33	2.34	1.06	1.97
Miscellaneous (million Btu/a)	0.48	2.13	0.18	0.79
Total energy (million Btu/a)	20.19	58.74	8.84	17.48
Yield (lb/a)	13000	30000	1200	4200
Energy productivity (lb/million Btu/a)	643.88	510.73	135.75	240.27

[1] OW = organic watermelon, CW = conventional watermelon, OP = organic peanut, and CP = conventional peanut plots.
[2] No peanut crop was harvested for OP in 1996. Yield and harvest energy used were recorded for OP was from 1995.
[3] Other *costs* include energy terms of variable and fixed costs of equipment less fuel costs.
[4] Miscellaneous items include lubricants used in equipment operation.

Table 2. Ranking of amounts of energy used in OW, CW, OP, and CP production'.

Ranking[2]	OW	CW	OP	CP
	------ Input/Energy (10^6 Btu/a) ------			
1	N/ 6.55	Plastic Mulch/ 12.72	Diesel/ 4.08	Diesel/ 6.44
2	Diesel/ 5.44	Drip tube/ 12.72	Rye seed/ 1.32	Equipment.' 1.97
3	Labor/ 3.37	Seedlings/ 7.40	Peanut seed/ 1.32	Lime and Gypsum/ 1.56
4	Crates/ 2.02	Diesel/ 6.62	Equipment/ 1.06	Peanut seed/ 1.32
5	Equipment.' 1.33	N/ 4.32	Labor/ 0.65	Nematicide/ 1.10
6	Miscellaneousl0.48	Irrigation diesel/ 2.75	Gasoline/ 0.23	Insecticide/ 1.00
7	Gasoline/ 0.46	Equipment/ 2.33	Miscellaneeous/ 0.19	N/ 0.82
8	PI 0.300	Labor/ 2.22	N/A	Miscellaneous/ 0.79
9	W 0.24	Miscellaneousl2.13	N/A	Labor/ 0.48
10	*Seed*/ 0.017	Gasoline/ 2.90	N/A	Gasoline/ 1.23
11	N/A	P/ 1.09	N/A	K/ 0.44
12	N/A	Fungicide/ 1.06	N/A	P/ 0.37
13	N/A	K/ 0.92	N/A	Fungicide/ 0.33
14	N/A	Lime/ 0.89	N/A	Herbicide/ 0.22
15	N/A	Crated 0.46	N/A	**Minor nutrients/** 0.14
16	N/A	N/A	N/A	N fixing bacteria/ 0.012
17	N/A	N/A	N/A	Epsom salts/ 0.0022

[1] OW = organic watermelon, CW = conventional watermelon, OP = organic peanut, and CP = conventional peanut plots.
[2] Rankings are from 1 = greatest amount of energy to 17 = least amount of energy.