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MODELING THE EFFECT OF SOIL AMENDMENTS (COMPOSTS) ON WATER BALANCE AND WATER QUALITY

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Nutrient loadings from agricultural and urban areas have increased nutrient concentrations in water, particularly phosphorus at the Everglades National Park. The soils in the region are mainly crushed limestone with low water holding capacity, high permeability, low organic matter, and low fertility. Application of composts as a soil amendment promises improved water holding capacity and chemical retention. The USDA Everglades Agro-Hydrology Model (EAHM) has been developed to evaluate the impact of agricultural practices on crop production, water balance, and the fate and transport of nutrients and pesticides. The model was modified to simulate the effect of different types and amounts of compost applications on water balance, yield and agro-chemical transport on a typical farm in south Florida. The model was used to select the best management practices (BMPs) while considering the long-term impact of composting on soil water balance, crop yield, and the fate and transport of nitrogen and a pesticide (atrazine) on a South Florida agricultural farm. Considering the poor soil quality, the model simulation test indicated that the application of 90 to 134 T ha^{-1} of compost annually will result in an increase of soil water content, crop yield, and reduced water seepage below the root zone, thus reducing the potential for N and atrazine to leach into groundwater.

INTRODUCTION

The quality of water seeping into the shallow Biscayne aquifer in south Florida is an environmental concern. Non-point source pollutants of water resulting from agricultural areas have been implicated as a source of water quality degradation in southern Biscayne Bay. In 1996, the United States Environmental Protection Agency published an interim report on South Florida Ecosystem Assessment (USEPA, 1996). The report stated that the nutrient loading from agricultural and urban areas had significantly increased nutrient concentrations, particularly phosphorus, at the Everglades National Park (ENP). The agricultural area of south Miami-Dade County, Florida, is bounded by urban development to the north, Biscayne National Park to the east, ENP to the west, and Biscayne Bay and Florida Bay to the south. The climate is maritime subtropical with a yearly mean temperature of 23 °C and an annual rainfall of 165 cm. Mean annual relative humidity is about 62 %. The warm climate, high humidity, and ample rainfall allow for the production of tropical and subtropical crops year round and traditional vegetable crops for eight months of the year. The three main soil types in South Miami-Dade, Krome, Chekika and Perrine marl, are well drained. These soils overlay bedrock of porous limestone containing the Biscayne aquifer. The soils have low water holding capacity and high permeability (Savabi, 2001). Since the soils have a low cation exchange capacity (CEC) and are low in organic matter content, they do not strongly retain nutrients and pesticides that are frequently applied to crops during a growing season to increase crop yields and to control a variety of pests. Therefore, the large quantities of water, fertilizers, and pesticides applied to crops have the potential of leaching into the shallow Biscayne aquifer.

Amending soils with composts improves the soil physical and chemical properties (Pinamonti et al., 1997), microbial population and density, enzyme activity (Parr and Hornick, 1992) and increases crop yields (Roe et al., 1993). However, the beneficial effect of composting on the retention of agro-chemicals and soil water has been overshadowed by the possible adverse effect of trace heavy metals (Nyamangara, 1998). Maynard (1989) monitored nitrate concentration in the ground water beneath plots receiving 112 T ha^{-1} chicken manure compost, 112 T ha^{-1} spent mushroom compost, and control plots receiving 1.5 T ha^{-1} fertilizer mixture (10-10-10). The study demonstrated that composts not only provided nutrients to plants but also modified the soil by increasing water holding capacity, organic matter content, yield, and nitrogen content in the soil so it does not leach into groundwater. A recent study (Konomi, 2001) suggests a significant reduction of P and atrazine leaching from soils amended with different composts.

Use of a computer model to simulate the hydro-physical and hydro-chemical processes that are affected by the application of composts has not been previously published. The objective of this study is to model the impact of a variety of composts on soil water balance, and the fate and transport of nitrogen and an herbicide (atrazine) in sandy soils near the Everglades National Park, Florida.

MATERIALS AND METHODS

Model Description

The EAHM (Savabi et al., 2002) is an upgrade of the Water Erosion Prediction Project model (WEPP; USDA-1995) and simulates plant growth, water balance, storm runoff, infiltration, evapotranspiration (*ET*), subsurface flow, erosion, and the fate and transport of agricultural chemicals at a farm scale (Figure 1). Only a brief description of water balance and the fate and transport of agro-chemicals is provided here. Extensive details are provided in WEPP (USDA, 1995), and GLEAMS (Knisel et al., 1993).

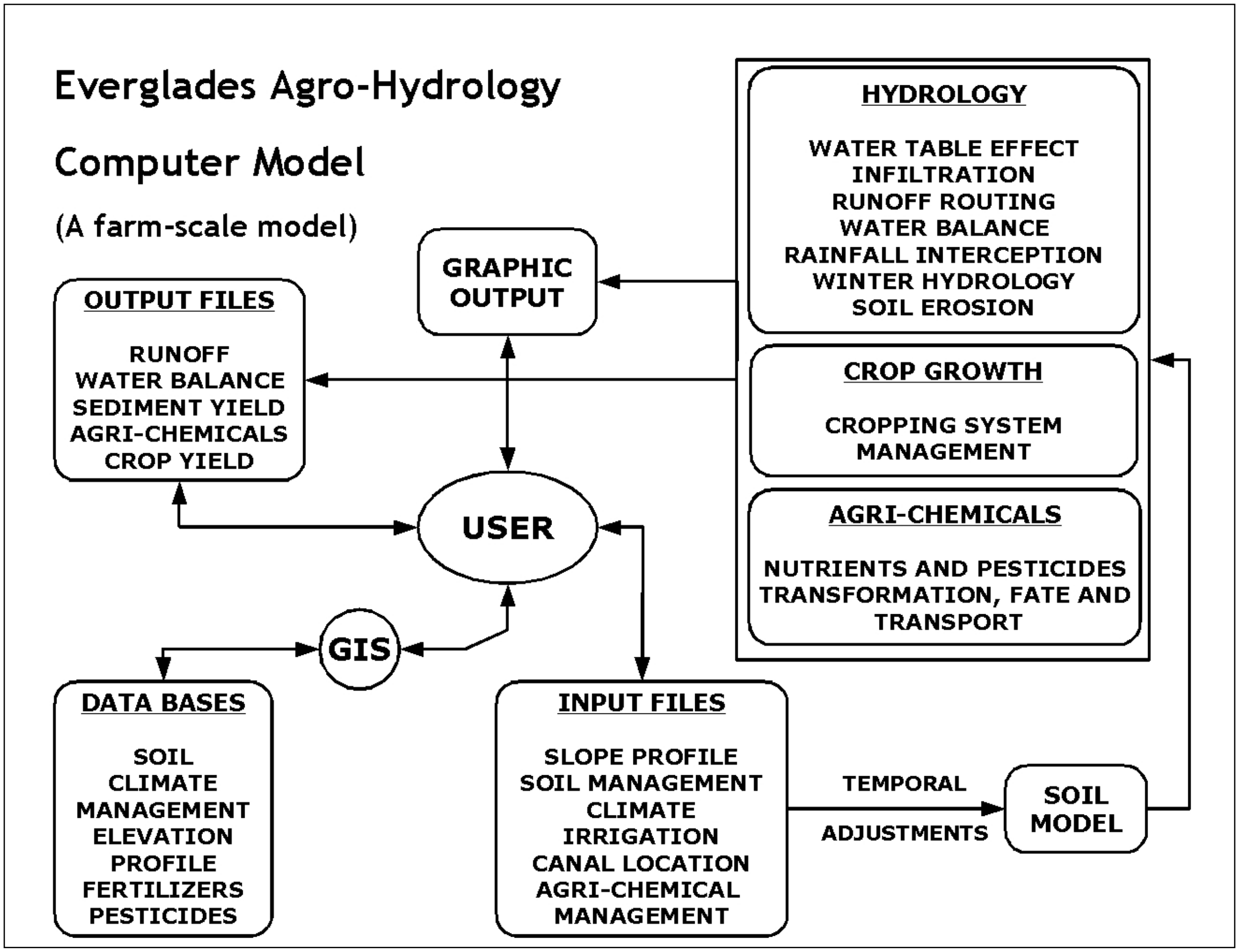

Figure 1. Schematic representation of the EAHM.

The model maintains a continuous daily water balance using the following equation (Savabi et al., 1989b):

$$\theta_d = \theta_{d-1} + P_d - (RO_d + D_d + Qd_d + ET_d + I) \tag{1}$$

where θ is root zone water content, d is day of simulation, P is daily precipitation, RO is daily surface runoff, D is daily deep seepage, Qd is daily subsurface drainage or subsurface lateral flow, ET is daily evapotranspiration, I is precipitation interception by vegetation and/or plant residue. The WEPP hydrology model maintains a continuous daily hill slope water balance by linking infiltration, ET, percolation, and subsurface drainage-flow (Savabi et al., 1989a). Excess rainfall is calculated as the difference between rainfall and infiltration. The infiltration equation used in the WEPP model is a solution of the single layer Green and Ampt (1911) equation for unsteady rainfall as presented by Chu (1978):

$$f = K_e\left[1 + \frac{N_S}{F}\right], \text{and} \tag{2}$$

$$N_S = (\theta_e - \theta_i)\psi_f . \tag{3}$$

where f (cm h^{-1}) is infiltration rate, K_e (cm h^{-1}) is effective saturated hydraulic conductivity, N_s

(cm) is effective matric potential, F (cm) is cumulative infiltration depth, θ_e (cm^3 cm^{-3}) is effective porosity in 0-20 cm of soil, θ_i (cm^3 cm^{-3}) is initial volumetric soil water content in 0-20 cm of soil, and ψ_f (cm) is average capillary potential across the wetting front. Values for effective saturated conductivity (K_e) is estimated by the model and adjusted for the effect of soil crusting, vegetation cover, and rocks (USDA, 1995).

The percolation component of the EAHM model uses storage routing techniques to predict flow through each soil layer in the root zone. In addition to percolation, the model simulates subsurface lateral flow and flow to drainage tile or ditches. In each layer, water content exceeding the corresponding field capacity is subjected to percolation through the succeeding layer. The water that percolates below the root zone is called deep seepage and it is considered lost from the WEPP water balance. Percolation of water in excess of field capacity from a layer is computed as

$$q_j = (\theta_j - \theta_{FC,j})\left[1 - e^{\left(\frac{-\Delta t}{t_j}\right)}\right]; \quad \theta_j > \theta_{fc,j} \tag{4}$$

where q_j (m d^{-1}) is percolation rate through the layer, θ_j (m) is soil water content for the layer, j represents the soil layer, $\theta_{FC,j}$ (m) is field capacity water content (water content at 33 KPa matric potential for the soil) for the layer (m), Δt is travel interval (24h), and t (h) is travel time through the layer which depends on soil hydraulic conductivity (m h^{-1}) of the layer adjusted for soil moisture, θ_j. The conductivity of each layer is adjusted for rocks, frozen soil, and entrapped air (Savabi et al, 1989b).

Daily evapotranspiration is calculated using the Penman equation with the original wind function method (Penman, 1963):

$$E_u = \frac{\Delta}{\Delta + \gamma}\left(R_{mj} - G\right) + \frac{\gamma}{\gamma + \Delta} 6.43\left(1.0 + 0.53u_z\right)\left(e_z^o - e_z\right) \tag{5}$$

where E_u (MJ m^2 d^{-1}) is latent heat of evaporation, R_{mj} (MJ m^2 d^{-1}) is net solar radiation, G (MJ m^2 d^{-1}) is soil heat flux, u_z (m s^{-1}) is wind speed, $e_z°$ (KPa) is saturated vapor pressure, e_z (KPa) is vapor pressure, Δ is slope of the saturated vapor pressure curve at mean air temperature, and γ (KPa °C^{-1}) is pyschrometric constant. E_u is converted to meters per day by dividing it by $2.501 + 2.361 * 10^{-3} * T$, where T (°C) is average air temperature (Harrison, 1963). Potential plant transpiration and soil evaporation are calculated separately based on the plant leaf area index (Ritchie, 1972). Actual soil evaporation is calculated in two stages depending on soil moisture (Savabi et al., 1989b). Daily plant transpiration is calculated based on leaf area index, soil water content in the root zone, plant water use efficiency, and root depth. If the soil moisture is less than plant-required transpiration, water stress (0-1.0) is calculated as the ratio between actual transpiration/potential transpiration. The water stress value is used in calculating crop yield.

Daily crop growth in the EAH model is similar to the EPIC model (Williams et al., 1989). The phenological crop development is based on daily-accumulated heat units, Photosynthetic Active Radiation (PAR), and harvest index for portioning grain yield. Potential biomass is calculated using the equation:

$$\Delta B_{p,i} = 0.0001 BE_j[(0.02092 RA)_i (1.0 - e^{0.65 LAI})_i] \tag{6}$$

where ΔB_{pj} is the potential increase in total biomass on day i (kg m^{-2}), BE_j is the crop parameter for converting energy to biomass for crop j (kg MJ^{-1}), RA is solar radiation (Ly), LAI is the leaf area index, and subscript i is the day of the year. Montieth's (1977) approach is used for determining potential biomass, as well as water, temperature and nutrient (N) stress adjustments. Potential daily biomass is adjusted if one of the plant stress factors is less than unity using the equation:

$$\Delta_{Bj}=\Delta B_j*\mathrm{Min}[(WS)(TS)(NS)] \tag{7}$$

where WS is water stress (0-1.0), TS is temperature stress (0-1.0), and NS is the nutrient stress (0-1.0). For more details see the EPIC documentation (Williams et al., 1989).

An approach similar to the GLEAMS model (Knisel et al., 1993) has been adapted to simulate the chemical transport in this model. In order to represent the daily nutrient state of the system, a relatively complete nitrogen cycle is included. The processes included are mineralization from crop residue, soil organic matter, and animal waste/composts; immobilization to crop residue, solution and adsorbed phases for transport, routing, and crop uptake. Some other processes considered are nitrogen fixation by legumes, denitrification, nitrogen in rainfall, ammonia volatilization from animal waste, and two-stage mineralization of nitrate (ammonification and nitrification).

A schematic representation of the nitrogen component is shown in Figure 2 with the processes and flow directions. Some of the compartments delineated in Figure 2 are for surface only (grain, stove, atmospheric N, and assimilated N), some are for both surface and subsurface computational soil layers (fresh organic N in crop residue and roots, fertilizer, nitrate, ammonia, and organic N in animal waste/composts), and the active and stable soil N occurs only in the soil.

The rainfall infiltrating into the soil surface moves some of the chemicals in the surface-active layer deeper into the soil. The mass of chemicals that are moved out of the surface-active layer

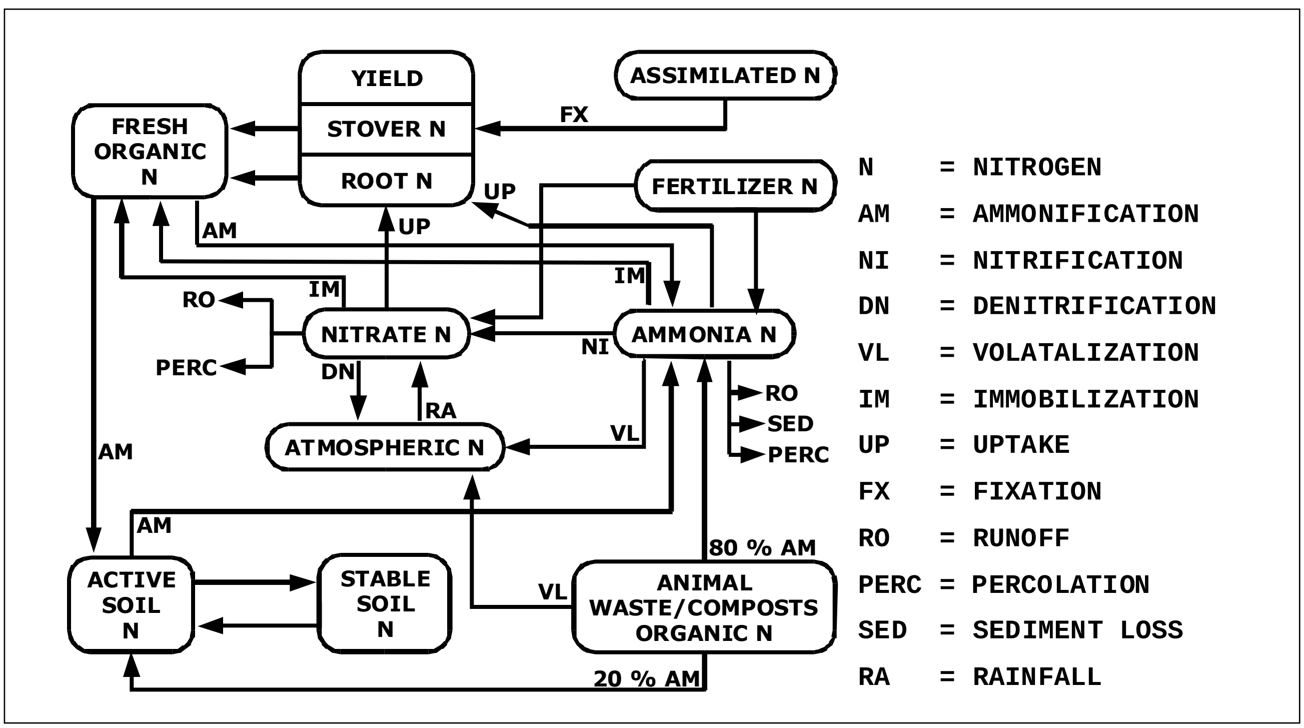

Figure 2. Nitrogen cycle as implemented in the model. (After GLEAMS-Knisel et al., 1993).

is dependent upon the chemical and soil characteristics. The surface-active layer interacts with the runoff stream, imparting some of the soil chemicals to the runoff water. Since the entire soil mass in the surface-active layer is not completely mixed, (dispersed) in runoff and since the solute concentration in runoff is less than the solute concentration in the soil pore water, the extraction process is incomplete (Knisel et al., 1993). This incomplete extraction is assumed reflected in an extraction coefficient ranging from about 0.05 to 0.5. The extraction of pesticides is related to the organic carbon content of the soil that determines the mobility of the particular compound (Leonard et al., 1987). Without repeating their entire development here, it will suffice to say that the partitioning coefficient, K_d (ml g^{-1}), between the solid (soil) phase and the solution (water) phase is:

$$K_d = \frac{C_s}{C_w} \tag{8a}$$

$$C_w = \frac{C_{av}\beta}{1+\beta K_d}\text{, and} \tag{8b}$$

$$C_s = \frac{C_{av}K_d\beta}{1+\beta K_d}\ . \tag{8c}$$

where C_s (μg g^{-1}) is the concentration in the soil, C_w (μg ml^{-1}) is the concentration in the water, C_{av} (μg g^{-1}) is the available concentration in the surface soil layer, and β is the extraction coefficient.

The chemical concentration in the top layer available for runoff and infiltration, C_{av} (μg g^{-1}), is defined as

$$C_{av} = C\exp\left[\frac{ABST-\theta_{\inf il}}{k_d\left(\frac{1-\theta_0}{2.65}\right)+\theta_0}\right] \tag{9a}$$

where C (μg g^{-1}) is the chemical concentration or chemical mass/soil mass, θ_{infil} (cm) is total storm infiltration, θ_0 (cm^3 cm^{-3}) is the porosity of the layer, and $ABST$ (cm) is the initial abstraction from rainfall estimated as

$$ABST = 0.2\left(\theta_s-\theta\right) \tag{9b}$$

where θ_s (cm cm^{-1}) is the water content at saturation and θ (cm cm^{-1}) is the soil water content.

The mass of chemical C_{mass}(kg ha^{-1}) available for runoff and leaching from the surface layer is

$$C_{mass} = C * S_{mass} \tag{10}$$

where S_{mass} (Mg ha^{-1}) is the soil mass in the top layer. The percolation component P_{mass} (kg ha^{-1}) of the available mass of chemical is:

$$P_{mass} = C_{mass} - \left(C_{av} * S_{mass}\right) \tag{11}$$

Average percolate concentration, C_{perc} (mg L^{-1}), of chemical from the top layer is the mass available for percolation divided by percolating water mass

$$C_{perc} = \frac{0.1 * P_{mass}}{q} \qquad (12)$$

where q (cm) is the depth of percolation flux.

The percolation mass determined in Equation (11) is added to the respective masses in layers below as well as the mass of water percolated. Computations are the same for layers underneath through the bottommost layer. The percolate and associated concentrations out of the last computational layer represent potential loadings to the vadose zone from the root zone.

Nitrogen uptake as adapted from GLEAMS is patterned after that in the EPIC model (Sharpley and Williams, 1990) for estimation of nitrogen demand. The uptake by transpiration differs in that GLEAMS contains both nitrate and ammonia uptake. All crops differ in their affinity for nitrate or ammonia, but it is assumed for model representation that nitrate and ammonia uptake is equal to the relative mass of each species in the soil layer from which transpiration occurs. The nitrogen stress is not in addition to moisture stress resulting from soil water deficiency, but the greater (most restrictive) of the two. More details can be obtained from Knisel et al. (1993).

The pesticide component of EAHM was also adapted from GLEAMS and has been extensively described by Leonard et al. (1987). The description is not repeated here. Other publications contain additional information as well (Knisel et al., 1989; Knisel et al., 1991; Leonard et al., 1989; and Leonard et al. 1990).

Soil Amendments Simulations

The results of the currently completed study were used to simulate the impact of composting on soil water balance and agro-chemical transport. A brief description of the study by Konomi (2001) is presented here.

Compost Study

Three composts; 1) Bedminster (BDM)- a mixture containing 75% municipal solid wastes and 25% sewage sludge, 2) Sewage sludge (SLG), and 3) Clean organic waste (COW)- consisting of municipal solid wastes cleaned of plastic material and metal containers, commonly used composts in south Florida, were selected for this investigation. The soil from the Frog Pond agricultural area near the ENP, south Florida, was mixed with the composts. The soil at Frog Pond is mainly Krome (loamy-skeletal, carbonatic, hyperthermic, Lithic udorthent). Table 1 shows some chemical and physical characteristics of the soil and the composts that were used in this study.

The distribution coefficient (K_d) for sorption of atrazine was measured separately with the batch equilibration method (Konomi, 2001). In addition, a portable rainfall simulator was used to determine the effect of different composts on water and chemical retention. The results indicated that soil water, P, and atrazine retention were affected by the application of compost.

Model Input

The EAHM computer model requires four input data files: climate, soil, slope, and management. Climate input files include daily maximum and minimum temperatures, solar radiation, and rainfall (amount and distribution parameters). Soil input files include such soil parameters as albedo, initial

Table 1. Chemical Properties of the Frog Pond Soil and Various Composts: BDM, SLG and COW.

Type	PH	*OC	N	P	K	Mg	Ca	§K_d	*FC	*WP
		%							ml g^{-1}	V/V
FP soil	7.0	3.10	0.28	0.36	0.07	0.18	35.95	2.69	16.4	8.2
BDM	7.4	26.40	1.82	0.72	0.30	0.38	3.68	15.61	77.3	44.9
SLG	5.3	27.90	4.08	4.52	0.06	0.60	7.21	39.09	75.3	57.2
COW	7.1	16.30	1.22	0.29	0.001	0.25	12.37	11.55	33.4	31.4

* OC = organic carbon, FC = field capacity, WP = wilting point

water content, textures, bulk density, saturated hydraulic conductivity, 33 KPa and 1500 KPa (field capacity and wilting point for most crops) soil water contents, percent rocks and cation exchange capacity (CEC). The slope file includes physical features such as slope length, steepness and aspect. The management file requires land use data such as information about the type of tillage, planting, harvesting, irrigation and date of each management practice. The model input data for a typical cornfield in the Frog Pond area were obtained from a soil survey and an interview with the farmer. The CLIGEN model (Nicks and Lane, 1989) generated simulated climate record (based on historic data) was used in model predictions.

Model simulation for 10 years at application rates 45 T ha^{-1} (44800 kg ha^{-1}), 90 T ha^{-1} (89600 kg ha^{-1}), and 135 T ha^{-1} (134400 kg ha^{-1}) of different composts were conducted. The applied composts were assumed to be mixed well with 10 cm depth of soil defined as the top/1st soil layer. Various input requirements for the top soil layer, such as bulk density, organic matter content, initial nitrogen content and K_d for atrazine, were estimated based on the soil compost mixing ratio (weight basis) in the top layer. The input values used during various simulations are reported in Table 2. A linear interpolation was made for bulk density between pure soil (1.35 g cm^{-3}) and pure compost (1.00 g cm^{-3}), depending on different mixing ratios. A similar procedure was applied to estimate saturated hydraulic conductivity between pure soil (50 mm h^{-1}) and a mixture of soil and compost applied at 90 T ha^{-1} (30 mm h^{-1}). Laboratory measurements of field capacity (33 KPa) and wilting point (1500 KPa) of compost material, soil and their various mixtures (estimated) are presented in Table 2. A curve fitting procedure was adapted to estimate the values for different mixing ratios based on their application rates (Figure 3). Other model input such as a management schedule is presented in Table 3.

RESULTS AND DISCUSSIONS

Water Balance

The model simulated soil water content, deep percolation below the root zone, and evapotranspiration are shown in Figure 4 (a-i). Percent deviation (% deviation = 100*(Model simulated value with compost application - Model simulated value without compost application) / Model simulated values without compost application) was calculated to compare the model simulated results from the farm with and without (control) compost application. Average daily soil moisture in the root

Table 2. Measured Values for Soil and Composts and Estimations Used for Simulations at Different Rates of Application of Composts.

Compost	**Rate** kg ha^{-1}	**OM*** %	**TN*** mg kg^{-1}	**Atrazine-K_d** ml g^{-1}	**FC*** (V/V)	**WP*** (V/V)
BDM	44800	6.57	2893	3.08	22.8	8.4
	89600	7.78	3136	3.47	25.6	9.1
	134400	8.99	3379	3.85	27.1	9.7
SLG	44800	6.65	3316	3.78	22.9	8.9
	89600	7.93	3760	4.87	25.5	9.7
	134400	9.22	4648	5.97	26.9	10.6
COW	44800	6.05	2901	2.96	22.3	9.4
	89600	6.73	3151	3.22	24.4	10.2
	134400	7.42	3402	3.49	25.3	10.9

* OM- organic matter, TN- total nitrogen, FC- field capacity, and WP- wilting point

zone was higher when different type and amounts of compost were applied. The effect of compost on soil moisture was greater for application of 133400 kg ha^{-1} (2-5 %) than a lower application of 44800 kg ha^{-1} (0-2.5 %). As shown in Figure 3, the addition of compost increased the soil water content at different soil tensions. An increase of water holding capacity (Figure 3) as a result of compost application resulted in less deep percolation. Percolation of water below the root zone depends on the soil water holding capacity and, more specifically, soil water content at 33 KPa and the saturated hydraulic conductivity of the soil (Equation 4). An increase of soil water at 33 KPa and a reduction of saturated hydraulic conductivity resulted in a reduction of simulated deep percolation (Figure 4 d-f). Saturated hydraulic conductivity of soil was reduced when compost was added to sandy loam soil with a significant amount of rocks (52 % by volume). Model simulated deep percolation was reduced by about 15 % when 134400 kg ha^{-1} of compost was applied to the soil. The difference between the reductions of deep percolation is not significant for the three types of compost used in this study. However, as the rate of compost application increased (44800-134400 kg ha^{-1}), the model simulated deep percolation decreased (Figure 4 d-i). The average daily evapotranspiration follows the same trend as the soil moisture. Considering the fact that no parameters that affect ET are altered in the model, an increase in soil moisture resulted in an increase of average daily evapotranspiration (Figure 4 g-i). However, we realized that the effect of compost on soil albedo should have been considered.

Results of the model simulated crop yield for a farm with and without compost are provided in Table 4. Corn yield increased as the result of compost application. We realize that this is not a new finding and several studies indicated that addition of compost would result in an increase of crop yield (Roe et al., 1993 and Vanai et al., 1996). However, in this study our model simulates the factors that contribute to the increase of corn yield, such as nutrients and soil water availability. Daily biomass production can be affected by temperature, soil water, and nutrient stresses

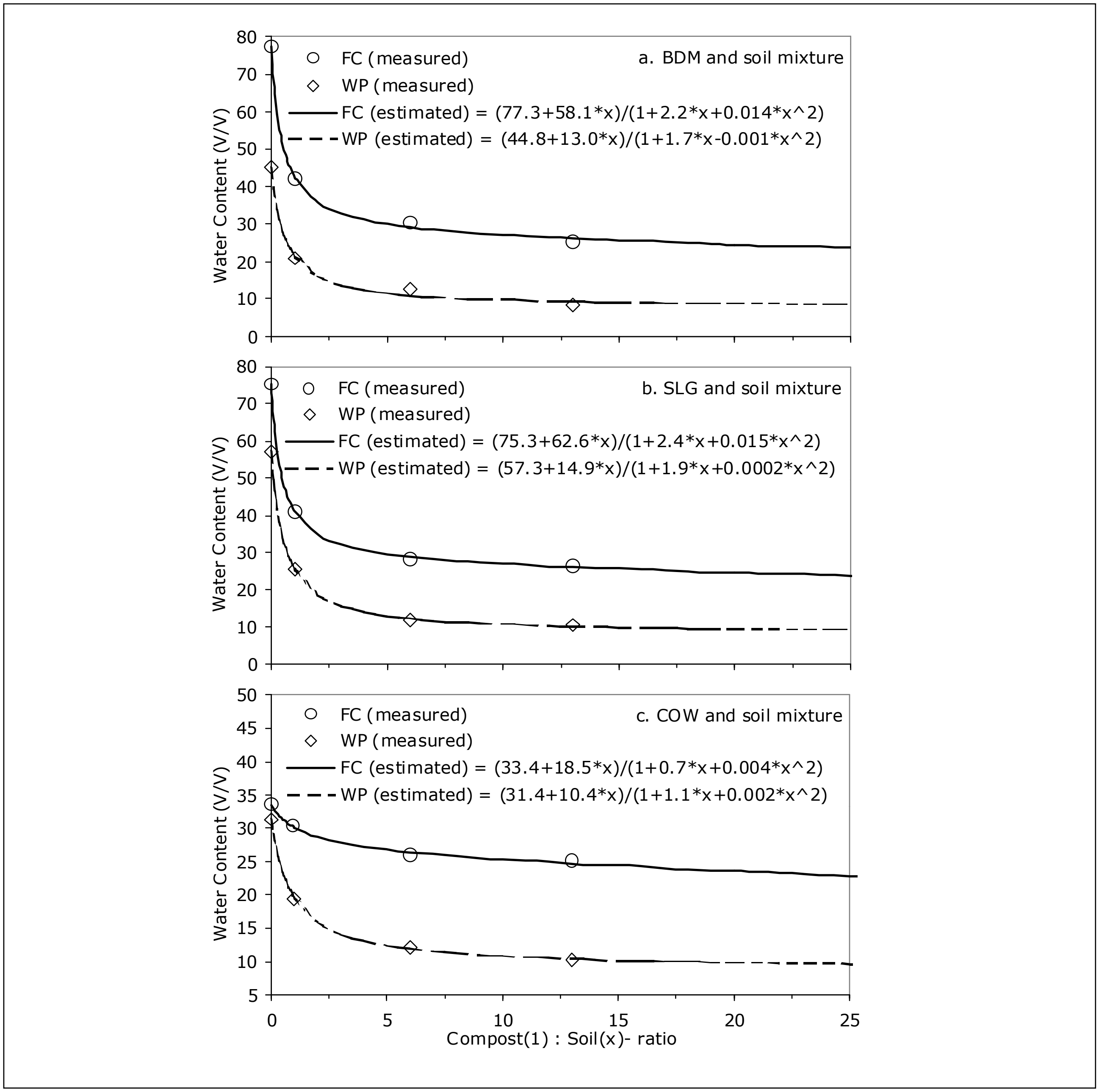

Figure 3. Field capacity and wilting point of composts and soil mixtures.

(Equation 7). Considering the fact that the temperature generally is not a limiting factor for crop growth in south Florida, the soil moisture and the nutrient stress need to be examined. Average daily soil water content was higher for the simulation with compost than without compost (Figure 4 a-c). Therefore, the effect of water stress on daily growth should be less on simulation with compost than without. Higher root zone soil water content resulted in higher plant water uptake (higher transpiration, Figure 4g-i). In addition, model simulated N uptake by crop was higher (Table 4) for the simulation with compost than the simulation without compost. Composts, specifically sludge, contain a high amount of nitrogen (Table 2) and therefore increase the N pool of the root zone. A combination of an increase in water and N uptake by the plants is the reason behind a higher crop yield (Table 4). The increased trend in crop yield follows the same trend for *ET* and N uptake for the composts studied here. The highest simulated yield was with Sludge compost (134000 kg ha^{-1}).

Table 3. Management Schedule for Sweet Corn Production at Frog Pond With Different Compost Applications.

Date	Operation	Details	Comment
01/01/2002	Initial Conditions	Corn after corn	Frog Pond
01/01/2002	Start Irrigation Schedule	Depletion- stationary	
01/15/2002	Harvest - Annual	Corn, in Frog Pond	High production 125 bu/acre
03/30/2002	Tillage	Disk chisel plow with sweeps	Depth: 10.00 in; Type: Primary
09/29/2002	Apply Compost	BDM, SLG, and COW	Variable rate-45, 90, and 135 T ha^{-1}
09/30/2002	Tillage	Chisel plow with sweeps	Depth: 6.00 in; Type: Sec
09/30/2002	Tillage	Planter, ridge-till	Depth: 6.00 in; Type: Sec
10/15/2002	Plant - Annual	Corn, Frog Pond, High production 125 bu/acre	Row Width: 30.00 in
10/15/2002	Apply Fertilizer	08-15-00 (grade: N-P-K)	Amount (kg/ha): 762
10/17/2002	Start Irrigation Schedule	Depletion - stationary	
10/24/2002	Apply Pesticide	Atrazine	Amount (kg/ha): 3
10/25/2002	Apply Fertilizer	07-00-00 (grade: N-P-K)	Amount (kg/ha): 284
11/5/2002	Apply Fertilizer	07-00-00 (grade: N-P-K)	Amount (kg/ha): 284

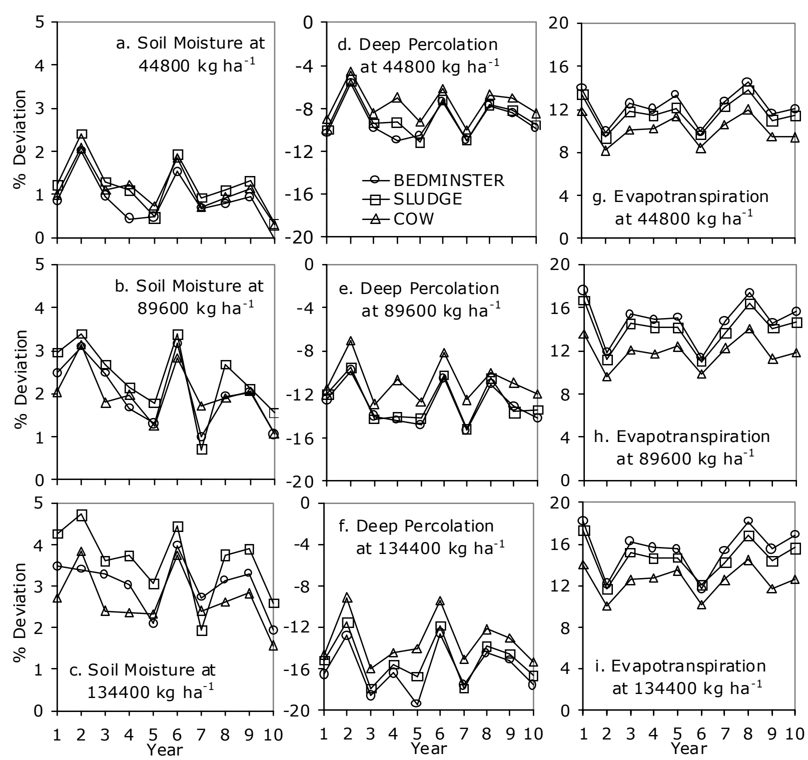

Figure 4. Soil moisture, deep percolation and evapotranspiration as affected by different rates of compost application.

Table 4. Percent Increase in N Uptake and Yield by Corn Crop as Simulated by EAHM.

Application Rate /Compost Type	44800 kg ha^{-1}		89600 kg ha^{-1}		134400 kg ha^{-1}	
	N Uptake	Yield	N Uptake	Yield	N Uptake	Yield
BDM	18.84	5.98	24.10	9.40	29.43	11.97
SLG	23.75	8.55	39.32	17.09	51.25	22.22
COW	25.81	5.13	29.05	6.84	31.84	8.55

Agro-chemical Retention and Leaching

The results for NO_3-N leaching are presented in Figure 5 (a,b,c). The highest reduction in leaching for NO_3-N was observed at the highest rates of composts application. Regardless of application rates, compost application in general resulted in reduction of NO_3-N leaching out of the root zone. One of the reasons for reduced leaching was higher retention of water in the root zone (Figure 4- a,b,c), which reduced the water stress and made more NO_3-N available for plant growth. This was reflected in higher yields (Figure 6) of corn at higher rates of compost application. The compost application also resulted in reduction of deep percolation (Figure 4- d,e,f) out of the root zone at various application rates of all the composts, which further explains the decreased leaching of NO_3-N with compost application. The general order of leaching at different rates of compost application was COW>SLG>BDM. This is in direct correspondence with results of percolation presented in Figure 4- d,e,f.

In the case of atrazine, a similar effect on reduced leaching was observed (Figure 5- c,d,e). As

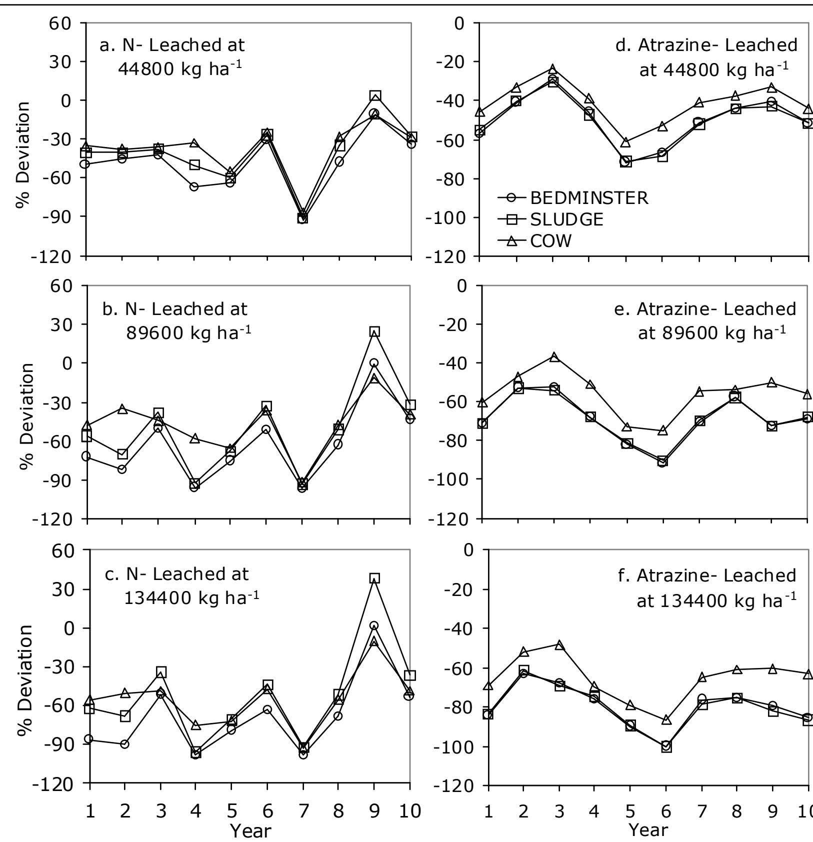

Figure 5. NO_3-N and atrazine leaching at different rates of compost application.

seen from Figure 4 (d,e,f), this was due to reduced leaching of water out of the root zone due to application of compost. Another reason for reduced leaching of atrazine was the effect of an increase in organic matter content of the soil due to compost application and the resulting increase in the sorption coefficient (K_d) values (Table 2). The application of various composts showed an order of leaching that was COW>BDM>SLG. However, this order was different from N due to the added effect of an increase in organic matter content due to the application of compost. This order corresponds to the order (Table 2) of organic matter content and K_d values (COW<BDM<SLG). In the case of atrazine, both the reduction in deep percolation of water and an increase in sorption coefficient (K_d) played a role in reduction of the leaching. Higher retention of atrazine in the profile by application of composts also led to a higher degradation (half-life = 60 days, data not presented), thus resulting in less availability for leaching.

SUMMARY AND CONCLUSIONS

The USDA- Everglades-Agro-Hydrology Model (EAHM) has been developed to evaluate the impact of agricultural practices on crop production, water balance and the fate and transport of nutrients and pesticides. The model was modified to simulate the effect of different types and amounts of compost applications on water balance, yield and agro-chemical transport on a typical farm in south Florida. The model was used to select the best management practice considering the long-term impact of composting on soil water balance, yield and the fate and transport of nitrogen and atrazine herbicide in South Florida cornfields. Considering the poor soil quality, the model simulations indicated that the application of 90 to 135 T ha^{-1} annually would result in an increase of soil water content and crop yield, along with reduction in water seepage below the root zone and the leaching of atrazine and NO_3-N.

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