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Statistical study of spatio-temporal evolution of plant infection by SCYLV in a disease free plot

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Abstract

In the framework of studying the evolution of infection by SCYLV (Sugarcane Yellow Leaf Virus) in the caribbean islands, we used a spatio-temporal model. This model was based on conditional intensities to investigate the infection evolution with respect to environmental heterogeneity. Since alate aphids may prefer some areas in a culture plot rather than others in relation with the variability in plant growth, wind direction, tree-shaded areas, primary and secondary infections were taken into account as in Gottwald *et al,* (1999). Different conditional intensities were considered and simulations were carried out with gradient effects.

Introduction

Statistical studies of spatio-temporal spread of viral diseases often require spatial and temporal modeling (Zhang *et al*., 2000). This is the case of plant viruses because most of them are transmitted by vectors. Thus, for investigating the evolution of infection by SCYLV in sugarcane fields, we used a spatio-temporal model based on conditional intensities. Since alate aphids may prefer some areas in a culture plot rather than others in relation with the variability in plant growth, wind direction, tree-shaded areas, primary and secondary infections were taken into account as in Gottwald *et al.* (1999). Different conditional intensities were considered and simulations were carried out. R packages for spatial dependence were also used to process the observed data.

Materials and methods

Sampling: several observations were carried out in Guadeloupe in 2004. A sugarcane trial (17 rows of 55m each) was established with 1,745 disease-free plants of cultivar SP71-6163. The number of SCYLV-infected plants was monitored on the whole plot, on weeks 6, 10, 14, 19 and 23 after transferring plants to the field, by tissue blot immunoassay (TBIA). Colonization of disease-free plants by aphid vector was monitored in plant cane and aphid population structure was estimated from 40 random identified plants on plant crop.

Statistical methods: We carried out Monte Carlo statistical tests based on the variance-mean ratio at several spatial scales of the observed plot. Similarly, we tested spatial autocorrelation at several scales based on Moran index (Celini and Vaillant, 1999) with neighbor-hood defined from a given distance between plants.

Stochastic modeling: the proposed model is such that during a first phase infections occur independently of each other. Then, there are local transmissions by apterous aphids which could move from one plant to another at a certain phenological stage of the sugarcane plants. The conditional intensity of infection at date t on plant x is denoted by $\lambda(x,t)$ and is such that $\lambda(x,t)dt$ is the probability that plant x is infected between dates t and $t+dt$.

For a non infected plant x at date t, we wrote:

$$\lambda(x,t) = (a + I(t)\sum \exp(-b.d(x,x_t)).h(t)$$

where a is the background infection parameter, b is the local interaction parameter, $I(t) = 0$ if date t belongs to the first phenological stage, $I(t) = 1$ if not.
$h(t)$ is the infective capacity at date t, $d(x,x_k)$ is the distance between plants x and x_k. $\sum$ indicates the sum over the whole set of infected plants x_k prior to date t.

Results and Discussion

We calculated the dispersion and Moran indexes for the number of SCYLV infected plants per quadrat. Different quadrat sizes were considered for each observation periods. The associated p-values clearly indicate that significant aggregation appears only from week 19. The hypothesis of completely random infection locations is rejected from week 19. Tables 1 and 2 show the results obtained for the smallest quadrat size (3m x 3m) considered in the analysis. After week 14, there exists a mechanism of local infection spread from infected plants to virus-free plants due to possibility for the infected apterous aphids to move easier from one plant to another. This was confirmed by calculating frequencies of infected nearest neighbors for both virus-free and infected plants (Fig. 1).

Week 14		Week 19		Week 23	
DI	P	DI	P	DI	P
1.155	0.111	1.152	0.115	1.281	0.018

Table 1. *Dispersion index (DI) and its p-value (P) for some observation dates.*

Week 14		Week 19		Week 23	
MI	P	MI	P	MI	P
0.040	0.153	0.169	0.001	0.198	0.000

Table 2. *Spatial Moran index (MI) and its p-value (P) for some observation dates.*

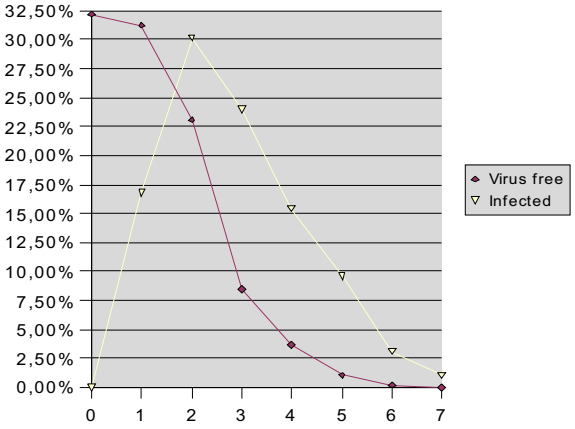

Figure 1. *Distribution of number of infected or non infected neighbors inside a circle of radius 1.5 m.*

The second phase of the stochastic model is described in figure. 2.

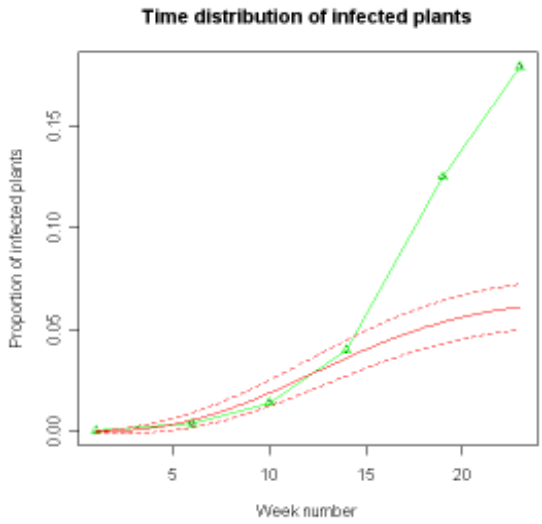

Figure 2. *Time distribution of infected plants. The green line corresponds to the observed proportions. The red lines correspond to the expected proportion in absence of spatio-temporal structure.*

Before week 14, the proportion of infected plants is inside the 95% confidence interval whereas after week 14, this proportion is much higher than the expected value under the hypothesis of completely random distribution of infections.

Conclusion

The early phenological stage of sugar cane fields corresponds to arrivals of alate aphids on the plot and first generations of apterous aphids. The statistical tests of dispersion and spatial structure are not significant before week 14. This suggests that SCYLV infections are completely randomly distributed due to non capacity of apterous aphids to move from one plant to another. From week 14, this moving is possible and local transmissions occur. This explains the significant overdispersion and aggregation observed at weeks 19 and 23.

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Tentative Estimates Of Carbon Storage Ability Within Coastal Forested Wetlands In The Caribbean

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Abstract

Since the beginning of Holocene, relative sea level variations along caribbean coasts have significantly impacted coastal wetland ecosystems at various spatio-temporal scales, either in terms of structure, functioning, dynamics, or evolution.

Several soil core samples (Martinique, Guadeloupe, Saint-Martin, Haïti) were studied and analyzed in order to reconstruct the main steps which led to the current organisation of forested coastal wetlands within the Caribbean region, and to assess the amount of carbon stored in their soils.

In the years or decades to come, several indicators (temperatures, rainfall variability, frequency and intensity of hurricanes…) might confirm a sharp shift of the disturbance regime to which some coastal forested wetlands would be especially sensitive because of the celerity of the processes involved. Nevertheless, it seems likely that the overall "carbon sink" function could hardly be outweighted.

Introduction

Since the beginning of Holocene, relative sea level variations along caribbean coasts have significantly impacted coastal wetland ecosystems, in terms of structure, functioning, dynamics, and evolution.

Evidences of these changes have been progressively included within the peculiar organo-minéral sediments of these ecotone environments which contain most of their carbon stock.

In this study, we combine the use of field data with interpretation of previous multidisciplinary literature data to evaluate to what extent caribbean mangroves and their associated wetlands can act as net "carbon sinks".

Materials & Methods

Several soil core samples (Martinique, Guadeloupe, Saint-Martin, Haïti) were drilled until the bottom of the soil's organic layer, using a 10 cm-diameter Edelman auger. They were compared and interpreted in order to reconstruct the main steps which led to the current organisation of forested coastal wetlands within the Caribbean region.

These soil samples were also used to assess their amount of carbon stored in caribbean coastal wetlands. They were classified within 3 classes of organic richness (0-33%, 33-67% and 67-100%) which accounted for 3 distinct water contents (respectively 80%, 250% and 500% of dry weight). Then, their estimated carbon stock was computed assuming that most organic compounds were cellulose and lignin.

Estimates of past and current sea-level rise drawn from photointerpretation and vegetation inventories [1,2] allowed us to propose a range of possible future carbon storage by coastal caribbean wetlands for the next few decades.

Results & Discussion

The core samples ranged from 0.8m to 7.0m in depth, averaging 3.0m (n = 63). Irrespective of their location (Guadeloupe, n=50; Martinique, n=8; Haïti, n=3; Saint-Martin, n=2), they had a very similar structure showing a clayey / muddy base underlying an organo-mineral layer itself topped by a typical highly organic mangrove peat.

On average, each core had a dry weight of 130g which contained 60g of organic matter, accounting for 24g of carbon. These estimates lead to an amount of 305 t C/ha within caribbean coastal wetlands.

Radiocarbon datings performed on control core samples (Guadeloupe and Saint-Martin) showed that the lower mangrove sediments were approximately 3,000 yrs old [3,4]. Therefore, the swamps have stored a little more than 100 kg C / ha per year up to now.

Based on photo-interpretation spanning the last 50 years, the landward shift of the inner mangrove border has ranged from 100 to 300m, which indicates a relative sea-level rise of between 5 and 15cm since 1950. Meanwhile, the

marine border has been quite steady, accounting for the rather good mangrove adaptability to this rise. However, recent satellite estimates of sea-level rise during the last decade [5] seem to show an additional increase in the speed of the rise that challenges mangrove's ability to cope with such a rise.

Thus, caribbean coastal wetlands may be able to store at least 200kg C/ha/yr in the next decades. Given that methane emissions from wetlands are about 2 orders of magnitude lower than C uptake, it seems that mangroves will still remain "carbon sinks" for a while.

During the last five centuries, regional changes resulting from growing human impacts upon native ecosystems have been superimposed to these sea-level driven landscape evolutions that had occurred up to then and had resulted in net below-ground accumulation of carbon.

However, recent and current vegetation dynamics, assessed either through successional photo-interpretation or forest inventories, seems to reveal a dramatic increase of both pace and magnitude of environmental changes related to the rise of sea-level, that might locally modify carbon cycle patterns both qualitatively and quantitatively.

Although it is still to be confirmed at a wider scale, this acceleration remains comparable with other recent environmental shifts, either within or outside the intertropical zone. Moreover, the changes that have occurred throughout the last decades are remarkably consistent with numerous expected consequences related to the regional impacts of Climate Change, most probably driven by excessive greenhouse gas emissions from the consumption of fossil energy resources.

In the years or decades to come, several climate indicators (temperatures, rainfall variability, frequency and intensity of hurricanes…) might confirm a sharp shift of the disturbance regime to which some coastal forested wetlands would be especially sensitive because of the celerity of the processes involved [6]. Nevertheless, it seems likely that the overall "carbon sink" function could hardly be outweighted.

As it seems unlikely that we achieve to limit the worsening of the disturbance applied to the climatic system by a significant, long-term downturn of our energy consumption, it appears more and more useful, and even vital for us to be efficiently prepared to cope with the consequences of the climate's increasing instability [7]. In that perspective, preservation and restoration of coastal forested wetlands [8] are precious allies, and even unbeatable in terms of ratio quality / price, for us as well as for them.

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Evaluation of a Direct Field Method of Soil Salinity Appraisal

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Abstract

Soil salinity strongly influences land productivity and its assessment is a routine practice for land evaluation. Traditional techniques to characterize salinity employed very dilute soil to water suspensions (1: 5). These suspensions do not simulate typical soil conditions and as such leads to erroneous data. Two methods, varying widely in approach were used to characterize salinity in a range of Trinidadian soils, with the intention of evaluating data accuracy. Both the field technique and the saturated paste extract resulted in electrical conductivities greater than the 1: 5 ratio. This resulted in variations in the classification of soils among the three methods. Although significant correlations existed among the methods the correlation coefficient was strongest between the field technique and the saturated paste. A strong significant relationship was observed between the saturated paste and the 1: 5 ratio, which allows for conversions of older reported salinity indicators and their use in land appraisal.

Introduction

Land evaluation provides the basis for planning and decision making leading to appropriate land management and use. Physical assessment of soil attributes represents an integral aspect of this process. Salinity assessment bears significance as it indicates the influence of ions in solution on soil and vegetative degradation with concomitant contamination of water sources (Dasberg and Nadler, 1988).

Regionally, salinity is associated with poor irrigation practices, salt water intrusion, effluent discharge from petroleum production and natural earth phenomenon (mud volcanoes). Shaw (1982) examined the dependency of soil salinization on the quality of the irrigation water for two southern coastal soils in Jamaica. Salt water intrusion and possible sea blast are chiefly responsible for salinity of coastal, swamp land soils through out the region (Brown and Bally, 1966). Impending sea level rise associated with global climate change seeks only to aggravate this situation (Trotz et al., 2001). Petroleum based produced waters (containing brine) will often cause "salt-scars" or areas of high salinity leading to degradation of soil structure and alteration of the osmotic gradient between plant roots and the soil (Holliday and Deuel, 1997). Land based oil exploration has been on the increase in Trinidad, which intensifies the need to assess and monitor salinity. Environmental regulations in Trinidad (WPR, 2000) do not include electrical conductivity (EC) or other indicator analyte for salinity, which indicates a lack of awareness and the need for correction.

Indicators of salinity in Trinidad were described by Brown and Bally (1966). Electrical conductivity was measured as part of the detailed soil survey using an extraction method, with a large soil to water ratio (1: 5). Dasberg and Nadler (1988) and Zhang et al. (2005) have shown this method to deviate from conditions normally present in the soil, but offer the user ease of determination. The preferred method adopted by the US salinity Laboratory (1954) uses a saturated extract and strongly represents the actual soil solution (Zhang et al., 2005). Because soil assessments and/or remediation recommendations are based on soil salt concentrations, soil salinity testing methods must be capable of providing accurate and precise results in a timely manner. The advent of electrical methods now allows for direct "in situ" soil measurements of EC.

The objectives of this study were to (i) validate the use of a salinity sensor (1401 EC-probe) over a range of Trinidad soils and (ii) to develop empirical relationships between EC determined by saturated extract and a 1: 5 soil: water suspension.

Materials and Methods

Soil samples were collected to provide a wide range of salinity levels based on previous work (Brown and Bally, 1966). Samples were taken at 0 - 25 cm and 50 - 75 cm depths, air-dried and ground to pass a 2 mm sieve prior to analysis.

Soil salinity was determined by the saturated paste extract method (Rhoades, 1996) and by the 1: 5 (soil: H_2O) method. For the 1: 5 methods the samples were stirred with a spatula for 1h and extracts were obtained by gravity filtration. Electrical conductivity of the saturated paste extract along with the 1: 5 extract was measured with dip-type conductivity cell. The concentration of Na+ in the extracts was determined using flame photometry. pH was measured in a 1:2.5 (soil/H_2O) suspension with a glass electrode. Cation exchange capacity (CEC) was determined using the unbuffered salt extraction method (Sumner and Miller, 1996). Direct measurement of apparent electrical conductivity (ECa) was determined using a four electrode probe (1401 EC-Probe, manufacturer) in the field at the two depth following methods described by Rhoades and Ingvalson (1971) and Nadler and Frenkel (1980).

Descriptive statistics were used to estimate precision, whilst comparisons of methods gave indications of accuracy. Correlation and regression analysis was used to determine the influence of other parameters on soil EC and the significance of the relationship between saturated extracts and soil water suspensions.

Results and Discussion

Brady and Weil (2006) and Shaninberg and Levy (2005) characterize salt affected soils based on pH, EC and Na content expressed as either Exchangeable Sodium Percentage (ESP) or Sodium Absorption Ratio (SAR). From the data presented in Table 1, all soils except Frederick and Piparo belonged to the category of normal soils. Frederick was categorized as a saline-sodic soil based on EC values from both the saturated paste and probe methods. Piparo was classed as a sodic soil. Using the suspension (1: 5 soil-water) extraction resulted in both soils being grouped as sodic soils. This indicates limitations in accuracy resulting from this procedure. Brown and Bally (1966) characterized soils throughout the Caribbean (English speaking) using this methodology, grossing underestimating true EC (Dasberg and Nadler, 1988) and in some cases falsely categorization. Based on their characterization Frederick clay (4000 ac) is characterized as a normal soil. Geomorphology provides an explanation for these two soils inherent salt affliction.

Soil	Lithology†	pH	EC			Na	CEC	ESP‡
			Paste	1: 5	Probe			
			dS m^{-1}			cmol kg^{-1}		%
Cacandee	Typic Pelluderts	4.05	0.26	0.10	0.39	0.65	18.28	3.56
Montserrat	Typic Tropudolls	5.9	0.21	0.08	0.67	0.59	35.97	1.64
Frederick	Vertic Tropaquolls	5.87	9.1	3.64	7.29	7.83	21.9	35.8
Piparo	Vertis Eutropets	9.35	2.82	1.09	2.59	3.91	4.57	85.6
Godineau	Thapto-Histic Sulfic Tropic Fluvaquents	4.01	0.32	0.13	0.58	0.72	41.15	1.75
River Estate	Fluventic Eutropepts	5.63	0.14	0.10	0.12	0.46	12.95	3.56
St.Augustine	Orthoxic Tropudults	5.27	0.28	0.07	0.08	0.72	8.89	8.10

† *Lithology extracted from Smith (1983)* ‡ *ESP calculated as Na/CEC * 100*

Table 1 Lithology, pH, EC and ESP for test soils at 0 - 25 cm

Frederick soil occurs below sea level, bordering the Caroni Swamp and is seasonally inundated with brackish water. Land use changes through development have resulted in contamination further inland. The Cacandee series which borders the Frederick series, but at a slightly higher elevation (Brown and Bally, 1966) was tested to determine the extent of exposure. Results indicate that this series has not been significantly influenced by salt water intrusion. Contrastingly, Piparo soil is associated with mud volcanoes (GSTT, 2007) which periodically erupt and deposit parent material (clay shale) rich in Na and other metals. The high pH (> 9) indicates the presence of Na which is associated with strongly alkaline soil conditions.

EC values determined by saturated extract ranged from 0.14 - 9.1 dS m^{-1}. The corresponding values for the 1: 5 extracts were proportionally lower in all instances, indicating a dilution effect with increased water content (Zhang et al., 2005). Electrical conductivity of saturation paste (EC_{SP}) was highly correlated with $EC_{1:5}$ for all the study soils ($r^2 = 0.99$, $P < 0.001$) (Fig. 1). The results of this study were similar to those of reported by other researchers (Zhang et al., 2005, Shirokova et al., 2000) who also found significant relationships between these variables. The slope of the relationship (3.03) is similar to that reported by Franzen (2003) but differs from that reported by Zhang (2005). Linear regression allows for accurate estimation of EC_{SP} from suspension extractions. This is favourable since the $EC_{1:5}$ or $EC_{1:1}$ provides a more efficient methodology with greater throughput. Secondly, data already present in reports and other publications where EC_{SP} was use can be mathematically converted to better represent soil conditions.

Apparent EC (EC_a) measured "in situ" showed similar variations among the soils (Table 1), but trends were different from laboratory methods. Values ranges from 0.08 dS m^{-1} for St.Augustine to 7.29 dS m^{-1} for Frederick. The significance of these differences was minor, as it did not affect soil characterization. A very strong correlation ($r^2 = 0.99$, $P < 0.001$) was also observed between the EC_a and EC_{SP} among test soils (Fig. 2). This data confirms the use direct EC measuring devices in providing accurate salinity data. Corwin and Lesch (2005) indicated that this technique is well suited for field scale application due to the ability of large volumes of measurement, which reduces local-scale variability.

However, they caution its use in soils where probe contact may be hindered.

Sodium concentrations and its derivative ESP were low (< 1 cmol kg^{-1}) for all soils except Frederick and Piparo, the latter soil

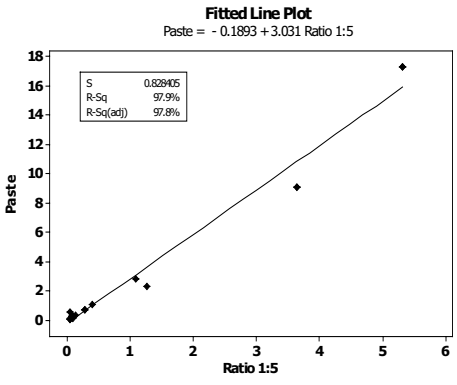

Figure 1. Relationship between electrical conductivity (EC) of saturated paste and 1: 5 soil/water extracts for 14 study soils. P < 0.001.

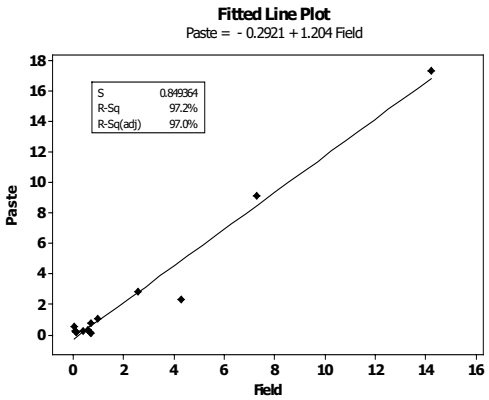

Figure 2. Relationship between electrical conductivity (EC) of saturated paste and apparent EC for 14 study soils. P < 0.001.

showing sodic properties. Exchangeable sodium percentage showed strong correlations with pH supporting the relationship between Na and alkalinity.

Trends among all variables were similar for samples at 50 - 75 cm (Table 2). pH decreased for all acidic soils except River Estate, whilst it increased for Piparo indicating increased Na and parent material with depth. Saturated paste EC increased with depth, doubling for Frederick, alluding to possible leaching of soluble ions to lower depth during periods of flooding. Although Na concentration increased with depth, especially for the salt-affected soils, this did not result in an increase in ESP as the CEC increased correspondingly.

Soil	pH	EC			Na	CEC	ESP
		Paste	1: 5	Probe			
		dS m^{-1}			cmol kg^{-1}		%
Cacandee	3.92	0.75	0.28	0.71	0.91	29.0	3.14
Montserrat	5.4	0.09	0.04	0.70	1.04	40.7	2.56
Frederick	3.77	17.3	5.32	14.2	11.09	36.0	30.8
Piparo	9.68	2.32	1.27	4.30	4.43	12.2	36.3
Godineau	3.69	1.09	0.40	0.98	0.72	42.7	1.69
River Estate	6.13	0.16	0.05	0.13	0.46	11.0	4.21
St.Augustine	4.9	0.57	0.04	0.04	0.52	25.4	2.05

Table 2 pH, EC and ESP for test soils at 50 - 75 cm

Conclusion

It is possible to achieve a satisfactory degree of precision and accuracy from utilizing field based methods of salinity assessment, namely EC_a. For large scale characterization studies this option offers many advantages, primarily taking account of present field conditions. Mathematically relationships established between $EC_{1:5}$ and EC_{SP} allow for conversion of older literature to be precisely describe soil salinity. Although the relationships established by this study was done on varied soil conditions, derived equations should be used with caution and appropriateness for local conditions evaluated.

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Paddy cultivation in Sodic Soil through Vermitech

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Introduction

Soils in India are affected by problems like salinity, alkalinity (sodicity) and water logging. Alkaline or sodic soil predominates in the northern plains of India characterised by pH greater than 8.5 and higher quantity of active sodium. Such soils have been deterred by human interference by way of inappropriate tillage and cropping practices, improper fertiliser application and water management. It is therefore necessary to use suitable organic amendments for proper soil management.

There are a number of organic amendments like bio-solids, straw, sawdust, manures including farm yard manure (FYM) and crop residues which have been used for bio-remediation of sodic soil but the most important among them is the compost. Addition of compost to soil results in the improvement of physical, chemical and biological characteristics of soil with increased crop production (Pera *et al.,* 1983).Vermicompost has been found to have a favourable influence on yield parameters of paddy, sugarcane and vegetables like, tomato, brinjal and okra (Ismail, 1997).

Material and Methods

Experiments have been conducted at the Shivri farm of Uttar Pradesh Bhumi Sudhar Nigam, Lucknow during the kharif season (1998-99), to assess the impact of organic amendment i.e, vermicompost compared to chemical fertilisers on paddy (variety-*Sarju*-52) in relation to sodic soil bio-remediation, fertility, plant growth, yield parameters and economics.

Plots each 250m^2 (20m x 12.5m) were marked for trial (in triplicate), during 1998 (Kharif) at the Shivri farm of the Uttar Pradesh Bhumi Sudhar Nigam, Lucknow.

Composite soil samples were taken from the trial plots at pre-transplanting and post-harvesting stage and were subjected to chemical analysis [pH, electrical conductivity, organic matter, organic carbon and available nitrogen available phosphorus, available potassium, sodium and calcium ions and exchangeable sodium percentage (ESP)].

Plot-A was amended using vermicompost and vermiwash produced at Shivri farm of UPBSN, Lucknow, using Vermitech (Ismail, 1993).Vermicompost and vermiwash used for the experiments, were analysed for the nutrient quality (pH, EC, organic carbon, total nitrogen, total phosphorus, total potassium, ferrous ions, zinc ions, copper ions). Plot-B was amended with chemical fertilisers according to standard recommendations prevalent there. Paddy (*Sarju*-52) was transplanted in experimental plots A and B in July 1998 in Randomised Block Design (RBD) with sub-plot size of 250m^2.

Following crop data were recorded after 95 days of transplanting, before harvest: plant height (cm), number of tillers, number of panicles per hill, length of panicle (cm).

On harvest of crop, after 100 days, the following data were recorded: total yield (kg/ha), grain yield (kg/ha), weight of 1000 grains (grams).

Results

It is evident that there is an increase in organic matter content from 0.38 to 0.96 %, organic carbon from 0.22 to 0.96 %, available nitrogen from 499.52 to 1245.44 kg/ha, carbonate ions from 0.20 to 0.23 meq/100 g of soil, calcium ions from 0.89 to 1.09 meq/100 g of soil and decrease in pH from 8.74 to 8.25, EC from 0.86 to 0.69 dSm^{-1}, sodium ions from 1.85 to 1.47 meq/100 g of soil and ESP from 67.51 to 57.42, suggesting bio-remediation and qualitative improvement of sodic soil, in plot-A, amended with vermicompost. There is reduction in pH by 5.61% and ESP by 14.95% in plot-A (vermicompost) while in plot-B (chemical) on the contrary there is an increase by 0.81% and 2.75% respectively. Organic carbon and available nitrogen increased by 154.55% and 149.33% in plot-A while in plot-B it was reduced by 40.74% and 41.82%.

The nutrient composition of vermicompost in comparison to FYM showed moderate percentage increase of organic carbon and nitrogen confirming a better C: N ratio of 16.35.

Vermicompost has been found to have profound effect on plant parameters like height, number of tillers, panicles per hill, grain weight, total yield and grain yield in comparison to chemical fertilisers .

Paddy yield of 4975 kg per hectare was recorded from plot-A amended with vermincompost and 4900 kg per hectare from plot-B amended with chemical fertilisers. Weight of grains from plot-A (vermincompost) compared to plot-B (chemical), suggested, better quality, in case of paddy grown through Vermitech.

Total cost of cultivation of paddy per hectare through conventional farming applying chemical fertilisers and pesticides was Rs 16,900, while the cost of cultivation of paddy through vermitech was Rs 18,100.

Net income per hectare from
plot-A (vermicompost) = Rs 4492.50
plot-B (chemical) = Rs 2970.00

Cost benefit ratio for
plot-A = 1: 1.30
Plot-B = 1: 1.16

Economics of paddy cultivation suggest that practising organic cultivation through vermitech could reduce the cost of production.

Discussion

The high organic matter content of vermin-compost (19.3%) promotes humification, increased microbial activity and enzyme production, which in turn increases aggregate stability of soil particles, resulting in better aeration (Haynes and Swift, 1990; Perucci, 1990).

Increase in soil nitrogen after harvest from plot-A (vermicompost) is likely to be due to an increase in the presence of nitrogen-fixing microbes through application of compost. Reduction in pH and increase in humus content of the sodic soils are observed due to the production of humic acid during decomposition thereby, reducing soil alkalinity in terms of pH, as also observed by Patcharapreecha *et al.,* (1990). The effectiveness of compost in sodic soil is due to the production of carbondioxide, humic acid, drop in redox potential and replacement of exchangeable Na^{+} ions by Ca^{+2} ions leaching out of the root zone, thus reducing the ESP (Dagar, 1995).

The higher yield, reduced cost of cultivation, less cost benefit ratio and higher net income from paddy cultivation through vermitech compared to the use of chemical fertilisers correlates with the earlier works on economics of crops by organic methods (Ismail, 1997).

Conclusion

Organic amendments like vermicompost facilitates humus formation and prevents leaching of nutrients from the soil by their slow release compared to the conventional farming by the use of chemical fertilisers (Thampan, 1995; Kale, 1996). Considering all the aspects such as soil studies, production and cost effectiveness, from the above investigations, vermitech could be applied in farming practices for sustainable bio-remediation of sodic soil.

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Agriculture / Plant Biology

Soil texture and organic matter effects on structural stability, infiltration, runoff and seal formation

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Abstract

Previous studies have shown that increasing clay concentration can increase aggregate stability on the one hand and on the other hand it can reinforce disruptive forces during wetting resulting in aggregate slaking, low infiltration rate, extensive seal formation, high runoff and the likelihood of erosion. In this study, the significantly higher water stable aggregates (WSA) and final infiltration rate of medium clay-high organic matter sample over its high clay-low organic matter counterpart under simulated rainfall suggests that the medium level (20-45 %) is the threshold clay level beyond which organic matter content must be high or disruptive forces will be strengthened during fast wetting leading to significant loss in aggregation and extensive seal formation.

Introduction

Aggregate stability is crucial for the maintenance of adequate pore space for infiltration and soil hydraulic properties. Maintenance of structural integrity under continuous wetting and raindrop impact is therefore important, particularly in the rainfall rich humid tropics.

The Caribbean region is characterised, by high rainfall amounts and intensities (Gumbs, 1982). The soils are of medium to heavy textures with low organic matter and low free iron oxides (Ahmad and Roblins, 1971). Under these conditions, the susceptibility of soils to structural breakdown with attendant runoff generation and soil loss are increased (Idowu, 2003).

Clay and organic matter have cementing and binding abilities which hold particles together in the aggregate and thus protects aggregates against disruptive forces. This paper test the hypothesis that increase in clay content if accompanied by an appropriate increase in organic matter content will suppress the extent of differential swelling and the volume of entrapped air thereby decreasing aggregate slaking during wetting.

Materials and Methods

Soils

Soil samples were taken from the top 0-10 cm of six agricultural soil series in Trinidad. Water stable aggregates were assessed using single sieve apparatus. Infiltration rate, time and infiltration depth prior to ponding, runoff and seal formation were assessed using a rainfall simulator in samples with three clay levels (low, <20 %; medium, 20-45 % and high, >45 %) and two organic matter levels (low, ≤3.0 % and high, ≥3.0 %). Analysis of variance was used to determine significance of treatments by comparing main effect and interaction means. Tukey's honestly significant difference test was used to discriminate among significant treatment means.

Results and Discussions

Aggregate stability

In both low- and high- organic matter soils, aggregate stability increased with increasing clay content.

Aggregate stability under fast prewetting increased in this order; Low clay-low organic matter (LL) < low clay-high organic matter (LH) < medium clay-low organic matter (ML) < high clay-low organic matter (HL) < medium clay-high organic matter (MH) < high clay-high organic matter (HH). This sequence illustrates that aggregate stability increases with increase in clay content up to the medium level after which increase in clay without accompanying increase in organic matter resulted in significant reduction in stability. This is shown by the signifycantly higher WSAf in the MH samples over their HL counterparts (Table 1). From a practical standpoint, this suggest that under disruptive forces of fast wetting which is common in humid tropics characterized by aggressive climatic conditions (Kral and Hawkins 1982), increasing and maintaining the organic matter concentration of medium clay soils that are often prone to disaggregation by fast wetting from low to high level may confer high aggregation and infiltration rate by increasing the amount of air encapsulation within soil aggregates during fast wetting sufficient to prevent slaking (Zaher et al., 2005). This also suggest that a threshold clay content exist above which high organic matter content is required to provide the cohesive force necessary to

protect the soil aggregates against disruptive forces during the wetting process.

Soil sample	WSAf‡	WSAs	FIR mm/h	Ip Mm	Tp h	Q mm
LL†	5.3aA††	18.9aB	5.7a	6.0a	0.05a	95.0de
LH	28.6bA	56.4bB	16.3b	7.3a	0.06a	86.3cd
ML	46.1cA	88.3cB	20.8b	15.5b	0.13b	77.3c
MH	61.5eA	94.1cB	109.9d	119.5d	1.00d	6.3a
HL	56.5dA	89.6cB	3.2a	4.7a	0.04a	100.6e
HH	68.8eA	93.8cB	60.7c	75.7c	0.63c	41.3b

WSAf Ratio (High-OM/Low-OM

Low clay (<20 %)	Medium clay (20-45 %)	High clay (>45 %)
5.4	1.3	1.2

Table1. Water stable Aggregate (WSA), final infiltration rate (FIR), time (Tp) and infiltration depth (Ip) prior to ponding, and runoff for studied samples.

†† Means followed by the same lowercase letter in the column, or same upper case letter in the row are not significantly different by Tukey's honestly significant difference test (P = 0.05)

†LL, low clay–low organic matter; LH, low clay–high organic matter; ML, medium clay–low organic matter; MH, medium clay–high organic matter; HL, high clay–low organic matter; HH, high clay–high organic matter.

‡ f (fast prewet); s (slow prewet).

Infiltration rate, seal formation and Runoff

In all the treatments, infiltration rate decreased with increase in cumulative rainfall until the attainment of a final infiltration rate (FIR) (Fig. 1). This decrease in infiltration rate with increase cumulative rainfall (Fig. 1) is an indication of increasing soil structural degradation caused by slaking due to fast wetting and the destructive impact of raindrops on soil aggregates. The destruction, led to aggregate breakdown and generation of finer particles that became substrate for seal formation. Once a seal was formed at the soil surface, the hydraulic conductivity of the soil layer was decreased leading to low infiltration and high runoff. The faster a seal was formed the lower the cumulative amount of water infiltrated until the attainment of FIR. Seal formation rate was slowest in MH and fastest in HL indicating that aggregate slaking and seal formation intensified with increase in clay when not accompanied with an appropriate increase in organic matter. Organic matter demonstrated its ability to reduce pressure buildup by reducing the rate of water entry into individual aggregates, lowering the potential at the wetting front and reducing the hydraulic conductivity of the aggregates (Zaher et al., 2005) during fast wetting. Thus, high stability and high infiltration rate are sustained when increase in clay is accompanied by increase in organic matter.

In a practical sense, cultivation of clay soils will be more effective if organic matter is high. Aggregates in these soils will remain stable and maintain a relatively high infiltration rate under continuous wetting and high-intense rainfall during the rainy season. On the other hand, high clay-low organic matter soils will easily succumb to aggregate slaking leading to seal formation and extremely low infiltration rate during the first few showers at the beginning of the rainy season. Although organic matter is most effective in stabilizing low clay soils (Table 1), soils with high clay soils must have high organic matter contents to avoid considerable slaking, dispersion and breakdown under rainfall effects.

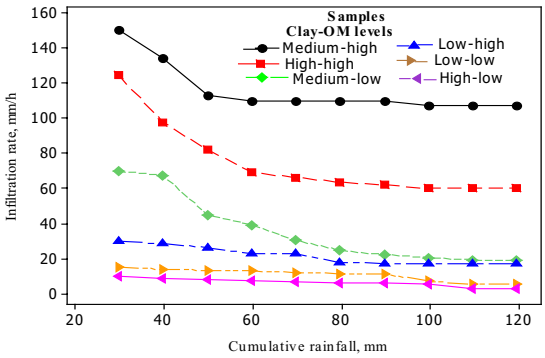

Fig. 1. Infiltration rate as a function of cumulative rainfall for low, medium and high clay samples at low and high organic matter (OM) levels.

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Agriculture / Plant Biology

Effects Of *Musa x paradisiaca* Plant Extracts On The Digestive Parasitic Nematode *Haemonchus contortus* In The French West Indies

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Abstract

Plants containing condensed tannins can represent a way of natural struggle to decrease the worm burden. The present study is aimed at testing the anti-parasitic potential of stem and leaf extracts (water, methanol end dichloromethane) of *Musa x paradisiaca*, a plant containing tannins. Water stem extract, dichloromethane and methanol leaf extracts had efficiency over 90%. Methanol stem extract had an efficiency of 79.5%. Water extract of leaves had the best efficiency on L3 migration inhibition (56%). Methanol stem extract had efficiency over 60% on adult worm motility. The results clearly indicate the anthelmintic properties of this plant extracts. Further researches into chemical compounds are necessary to seek whether the potential activity is due to tannin, other secondary metabolites, or to synergy between two or several compounds.

Introduction

Digestive parasitoses are the major pathologies of small ruminants in the Caribbean area. They are essentially due to the nematode *Haemonchus contortus*. For example, in Guadeloupe (French.West.Indies), the prevalence of this parasite varies between 80 and 100%. More than ¾ of mortality before weaning (that is to say 40%) is linked to gastro-intestinal strongylosis (Aumont et al, 1997). The control of parasites relies mainly on chemical anthelmintics. However, the frequent use of anthelmintics led to apparition of *Haemonchus contortus* strains resisting to benzimidazoles and avermectines in Guadeloupe and Martinique as everywhere in the tropics. Facing such a zootechnical deadlock, it seems urgent to search for alternative methods in order to decrease the parasite burden. Among these methods, figures phytotherapy. Indeed, cares by plants can represent a way of natural struggle to minimize the ailment and find new anthelmintic molecules.
Recent studies have shown that often, plants containing condensed tannins have anthelmintic properties. The present study is aimed at testing the anti-parasitic potential of banana tree (*Musa x paradisiaca)*, a plant containing tannins.

Materials and Methods

Banana tree material was collected in Guadeloupe (F.W.I). Fresh plant material was used for extraction. Three extracts (water, methanol and dichloromethane) of stem and leaves were prepared, in order to test a large range of compounds. The water extract decoction was filtered and lyophilised to obtain a powdered extract. To prepare the other extracts, fresh plant organs were lixiviated by solvents (methanol or dichloromethane) during 3h sheltered from light. The filtrates were collected and evaporated under low pressure at 40°C.

The extracts were tested *in vitro* on four different development stages of the nematode: eggs hatching, L1-L2 larval development, L3 migration and adult worm motility. Different doses of extracts were tested in five replicates for the three first assays and in three replicates for the last one. Negative controls (PBS or DMSO if used for extracts solution) were used. Parasite materials (eggs and adult worms) were obtained from Black belly donor lambs experimentally infected by *H. contortus* (Hubert and Kerboeuf, 1984).

The egg hatch assay was realised according to a modification of the method used for testing anthelmintic resistance (Assis et al., 2003).
The larval development assay was derived from the technique described by Hubert and Kerbouef (1992), (*in* Assis et al., 2003).
The L3 migration assay was performed according to Rabel et al. method (1994), (*in* Hounzangbe-Adote et al., 2005).
The adult worm motility assay was performed according to Hounzangbe-Adote et al. (2005).

The data were analysed by using the general linear model (GLM) procedure (Minitab® Release 14 software). The model took to account the nature of the extract and the dose response.

Results and Discussion

Egg hatch assay
No significant difference between the negative control and the extracts was observed. Banana tree extracts seemed to have no effect on egg hatching.

Larval development assay
Compared to the negative controls, the results of the assay showed that several extracts stopped

efficiently the larval development. Water stem extract, dichloromethane and methanol leaf extracts had efficiency over 90%. Methanol stem extract had an efficiency of 79.5%.

L3 mobility assay
Water extract of leaves had the best efficiency on L3 migration inhibition (56%).

Adult worm motility assay
Methanol stem extract had efficiency over 60%.

Stem and leaves extracts of Banana tree had a significant *in vitro* anthelmintic effect on three development stages of the parasite: larval development, L3 and adult stages. No effect was observed on eggs. These results showed that the extracts had specific targets.
Banana tree is known to contain tannins. The anthelmintic effect of the extracts could be due to the presence of these phenolic molecules. The variability of secondary metabolites present in the extracts could also explain the variability of efficiency on the four development stages according to anatomo-physiological particularity of the parasite.
Concerning the other suspected compounds, the efficiency of the three different extracts (water, methanol and dichloromethane) allows to imagine that several molecules could be responsible for the anthelmintic activity. In the banana tree, the suspected compounds are: terpens, carbohydrates, flavonoids and polyphenolics.
Studies on anthelmintic vegetal compounds showed that condensed tannins had activity against *Haemonchus contortus* (Paolini, 2004, Athanasiaodou et al, 2001). Water or methanol extracts of Banana tree could contain these compounds.
Several action modes could explain the direct *in vitro* effect on the parasite. The adult cuticule as the L3 sheath contain proteins with proline. These proteins have a high affinity for condensed tannins. The fixation of these two compounds could affect the normal moulting of the L3 or adulteration of adult worm cuticule. Enzymatic processes could be spoiled by linking between tannins and enzymes responsible for essential functions of the parasite like motility.
Concerning other secondary metabolites, the action mode could be classical anthelmintic-like. A study showed that Banana tree juice induced twitch augmentation in skeletal muscles of mice (Singh et al, 1990). This mechanism looks like Imidothiazoles action mode. Such compounds could also spoil nervous system by acting on synaptic functions.

Conclusion

These results clearly indicate the anthelmintic properties of *Musa x paradisiaca* extracts. However, further researches into chemical compounds are necessary to seek whether the potential activity is due to tannin, other secondary metabolites, or to synergy between two or several compounds.

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Agriculture / Plant Biology

The Ectomycorrhizal Fungus *Scleroderma bermudense* Improves Water Status and Limits Sodium and Chloride in Seagrape (*Coccoloba uvifera* L.) Seedlings

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Keywords: Ectomycorrhiza, *Coccoloba uvifera*, *Scleroderma bermudense*, Ectomycorrhizal dependency, Salt stress

Abstract

Coccoloba uvifera (L.) L. (Polygonaceae), also named seagrape, is a small tree widely distributed along Altlantic, Caribbean and Pacific coasts of the American tropics and subtropics. It is an important tree for edible fruits, ornemental plantings and coastal windbreaks along Caribbean's Beach and Roadside. *C. uvifera* is considered as a drought-hardy and non-halophytic woody plant relatively tolerant to salt, growing often in pure stands within well-drained sandy soils that are slightly to moderately alkaline.

The purpose of this study was to test the hypothesis that the ectomycorrhizal (ECM) fungus, *Scleroderma bermudense*, have a high capacity to alleviate the saline stress in *Coccoloba uvifera* (L.) L. seedlings. Plants were grown over a range (0, 200, 350 and 500 mM) of NaCl levels for 12 weeks, following 4 weeks of non-saline pre-treatment under greenhouse condition. The *C. uvifera* seedlings growth and nutrition were stimulated by *S. bermudense* regardless of salt stress. Although ECM colonization was reduced with increasing NaCl levels, ECM dependency on *C. uvifera* seedlings was increased. The number of leaves and leaf area were significantly higher in ECM than non-ECM plants. ECM plant tissue had significantly increased concentrations of P and K but lower Na and Cl concentrations than non-ECM plants. Higher K concentrations in ECM plants suggest a higher osmoregulating capacity of these plants. In this respect, the water status of ECM plants was improved despite their higher evaporative leaf surface. The results suggest that the reduction in Na and Cl uptake together with a concomitant increase in P and K absorption and a high water status in ECM plants may be important salt-alleviating mechanisms for *C. uvifera* seedlings growing in saline soils.

Leaf Allometry in Long and Short Shoots Betula papyrifera

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Abstract

The morphology and developmental characteristics of shoot dimorphism in paper birch (*Betula papyrifera* Marsh.) has been well documented [1-3]. However, the allometric relationships (from the basic allometric equation $y = b \times x^{K}$; where **K** is the allometric coefficient of the relative growth rates of y and x) of leaf morphological attributes in the long and short shoot types have not been examined in those reports. Here we present data on the allometric parameters influenced by the dimorphic

development of shoots by comparing allometry of leaf lamina length versus width, lamina length versus petiole length and leaf dry weight versus leaf size. Calculated allometric coefficients, **K**, for the early leaf parameters indicates short shoot early leaves have ontogenetic tendency for increased rate of growth of lamina width faster than lamina length resulting in lower lamina length to width ratios. Long shoots, on the other hand, tend to have reduced tendency leading to higher lamina length to width ratios. The photosynthetic attributes of the two shoot types in relation to shoot distribution within the canopy will be briefly discussed.

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Biodiversity in Rain Forests of the Lesser Antilles

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Abstract

The diversity of the tree communities reaches very high levels in the forests of the Lesser Antilles. The Archipelago is thus included in one of the 34 hot spots of the biodiversity of the world. Clearly the number of native tree species depends: 1) on the land area but also 2) on the landscape diversity (diversity of the ecological conditions). So the volcanic islands with high elevation biota, usually posses more tree species than low islands without montane habitat.

Large parts of the primary vegetation were modified for human uses. In the volcanic islands however, rain forest were partly saved because of the soils and climates are not proper to crop production. In Guadeloupe for example, 40% of the rain forests are yet not far from their natural condition. Such formations exhibit the major part of the Lesser Antilles flora and their functions show a great concern with soils conservation, water resources sustainability or natural risks prevention.

The tree diversity of rain forest stands may be appreciated at the local scale as well as at the ecosystem one.

When considering 800m^2 plots, the richest forest stands lies at middle elevation on the leeward slopes of volcanic hills. Beside this particularity, both the forest richness (number of tree species in a plot) and the equitability of Shannon-Weaver, decreases as the elevation increases. These altitudinal trends suggest that the environmental conditions at high elevation act as a selective filter and limit the plant diversity. The montane rain forest thus exhibits the smallest local (or α) biodiversity.

At the ecosystem scale however, the montane rain forest seems to be as rich as the others forest types. In addition, the montane rain forest posses the highest endemism since no less than ¼ of its tree species are endemic of the Lesser Antilles archipelago.

We conclude that the montane tree stands, because of combining high ecosystem (or β) diversity with low local (or α) one, exhibits inhomogeneous spatial organisation. Such an organisation could be an adaptative response to montane constraints and disturbance regime.

The understanding of the dynamical process that generate such spatial organisation could be essential for the conservation biology in the tropical islands and for the restoration of the disturbed mountain areas.