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The Impact of Selected Cover Crops on Soil Fertility, Weed and Nematode Suppression Through Farmer Participatory Research by Fairtrade Banana Growers in St. Vincent and the Grenadines

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Abstract: Banana farmers in St. Vincent and the Grenadines must urgently adopt alternative strategies to control noxious weeds, nematodes and build soil fertility in order to meet Fairtrade criteria. A potential solution to the control of *Commelina diffusa,* the major weed and nematode host is to intercrop the banana with a fast, low-growing shade tolerant cover crop. In Researcher-managed trials conducted in St. Vincent and the Grenadines in 2003/2004, three cover crops (*Mucuna pruriens, Desmodium heterocarpon* var *ovalifolium* and *Arachis pintoi*) showed promise in suppressing weed infestations and improving soil coverage therefore reducing soil erosion. This project used a Participatory Approach to design, conduct and evaluate the potential of these cover crops. Farmers in partnership with researchers tested several alternative strategies on their farms. The study showed that farmers are capable of designing, conducting and evaluating their own experiments. Farmers and Researchers agreed that the use of cover crops could significantly reduce weed levels and improve weed management of the troublesome weed species *C. diffusa* in banana fields as well as manage nematode levels and enhance soil fertility. The most promising cover crop was *D. heterocarpon* as weed levels were lowest under this treatment. We conclude that eco-friendly pesticide free production solutions can address the problems being faced by limited resource banana farmers. Dissemination to other farmers and to the research community in the region was achieved through presentations by the Research team, farmer-to-farmer extension and field days.

Key words: Farmer Participatory Research · cover crops · soil fertility · weed and nematode suppression · Fairtrade

INTRODUCTION

Farmers in St. Vincent and the Grenadines practice Fairtrade which stipulates the use of fewer chemicals, has measures against soil erosion, promotes diversification and integrated crop management. Although the use of certain nematicides are allowed, the use of herbicides is totally prohibited by Fairtrade farmers.

Commelina diffusa (watergrass) which was once encouraged on hillsides to prevent soil erosion [1] and increase soil moisture levels presents one of the most serious threats to Fairtrade systems. The roots of this weed has been shown to be closely associated with the reniformis and burrowing nematodes which cause extensive damage to banana plants by inhibiting root growth, slowing plant development and significantly reducing yields and income. Additionally this weed competes for nutrients thus reducing fertility levels in the soil. As a result of the reduction in herbicide use in keeping with Fairtrade criteria, heavy infestations of this weed have been identified. As such there is need to find sustainable solutions to its management.

The scientific hypothesis that "cover crops will not only enhance soil fertility, decrease nematode levels, reduce the need for soil tillage under banana plantations and suppress *Commelina diffusa* thereby increasing banana production in St. Vincent and the Grenadines without the need for agrochemicals" guided the study.

Cover crops are known to improve the physical, chemical and biological quality of the soil [2]. They

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suppress noxious weeds, add organic matter to the soil, increase infiltration, decrease soil erosion, conserve soil moisture, reduce soil compaction, increase nutrient availability, reduce nitrate leaching, supply nitrogen to crops, suppress soil-borne diseases and nematodes, attract beneficial insects, increase yields and improve soil quality [3-5].

Research objectives: The purpose of this investigation was to facilitate the adoption of sustainable approaches to secure enhanced soil fertility and improved weed management using a Participatory Research and Development process.
This study was planned to:

- Facilitate farmers' evaluation of selected cover crops
  - To build up soil fertility
  - To reduce soil erosion
  - To suppress *Commelina diffusa* and other weeds which encourage nematodes, thus reducing the need for agrochemicals
- Determine the impact of cover crops on yield and yield components of banana
- Promote Farmer Participatory Research methodology as the preferred approach for mobilizing farmers to solve their own problems

PROJECT IMPLEMENTATION AND MANAGEMENT

Selection of participating farmers: The participating farmers were selected during a farmer participatory training workshop held in St. Vincent and the Grenadines in May, 2005. The Workshop introduced participating farmers to the scientific process. Only Participatory learning and reflection techniques were used and they were based on the principles of experiential learning. No lectures were done. At this workshop, several agreements were made based on the requirements for the trial. These were:

- The site should be easily accessible for other farmers to view.
- Experimental sites would be in the most problematic areas where there is a high incidence of *Commelina diffusa*.
- The participating farmers must keep records of activities undertaken.
- The participating farmers should be willing to share information with other farmers.
- The participating farmer must have 2 plots including a cover crop and the accepted farmer's practice.
- Some farmers were required to use fertilizers and others none.
- The farmers were assigned to experiments randomly.

Thirty six (36) farmers who attended the Workshop volunteered to participate as Farmer-Researchers to conduct research trials on their farms.

Selection of treatments: Fairtrade banana farmers are required to produce their crop with restricted or no herbicide use. Restrictions are intended only in the case where fields are heavily infested with *Commelina diffusa*. Strategies that would suppress the growth of this weed in an ecological and sustainable manner were therefore highly favoured.The practice of using cover crops in St. Vincent is not the norm. Cover crops use addresses the twofold problems of soil fertility and weed suppression. The selected cover crops included the use of *Mucuna pruriens, Desmodium heterocarpon* and *Arachis pintoi.* Farmers used a Matrix Ranking procedure to rank several potential treatments based on cost, availability, environmental effects, ease of application and duration. Farmers ranked three cover crops highest for trials. The current farmers' practice, to control weeds, the use of banana mulch was designated the control in the trials. Other more enterprising farmers who tried another cover crop, *Vigna unguiculata* experienced difficulties in its general performance as the species was not found to be shade tolerant.

Plot size: After a process of negotiation, farmers agreed to establish 10 m x 10 m plots. This area had approximately 36 banana plants at 2×2 m spacing.

Treatment application: The farmer was required to clear by clean weeding the experimental area prior to planting of the cover crop. On the advice of the Weed Researcher, the cover crops were planted at different rates:

- Freshly inoculated *Arachis pintoi* cv. Amarillo seed in shell (50 kg ha^{-1}) was planted by seed and then by stem cuttings drilled into the soil in rows 16 cm apart with 5 seeds per hole. Seeds were planted to a depth of 3 cm to ensure germination.
- *Mucuna pruriens* was also drilled into the soil in rows 30 cm with 3 seeds per hole apart to a depth of 5-7 cm.
- *Desmodium heterocarpon* var *ovalifolium* (CIAT 13651) broadcast at a rate of 5 kg ha^{-1} and lightly raked into the soil.
- Farmers were supplied with the seeds.

Table 1: Observation matrix of data recorded by formers

Observation	How?	When?
Weeds	0.25×0.25 m samples	Weekly counts and scores during first weeks
Banana yield	Taken from selected plants throughout the growing season	
Pseudostem height (cm)		Fortnightly
Pseudostem girth (cm)		Fortnightly
No. of leaves per plant		Fortnightly
Days to flowering		
Days to harvesting		At harvest
Number of hands per bunch		
Number of fingers per bunch		At harvest
Length of fingers		
Finger girth (cm)		At harvest
Bunch weight (kg)		At harvest
		At harvest
Nematodes	From roots and bulk soil	Once

The area for the farmer's practice was also cleared and farmers began to place banana mulch using leaves in between rows. Where there were insufficient leaves for coverage farmers were encouraged to continue placing leaves after banana harvests.

Field evaluation: The farmer recorded all operations performed in the experimental plots in a record book which was provided to all farmers. The farmers agreed to keep records of all activities undertaken according to an observation matrix that they developed (Table 1). These included: commencement date, weed counts and scores, variety, plant growth parameter, environmental and climatic data.

Soil fertility: 10 soil samples were collected from treatments at each farmers field by the Weed Researcher using a soil corer at the beginning (May/June 2005) when trials were established and 5 samples at the end of the project (January-April 2006 after final harvests) to conduct soil chemical analyses. Samples were taken at a 0-15 cm depth using a soil corer. These soil samples were bulked and sub-sampled for analyses. These samples were dried at 40°C and passed through a 2-mm sieve to remove roots and stones before grinding.

Soil organic Carbon (C) was determined using the Walkley and Black [6] procedure. The pH (0.01 mol $CaCl_2$/L) was also determined using a soil pH meter. Available nitrogen was determined using the Kjeldahl procedure. Available phosphorus was extracted using the sodium bicarbonate method and the the Exchangeable cations (K, Mg and Ca) were extracted and determined. The cation exchange capacity was determined using the buffered salt extraction method.

Nematode level evaluation: Nematodes were extracted from soil and root samples using the sieving/filtration according to procedures of Hooper [7].

Several bulk samples of soil and root were taken at banana fields where cover crops were planted using a shovel. These samples were taken by walking the area in a zigzag fashion while stopping to take samples at predetermined intervals. Samples were placed in labelled waterproof plastic bags, secured by knotting and placed in a cooler.

At the Laboratory soil samples were first sieved using a 5-mm sieve to remove debris and other extraneous material, mixed by separating and coning and 100 ml of soil was placed in extraction dishes and left for 48 h. Roots were removed from the soil, washed thoroughly, cut into small pieces and 100 g of roots were weighed and placed in the extracting dish for 48 h.

Extracted nematodes were first placed in a beaker and allowed to settle to obtain a concentrated solution. 1 cc of liquid was removed by pipette, placed on a counting slide and viewed under a dissecting microscope. Nematode populations were then counted and identified into parasitic and non-parasitic species.

Experimental design: Each participating farmer had to evaluate at least two treatments: a cover crop to suppress weeds and the farmers' practice as the control.

Since each farmer was expected to investigate only two treatments based on a single replicate and the farmers were distributed widely throughout the experimental zone, it was decided to use the Paired Treatment design. The number of experimenting farmers allowed for 3 replicates to be done. Farmers conducting the same experiments would constitute the replicates.

The farmers were assigned treatments randomly. All possible treatment pairs were written on a piece of paper and placed in a container and farmers came up and randomly picked a piece of paper. Five (5) more resourceful farmers came up and chose at least one additional treatment pair to test.

Variations had to be made to the original experimental design where treatments were used with and without fertilizer. This was unavoidably due to the fact that there were institutional problems with importation of fertilizers and as such these inputs were not available to farmers during the latter part of the research period (October-March, 2006). Data therefore had to be pooled.

Weed evaluation: Before the planting of the cover crops a visual weed assessment was done to determine the weed species composition. Subsequently, farmers were required to take weed counts fortnightly after the germination of cover crops. Farmers counted all weeds within a 0.25m^2 quadrat that was thrown randomly at 3 locations each in the cover crop treatment and the farmers' practice.

After complete establishment of the cover crop, weed scores were taken using a scoring of 1-5 where 1 represented a higher number of weed species with little or no cover crop and 5 represented little or no weeds and a higher proportion of cover crops. Counts and scores of all the weeds were recorded for statistical analysis.

Plant parameters: Three young healthy suckers were randomly selected within each plot and tagged. These tagged suckers were observed and measured for one growing cycle. The plant parameters that were measured were: the pseudostem height (cm) which was taken fortnightly from the date when treatments were applied and henceforth until just before bunch cropping from the ground level to the "V" formed by the petioles of the two last issued leaves fully folded using a measuring tape; pseudostem girth was also measured fortnightly. The total bunch weight (kg) was measured at harvest using a weighing balance. Because of reduced fertilizer inputs, the days to harvesting and the weight of bunch were severely affected.

Field day: At a field exercise during the workshop, farmers were taught how to use the quadrat, line up plots, conduct random sampling within plots, count and score weeds, tag banana suckers and measurement plant parameter. This was further demonstrated to farmers on the day of establishment of their treatment plots.

Monitoring: Two months after the start of the trials, the research team visited farmers to encourage data collection and motivate farmers as well as to resolve any problems encountered. These visits were continued monthly by the main researcher. Telephone calls were made to farmers regularly to monitor data collection. These calls became necessary as many farms were inaccessible and could not be visited regularly.

Evaluation workshop: A second workshop, which included a field day, was conducted 1 year later during which participating farmers analyzed data, drew conclusions from the results, shared experiences and discussed the way forward. A smaller number of farmers attended this workshop. Farmers visited two farms that represented the two best performing cover crops (*Desmodium heterocarpon* and *Arachis pintoi*). The host farmers, in an interactive session, discussed with other farmers their experience in carrying out the trial on their farm.

Data analysis: For the benefit of the farmers the Overlap Test (8) was used by participating farmers to evaluate weed suppression differences between the treatments. This is based on calculated minimum-maximum ranges of the treatments. These results were prepared in tables and graphs for the benefit of other non-participating farmers.

Data were subjected to ANOVA and means separated at the 5% probability levels using the Least Significant Difference (LSD) test [9]. Comparisons of means and t-tests were also performed.

RESEARCH FINDINGS

Description of farmer experimenters: Data were collected from direct observation using an observation checklist and from semi-structured interviews with farmers done during the conduct of the trials on farmers' fields [10].

Characteristics of farmer experimenters: Overall more men (52.8%) than women (47.2%) participated in trials. However, of the total number of farmers attending the training Workshop (45 farmers: 26 male: 19 female) women were more willing to commit themselves to participate in the trials. A small number of these women (1.2%) who pledged their participation in the project actually used their male partners' names which caused some methodological limitations at the establishment of trials as concepts and methodologies had to be reintroduced to these collaborators due to their absence from training sessions.

An underlying reason for this may have been due to the fact that 41% of these women were not in any stable marital relationships as such they were only "working along" with their male partners and never really had access to their own land. Interestingly all of these women were found in the 20-40 age bracket while older women (40 and over) tended to be married and owners of holdings either independently (5%) or jointly (54%). Du Gueny and Topouzis [11] commented that rural women, in their efforts to satisfy the basic needs of their families and lacking alternative means of employment or access to capital are frequently pushed to overexploit resources and this is largely due to gender inequality, in particular to the fact that resource access and land tenure systems tend to favour men. This fact engenders the stereotypic assumption that farmers are "male" while their wives are more assistants to them. It was also found that more males (63%) than females (47%) farmed on>½ hectare of land.

All farmers, both male and female had at least primary school education. The older farmers in the 40-50 and>50 age range tended to have only primary school education whereas farmers under that age bracket had both primary and secondary school education.

Many farmers indicated planting other crops such as *Colocasia esculenta*, *Dioscorea* sp, *Xanthosoma sgittifolium* and vegetables in smaller plots to earn additional income.

Ninety seven percent (97%) of all the farmers indicated that banana leaf mulch was used for weed suppression after every harvest when banana plants are "lapped-up" (i.e. cutting of entire plant, trunk and leaves after harvest) and when foliage are thinned.

Hand weeding and cutlassing were used to a lesser extent as farmers found these practices burdensome. Weed control, using a mechanical whacker was the second most popular weed management practice and was used more by males than by females. However, farmers limited there use of this because it only intensified the spread of *Commelina diffusa*.

Overall, farmers were well informed of many farming constraints. Eighty percent (80%) of all farmers were aware that they had high nematode levels as evidenced by the high toppling of banana plants on their fields.

Analysis of weed data: Desmodium heterocarpon significantly suppressed weeds compared to the other cover crops (Table 2).

Several problems were encountered in the conduct of these trials on farmers' fields and a number of lessons were learnt from the exercise. Farmers discussed reasons why there was a lapse in regular data collection. A number of farmers were not consistent with data collection as confidence levels fell during the course of the trials. Many factors contributed to this fact ranging from changing in weed floral composition to inclement weather patterns. Intense rainfall patterns at the onset of establishment of trials impeded proper growth and development of cover crops particularly in steeper fields. Additionally, after the removal of *Commelina diffusa* before the establishment of cover crops in fields many farmers complained that *Laportea aestuans* (Stinging nettle) had developed as the dominant weed where cover crop establishment was not good. Farmers either abandoned data collection by

Table 2: Effects of treatments on weed counts (per 0.25 m^2) at 84 Days after Treatment (DAT) and weed score at 140 DAT

Treatments	Weed counts per 0.25 m^2 84 DAT	Weed score 140 DAT
Desmodium heterocarpon (DH)	6.67	4.52
Mucuna pruriens (MP)	50.57	1.75
Arachis pintoi (AP)	27.33	2.96
Farmers' practice (FP)	30.22	3.09
F-test	27.41	27.45
LSD (0.05)	5.58	1.54

Table 3: Effect of various cover crop treatments on the agronomic performance of Fairtrade banana in St. Vincent and the Grenadines

Treatments	Pseudostem height (cm)	Pseudostem girth (cm)	Number of leaves per plant	Days to flowering	Days to harvesting	Bunch weight (kg)
Desmodium heterocarpon	384.3a	69.7a	8.5a	292.3a	393.8a	13.1a
Mucuna pruriens	332.0b	66.4a	8.7a	299.7a	401.2a	13.8a
Arachis pintoi	300.5c	72.7a	7.8b	312.8a	411.7a	13.1a
Farmers' practice	267.8d	60.1b	9.0a	296.2a	397.5a	12.5a
LSD	10.0	7.5	2.3	8.6	8.9	2.7

Table 4: Soil analysis before and after the trials carried out to study the soil fertility enhancement using cover crops and farmers' practice in 2005/2006

Analysis time	pH	Organic matter	Total N (ug gm^{-1})	Available P (ppm)	Available cations (cmol(+)/kg) K	Ca	Mg	CEC analysis
Before trial	4.5	2.4	133.5	624.3	0.7	1.4	0.4	8.5
After trial								
DH	5.2	2.1	1435.0	558.7	1.6	4.8	1.8	7.5
AP	4.3	1.4	800.8	469.5	2.6	4.5	1.9	7.2
MP	5.3	2.6	1833.5	435.0	2.7	10.0	3.1	8.4
FP	4.0	1.7	1002.7	386.5	0.7	2.4	0.6	7.6

Table 5: t-Tests of nematode densities at harvest comparing control with cover crop treatments

Parameter tested	Sig. difference (yes/no)	Probability level	Lower mean
Tot PPN soil	y	0.048	cov crop
Tot PPN root	n	0.71	[cov crop]
Heli soil	n	0.89	[cov crop]
Heli root	n	0.35	[control]
Radoph soil	n	0.21	[cov crop]
Radoph root	n	0.52	[cov crop]
Heli+Rad soil	n	0.65	[cov crop]
Heli+Rad root	n	0.97	[cov crop]

Key: Total Plant Parasitic Nematodes (PPN); *Helitylenchulus* spp (Heli); *Radopholus* spp. (Radoph)

removing all existing vegetation or left this weed to flower and set seed. The availability of fertilizers by farmers also affected the outcome of data as results had to be pooled and no comparison of cover crop with and without fertilizer could be made.

Analysis of plant parameters: The effects of the various treatments on the measured agronomic parameters taken are shown in Table 3. There was a significant difference between treatments in Pseudostem height (cm) where *D. heterocarpon* was significantly taller than all other treatments and the Farmers' practice produced the shortest plants ($p<0.05$). The average height of Robusta bananas is 400-500 cm. No differences were however observed in the other agronomic parameters. The days to harvesting which is usually 90 days after flowering was longer than the average days for the major variety of banana used by farmers in this trial (i.e. Robusta). This may have been as a result of several reasons: (1) the fact that plants were not fertilized regularly; (2) the high levels of nematodes in the soil from data collected and significant damage to banana roots; (3) the practice of maintaining the number of leaves per plant to 6-8 which may have caused significant reductions in bunch weight. The average bunch weight obtained for Robusta with proper fertilizer and other inputs is 30-35 kg per bunch.

Soil analysis: During the trials cover crops which included fertiliser were fertilised with 13:7:23+3.5MgO using a standard measuring cup per mat (141 g). This was applied only once in most instances as farmers had difficulties in obtaining fertilisers for the duration of the trial. Soil microbial analyses were not conducted because of the small variations in results from soil analyses. Table 4 shows the overall means for the soil analysis before and after the trial. The data represents means of soil analysis for several soil types from different farming zones. Overall there were no significant changes in the soil pH although a general reduction in soil pH was expected from the leguminous treatments due to the production of N and other root exudates. No significant differences were observed in the soil organic matter probably because of the short duration under which the experiment was conducted.

Nematode levels: Table 5 shows t-tests of nematode densities at harvest comparing control with cover crop treatments. Nematode analysis indicate that there was a significant difference in the t-test only in the soil total Plant Parasitic Nematode numbers (PPN) after data were transformed (square root of x+0.5) ($p<0.05$). The total PPN included the species; *Paratylenchus* sp., *Rotylenchulus reniformis*, *Helicotylenchus multicinctus*, *Radopholus similis* and *Meloidogyne* sp. The non-parasitic organisms found in samples included many unknown species of non-parasitic nematodes (possibly *Caenorhabditis elegans* and others), endoparasitic nematophagous fungi such as *Hirsutella* sp. [12] and Tardegrades "Water bears". These were found parasitizing some of the parasitic nematodes.

There were no significant differences in root total PPN, *Helitylenchulus multicinctus* and *Radopholus similis* both in the root and soil (Table 5). Paired t-tests using actual nematode numbers indicated a trend for

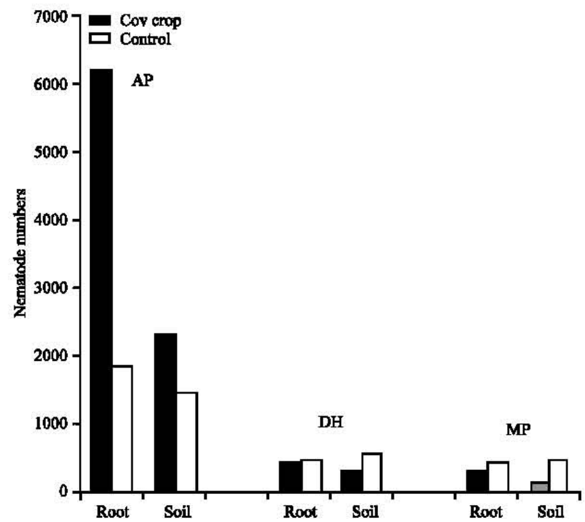

Fig. 1A: Total Plant Parasitic Nematode (PPN) in three cover crop treatments compared to the control

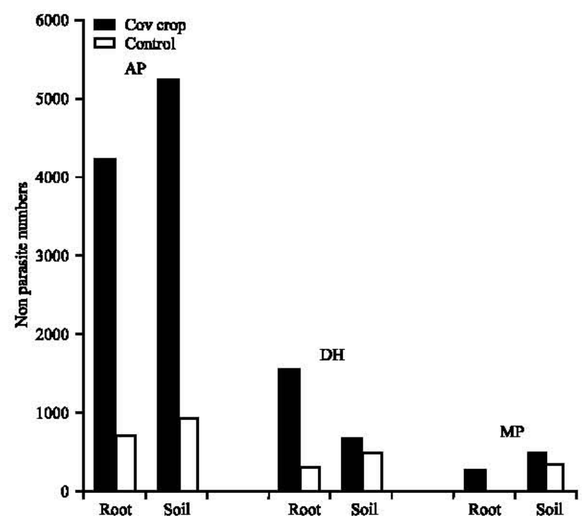

Fig. 1B: Total non-parasitic organisms in three cover crop treatments compared to the control

Key: *Arachis pintoi* (AP); *Desmodium heterocarpon* (DH); *Mucuna pruriens* (MP)

Radopholus similis with p = 0.07 with less numbers in cover crops than control plots.

Figure 1 (A) shows that the overall nematode levels were generally higher than accepted threshold levels which were 250 nematodes per 100 ml soil and 1500 nematodes per 25 grams of root (WIBDECO, unpublished data) for *Arachis pintoi* in particular. Highest counts were recorded under *Arachis pintoi* compared to the other cover crops and controls. Several studies indicate high levels of nematodes using *Arachis pintoi* [13-16]. Lower levels of nematodes in both the soil and the root were observed in *Desmodium heterocarpon* and *Mucuna pruriens*. Results indicate that root nematode levels were acceptable for *Desmodium heterocarpon* and *Mucuna pruriens* (434 and 289 nematodes per 100 grams of root respectively) and soil nematode levels were below threshold levels for *Mucuna pruriens* (128 per 100 ml soil) but a little higher for *Desmodium heterocarpon* (292 per 100 ml soil).

Mucuna pruriens has been reported as having repellent, insecticidal or nematicidal properties [17, 18] however it is not known whether decaying leaves of this cover crop or site variability had a role to play in the lower numbers of nematodes in both root and soil extractions. There are no reports of *Desmodium heterocarpon* having nematicidal properties yet numbers were relatively low. Further work is however required by increasing the number of nematode sampling sites to ascertain whether these trends in lowered nematodes levels under in the *Mucuna pruriens* treatment are valid.

A remarkably high number of total PPN found in *Arachis pintoi* was interestingly concomitant with a high number of non-parasitic organisms in both the root and the soil (Fig. 1B).

These findings were shared and explained to farmers who concluded that it may be necessary to test the efficacy of *Mucuna pruriens* against plant parasitic nematodes namely *Radopholus similis*.

Attitudes to the participatory research process:

Farmers' assessment of the approach and process: While most farmers were favorable toward the involvement in on farm research after the initial process" construct, there was some concern that they could carry out the process on their own. There was concern also about the support provided. While there was general strong agreement that the learning experience was enjoyable, that the facilitators were knowledgeable and the techniques used were not too childish, there were concerns about the quantum of time allocated to the training and the extent of farmers' participation in the training sessions. Grandstaff *et al.* [10] stated that the adoption level of experimental results and the impetus for follow-up activities will be high if farmers are involved in all stages of a field study. Farmers rated their overall experience being involved in the Farmer Participatory Research Process as "Fair" (9%), "Good" (26%), "Very good" (52%) and "Excellent" (13%).

CONCLUSIONS

The study showed that farmers are capable of designing, conducting and evaluating their own experiments. Researchers as well as farmers agreed that the use of cover crops could significantly reduce weed levels and improve weed management of the troublesome weed species *C. diffusa* in banana fields in St. Vincent and the Grenadines. The most promising cover crop was *D. heterocarpon* as weed levels were lowest under this treatment. All farmers who planted this cover crop were satisfied with its performance. *Mucuna pruriens* treatments had higher weed levels which was attributed to the poor establishment in most areas as a result of either poor seed quality or high rainfall. *Arachis pintoi* performed poorly as its establishment was slow, seed quality was low and this crop succumbed to predation by animals. It was agreed that Sustainable Pesticide Free Production (PFP) can be achieved by using cover crops and dead mulches (farmers' practice). Farmers were generally quite favorable with the approach to solving their problems. The training methodology used appeared to be appropriate and as a consequence most farmers indicated that they will continue to be involved in on-farm research as Farmer-Experimenters.

The long term agronomic, environmental and sustainable benefits of cover crops should be taken into consideration. A cost of production study of using such cover crops would be useful in assessing the potential of these live mulches for use by Fairtrade banana growers.

Lessons learnt: Several problems were encountered in the conduct of these trials on farmers' fields and a number of lessons were learnt from the exercise.

1. The need to have a facilitator visit farmers regularly to encourage data collection, sort out any problems being encountered.
   A number of farmers were not consistent with data collection as confidence levels fell during the course of the trials. Many factors contributed to this fact ranging from changing in weed floral composition to inclement weather patterns. Intense rainfall patterns at the onset of establishment of trials impeded proper growth and development of cover crops particularly on steeper fields. Additionally, after the removal of *C. diffusa* before the establishment of cover crops in fields many farmers complained that *Laportea aestuans* (Stinging nettle) had developed as the dominant weed where cover crop establishment was not good. Farmers either abandoned data collection by removing all existing vegetation or left this weed to flower and set seed.
2. *Economic costs needs to be assessed:*
   Farmers indicated a further interest in continuing the trials extensively to obtain a better idea of the cost of production in using alternative approaches to herbicides in controlling weeds on their farms. It was decided that the trials will be repeated with some persons on larger plots and that further work be done on all three cover crops. This decision by farmers was derived from nematode level counts which were done by researchers.
3. Need to link closer with the organization that provides extension for these farmers. There was no assistance from Extension services and there was need for a Technical officer to be assigned to the project to facilitate the further encouragement of farmers and the assessment of final yield.

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