

Weed Composition of Banana Fields in St. Vincent with Emphasis on the Occurrence of *Commelina diffusa*

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Abstract: Banana (*Musa* sp.) production is the foundation of the agricultural sector in St. Vincent and weed management is a major cost factor. Herbicides are no longer an option for Fairtrade banana growers who have to rely on alternative weed management strategies. Weed communities in three major banana growing areas in St. Vincent were characterised in 2003-04 wet and dry seasons by measuring species population densities and biomass in 15 newly established and 25 established fields, respectively in the absence of herbicide treatments under irrigated and non-irrigated regimes. A total of >93 species in >82 genera were recorded representing a total of 37 families with Asteraceae, Poaceae and Euphorbiaceae predominating. Annuals (a) were more common (60 taxa) than perennials (p) (27 taxa) and both a or p (6 taxa). However, two perennial weeds predominated both newly established and established fields (*Urena lobata* and *Commelina* species, respectively). Weed population densities varied greatly between species, location and irrigation regime. Fifty of the >93 weed species identified are recorded as having medicinal uses and >11 have other uses. Opportunities for uprooting, processing and selling useful medicinal weeds which can help farmers in the region recover the cost of hand weeding are discussed.

Key words: Weed community • Flora • Biomass • Population density • Banana • *Commelina diffusa*

INTRODUCTION

The banana is the foundation of the agricultural and rural-based community life of the Windward Islands where about 8000 farmers are involved in its production. Banana is primarily grown on small farms in hilly areas, usually owned by local family farmers and exported mainly to Britain and Europe. To qualify for changing market demands banana growers must have sustainable production systems which use fewer chemicals.

It is estimated that weed control accounts for approximately 50% of the total cost of banana production [1]. There is no detailed information available about the amount of crop yield losses due to weeds in St. Vincent. However, certain weeds associated with banana are known to harbour pests, which cause major losses in production. Among them, *Commelina diffusa* (watergrass) that harbours the root-knot nematodes, *Rotylenchulus reniformis*, which usually feeds on the secondary and tertiary roots of banana feeder roots and at high populations, causes severe necrosis and toppling of plants.

Commelina diffusa has proliferated as the dominant weed in banana fields throughout the Windward Islands for a number of reasons. Weed control in the Windward Islands has been dominated by the use of herbicides for a number of years. The over reliance on herbicides for weed control in these islands has resulted in shifts in the weed flora and the selection of herbicide-resistant biotypes. Prohibitions of these chemicals by Fairtrade farmers have within recent times compounded weed problems in banana fields allowing farmers to revert to hand weeding and more recently the weed whacker techniques which in some cases further exacerbate the spread of the weed.

The presence of weed populations in banana fields is the result of ecological reactions to previous management practices, soil characteristics of the site, and the climatic and weather conditions [2, 3]. Cultural, chemical and mechanical weed control activities can have a strong influence on the weed populations thus knowledge of the weed community structure is an important component of the development of an effective weed management programme. [4] noted that

weed science should focus on those species that are causing, or are likely to cause, significant damage and loss of income in a particular industry or region.

The objectives of this study were: (i) to determine the prevalence of weed species in banana, in the absence of herbicide treatment their population density by estimating the frequency and their dry matter weights by harvesting above ground plants; (ii) to assess the influence of irrigated and non-irrigated regimes on weed species composition and distribution; and (iii) to investigate the association of *C. diffusa* with other components of the weed flora.

MATERIALS AND METHODS

Study Area: Banana is the principal crop of St. Vincent and the Grenadines, accounting for 50 % of all agricultural exports. Several other agricultural commodities are produced, including dasheen (*Colocasia esculenta*), coconut (*Cocos* spp.), sweet potato (*Ipomoea batatas*), plantain (*Musa* spp.), eddoe (*Colocasia* spp.), tannia (*Xanthosoma sagittifolium*) and yam (*Dioscorea* spp.). St. Vincent is made up of volcanic ash soil in the north of the island. These are young, coarse textured sandy soils, which are free draining and have the propensity to release their nutrients when cultivated. Above the 600 ft (183 meters) level are the zonal or high-level yellow earth soils, which are deeply weathered, poorly drained, leached and acidic due to their location in high rainfall areas. Below the 600-ft (183 meters) level are the low-level yellow earth/brown soils. These are less leached and drain more freely. These are usually more fertile and occur on gentle slopes.

Three major banana-farming regions were selected for this survey representing different soil series in St. Vincent. These areas included (1) Langley Park (major irrigated farming region on Windward side of Island; Soufrière cindery gravely sandy loam); (2) Greggs/Lowmans (non-irrigated region on Windward side of Island; Greggs loam and clay loam) and (3) Richmond/Chataubelair (non-irrigated region on Leeward side of Island; Letwoods gravely sandy loam to gravely clay loam).

Weed Survey: A survey of the weed flora of banana in St. Vincent was carried out in the rainy (June to December) and dry seasons (January to April) from 2003-2004 in various banana-farming areas with established banana (from 5 to 9 months old). Twenty five established

orchards under irrigated and non-irrigated regimes were surveyed. The orchards were selected regardless of size and on the grounds of accessibility in the Richmond, Greggs and Langley Park areas.

The weeds were sampled in irrigated (12) and non-irrigated (13) established orchards, giving two data sets. The weeds present in a 1-m² area using a quadrat was used following an “Inverted W” pattern [5]. This technique involved walking through the field in a regular grid pattern and rating the degree of infestation for each weed species in a numerical scale. The area surrounding each field was also checked.

A 1-m² quadrat was placed at 10 sampling points spaced 5 m apart along the “Inverted W” grid and the weeds were harvested at each point. At each point the weed presence and abundance were recorded. Weeds were identified (to species level where possible) and counted. The percentage ground cover was estimated by eye for each of the weed species in each quadrat and weeds were harvested and fresh biomass (g/m²) was taken by species. Identification in the field was based on weed identification guides and weeds difficult to identify in the field were collected, pressed and identified in the National Herbarium, the University of the West Indies, St. Augustine, Trinidad.

The two data sets (irrigated vs non-irrigated) were analysed to reveal the relative importance of each weed species. Using these averages the percentage frequency, f , of occurrence of each species at each sampling in each of the orchards was calculated as:

$$f = (n_p / n_t) \times 100$$

where n_p is the number of orchards in which the species was present and n_t is the total number of orchards sampled. The average biomass per unit area and average frequency of occurrence of each weed species were calculated in the same manner. These two frequency variables and the density and biomass variables were then each averaged over the irrigated and non-irrigated orchards separately for each sampling. For each variable and each weed, the average percentage difference, d , between irrigated, I and non-irrigated, NI , was then calculated for each season as:

$$d = (I - NI) / (I + NI) \times 100$$

and the resulting values were subjected to a t-test to check for differences between irrigated and non-irrigated orchards.

Data were subjected to a number of indices to measure α -diversity which is a measure of the amount of diversity within a community type. The Shannon-Weiner index (H') [6] is based on a number of variables including the proportional abundance of each species. This index gives an indication of species richness and Evenness (E) using the following formula:

$$H' = - \sum [p_i (\ln p_i)]$$

where p_i = Proportional abundance of a given species (i)
 when $p_i = n_i / N$
 n = Population density or number
 n_i = Density or number of the i th species
 N = Total density or number of individuals of all species in the community
 \ln = Natural logarithm

For this index higher numbers indicate a more diverse community. Species Evenness (E) is calculated using:

$$E = H' / \ln S$$

where, S = number of species present.

To calculate whether the diversity of the irrigated (I) and non-irrigated (NI) communities were statistically different the following formula was used:

$$H'_{var} = 1/N * \{ \sum p_i (\ln p_i)^2 - [\sum p_i (\ln p_i)]^2 \}$$

The df and critical value of t (t_{crit}) were calculated using the formula:

$$df = \frac{H'_{var(I)} + H'_{var(NI)}}{\{ [H'_{var(I)}]^2 / N_{(I)} + h'_{var(NI)}^2 / 2N_{(NI)} \}}$$

$t_{(crit)}$ was determined using the t-table.

The value of $t(t_{obs})$ was calculated using the formula:

$$t_{obs} = [H'_{var(I)} - H'_{var(NI)}] / [H'_{var(I)} - H'_{var(NI)}]^{0.5}$$

Similarity coefficients were also used to determine whether the composition of the two communities were similar. The indices are based on the number of species common to both communities (Jaccard's coefficient) or on the species abundances (Steinhaus' coefficient).

The Jaccard coefficient (S_j) was used to determine how many species were common to both the irrigated and non-irrigated communities:

$$S_j = j / (I + NI + j)$$

where:

- j = Number of species found in both communities
- I = Number of species found only in Irrigated community
- NI = number of species found only in Non-irrigated community.

The Steinhaus' coefficient:

$$S_A = W / \{(I + NI) / 2\} = 2W / (I + NI)$$

where,

- W = Sum of the lower of the two abundances of each species in the community
- I and NI = The sum of abundances of all species in each community.

RESULTS AND DISCUSSION

Taxa Found in the Study: A total of 38 families were represented among the weeds occurring in banana over the period of this study. The most important families, based on the number of taxa, were Poaceae (12) and Asteraceae (13) (Table 1). These families are very species rich so it is not surprising that they contain many weeds. More than 93 species occurred and more than half of these were species with annual life histories. Although annuals were more common (60) than perennials (27), the most abundant species was the perennial weed species *Commelina diffusa*.

Identification of *Commelina* to the species level was difficult in some orchards owing to variations in leaf size and no floral structures at the time of enumeration. The genera which were first lumped together included three species (*C. diffusa*, *C. elegans* or *C. communis*). *Commelina diffusa* was later identified as the most dominant of the three at all sampled orchards based on characteristic morphological features.

Weeds in Established Banana Orchards

Frequencies of Occurrence: The frequencies of occurrence of each weed species in both irrigated and non-irrigated orchards (f) are given in Table 2. Here the weeds are ordered according to their overall mean frequency. Most weed species were more frequent in established banana orchards than newly established orchards (data not presented). This can be explained by

Table 1: Botanical and common names of all weeds recorded in the sampled banana orchards in St. Vincent over two seasons. Taxa identified only to generic level are shown as (species.). Life histories shown as annual (a), and perennial (p). Uses shown as medicinal (M), other (O) and none (X)

Species	Family	Common name	Life history	Uses
<i>Blechum pyramidalatum</i>	Acanthaceae	John Bush	p	X
<i>Ruellia tuberosa</i>	Acanthaceae	Heart bush	p	X
<i>Trianthema portulacastrum</i>	Aizoaceae	Horse purslane	p	X
<i>Achyranthus aspera</i>	Amaranthaceae	Soldier's rod	a	M
<i>Alternanthera sessilis</i>	Amaranthaceae	Rabbit Meat	a	M
<i>Amaranthus spinosus</i>	Amaranthaceae	Bhaji	a	M
<i>Cyathula prostrata</i>	Amaranthaceae	Cyathula	a	M
<i>Catharanthus roseus</i>	Apocynaceae	Periwinkle	a	M
<i>Ageratum conyzoides</i>	Asteraceae	Billy Goat Weed	a	M
<i>Bidens cynapiifolia</i>	Asteraceae	Spanish needle	a	X
<i>Bidens pilosa</i>	Asteraceae	Railway Daisy	a	M
<i>Centratherum punctatum</i>	Asteraceae	Marguerite	a	X
<i>Eclipta prostrata</i>	Asteraceae	False Daisy	p	M
<i>Eleutheranthera ruderalis</i>	Asteraceae	Porter's bush	a	X
<i>Emilia sonchifolia</i>	Asteraceae	Consumption Weed	a	M
<i>Mikania micrantha</i>	Asteraceae	Mile-a-minute	a	X
<i>Parthenium hysterophorus</i>	Asteraceae	White Top	a	M
<i>Tridax procumbens</i>	Asteraceae	Button weed	a	X
<i>Synedrella nodiflora</i>	Asteraceae	Fatten barrow	a	X
<i>Vernonia cinerea</i>	Asteraceae	Inflammation Bush	a	M
<i>Wedelia trilobata</i>	Asteraceae	Carpet Daisy	p	M
<i>Heliotropium angiospermum</i>	Boraginaceae	Scorpion tail	a	X
<i>Cleome ruidosperma</i>	Capparidaceae	Spider Plant	a	X
<i>Cleome viscosa</i>	Capparidaceae	Caia	a	M,O
<i>Drymaria cordata</i>	Caryophyllaceae	West Indian Chickweed	a	M,O
<i>Ipomoea quamoclit</i>	Convolvulaceae	Sweet William	a	O
<i>Ipomoea tiliacea</i>	Convolvulaceae	Morning Glory	a	X
<i>Jacquemontia tamnifolia</i>	Convolvulaceae	Hairy Clustervine	a	X
<i>Merremia aegyptia</i>	Convolvulaceae	Hairy woodrose	a	X
<i>Commelina species</i>	Commelinaceae	Watergrass	p	M,O
<i>Mormordica charantia</i>	Cucurbitaceae	Wild carilla	a	M
<i>Cyperus luzulae</i>	Cyperaceae	Razor Grass	p	O
<i>Cyperus rotundus</i>	Cyperaceae	Nut Grass	p	M
<i>Pycurus polystachys</i>	Cyperaceae	-	p	X
<i>Cyperus sphaelatus</i>	Cyperaceae	-	p	X
<i>Cyperus kyllingia</i>	Cyperaceae	-	p	M
<i>Acalypha arvensis</i>	Euphorbiaceae	-	a or p	M
<i>Chamaescyce hirta</i>	Euphorbiaceae	Milk Weed	a	M
<i>Chamaescyce hyperifolia</i>	Euphorbiaceae	Milk Weed	a	X
<i>Croton lobatus</i>	Euphorbiaceae	Croton	a	X
<i>Euphorbia heterophylla</i>	Euphorbiaceae	Red milkweed	a or p	X
<i>Phyllanthus amarus</i>	Euphorbiaceae	Seed under leaf	a	M
<i>Phyllanthus tenellus</i>	Euphorbiaceae	Seed under leaf	a	M
<i>Centrosema pubescens</i>	Fabaceae	-	p	O
<i>Desmodium incanum</i>	Fabaceae	Spanish Clover	p	M
<i>Indigofera hirsute</i>	Fabaceae	Hairy indigo	a	M
<i>Vigna hosei</i>	Fabaceae	Sarawak bean	a	O
<i>Nautilocalyx melittifolius</i>	Gerneriaceae	St. Vincent	p	M
<i>Marsypicantes chamaedrydys</i>	Labiatae	Ortela	a	X
<i>Hyptis lanceolata</i>	Lamiaceae	Woman piaba	a	X
<i>Hyptis verticillata</i>	Lamiaceae	Wild mint	a	M
<i>Leonotis nepetifolia</i>	Lamiaceae	Christmas Candlestick	a	M
<i>Tephrosia purpurea</i>	Leguminosae	Purple Tephrosia	p	M
<i>Spigelia anthelmia</i>	Loganiaceae	Worm Bush	a	M
<i>Sida rhombifolia</i>	Malvaceae	Broom Weed	a	M
<i>Urena lobata</i>	Malvaceae	Congo jute	p	M
<i>Clidemia hirta</i>	Melastomataceae	Soap Bush	p	M
<i>Mimosa pudica</i>	Mimosaceae	Timari	a or p	M
<i>Boerhavia diffusa</i>	Nyctaginaceae	Hog Feed	a or p	M
<i>Ludwigia octovalvis</i>	Oenotheraceae	Wild Clove	p	X
<i>Oxalis barrelieri</i>	Oxalidaceae	-	a	M
<i>Microtea debilis</i>	Phytolacaceae	Demoiselle	a	M

Table 1: Continued

<i>Peperomia pellucida</i>	Piperaceae	Shinning bush	a	M
<i>Piper dilatatum</i>	Piperaceae	Elder Bush	a	M
<i>Cenchrus echinatus</i>	Poaceae	Burr grass	a	M&O
<i>Chloris barbata</i>	Poaceae	Purple top		X
<i>Cynodon dactylon</i>	Poaceae	Bermuda Grass	p	M&O
<i>Dactyloctenium aegyptium</i>	Poaceae	Crow Foot Grass	a	X
<i>Digitaria horizontalis</i>	Poaceae	Jamaica Crabgrass	a	X
<i>Digitaria insularis</i>	Poaceae	Cotton Grass	p	X
<i>Echinochloa colona</i>	Poaceae	Jungle Rice	a	X
<i>Eleusine indica</i>	Poaceae	Fowl Foot Grass	a	M
<i>Panicum trichoides</i>	Poaceae	Tickle Grass	a	X
<i>Paspalum conjugatum</i>	Poaceae	Sour Grass	p	X
<i>Rottboellia cochinchinensis</i>	Poaceae	Itch Grass	a or p	X
<i>Setaria barbata</i>	Poaceae	Corn Grass	a	X
<i>Thelpteris dantata</i>	Polypodiaceae	Downy Maiden	p	X
<i>Portulaca oleracea</i>	Portulacaceae	Purslane	a	M&O
<i>Diodia ocymifolia</i>	Rubiaceae	-		X

Table 2: Percentage frequencies of occurrence (f) of weeds in established banana orchards. Species are ordered according to their overall mean frequencies of occurrence across irrigation regime and have been assigned "Codes" to enable easy comparison with Tables 2, 3 and 4. The last column gives the statistical significance of the difference (d) between the mean frequencies for irrigation regimes

Code and weed species	Irrigated field	Non-irrigated field	Overall mean	Signif. diff.
1 <i>Commelina diffusa</i>	100.0	100.0	100.0	NS
2 <i>Peperomia pellucida</i>	100.0	60.0	80.0	NS
3 <i>Mormordica charantia</i>	78.0	80.0	79.0	NS
4 <i>Ageratum conyzoides</i>	78.0	67.0	72.5	NS
5 <i>Laportea aestuans</i>	78.0	67.0	72.5	NS
6 <i>Drymaria cordata</i>	78.0	60.0	69.0	NS
7 <i>Spigelia anthelmia</i>	78.0	47.0	62.5	NS
8 <i>Phyllanthus tenellus</i>	67.0	53.3	60.2	NS
9 <i>Oxalis barrelieri</i>	67.0	53.3	60.2	NS
10 <i>Portulaca oleracea</i>	78.0	40.0	59.0	NS
11 <i>Cyperus luzulae</i>	89.0	27.0	58.0	p<0.05
12 <i>Croton lobatus</i>	89.0	27.0	58.0	p<0.05
13 <i>Mimosa pudica</i>	56.0	60.0	58.0	NS
14 <i>Cleome rutidosperma</i>	78.0	33.3	55.7	p<0.05
15 <i>Setaria barbata</i>	67.0	33.3	50.2	p<0.05
16 <i>Amaranthus spinosus</i>	78.0	20.0	49.0	p<0.05
17 <i>Eleusine indica</i>	67.0	20.0	43.5	p<0.05
18 <i>Hedyotis corymbosa</i>	56.0	27.0	41.5	p<0.05
19 <i>Marsypianthes chamaedrys</i>	22.0	53.3	37.7	p<0.05
20 <i>Emilia sonchifolia</i>	44.0	27.0	35.5	p<0.05
21 <i>Boerhavia diffusa</i>	57.0	13.3	35.2	p<0.05
22 <i>Panicum trichoides</i>	0.0	67.0	33.5	p<0.01
23 <i>Synedrella nodiflora</i>	33.0	33.3	33.2	NS
24 <i>Chamaesyce hyperifolia</i>	44.0	20.0	32.0	p<0.05
25 <i>Microtea debilis</i>	44.0	20.0	32.0	p<0.05
26 <i>Blechnum pyramidatum</i>	11.0	47.0	29.0	p<0.05
27 <i>Cyperus esculentus</i>	11.0	47.0	29.0	p<0.05
28 <i>Ipomoea quamoclit</i>	44.0	13.3	28.7	p<0.05
29 <i>Bidens pilosa</i>	22.0	33.3	27.7	NS
30 <i>Lindernia diffusa</i>	33.0	20.0	26.5	NS
31 <i>Chamaesyce hystis</i>	22.0	27.0	24.5	NS
32 <i>Centrosema pubescens</i>	22.0	27.0	24.5	NS
33 <i>Nautilocalyx melittifolius</i>	0.0	47.0	23.5	p<0.01
34 <i>Jacquemontia tamnifolia</i>	11.0	33.3	22.2	p<0.05
35 <i>Phenax someratii</i>	11.0	33.3	22.2	p<0.05
36 <i>Catharanthus roseus</i>	44.0	0.0	22.0	p<0.01
37 <i>Cyathula prostrata</i>	0.0	40.0	20.0	p<0.01
38 <i>Acalypha arvensis</i>	0.0	40.0	20.0	p<0.01
39 <i>Eclipta prostrate</i>	11.0	27.0	19.0	p<0.05
40 <i>Euphorbia heterophylla</i>	11.0	27.0	19.0	p<0.05
41 <i>Thelpteris dantata</i>	11.0	27.0	19.0	p<0.05
42 <i>Pycnopus polystachys</i>	22.0	13.3	17.6	NS

Table 2: Continued

43	<i>Tephrosia purpurea</i>	22.0	13.3	17.6	NS
44	<i>Alternanthera sessilis</i>	0.0	33.3	16.6	p<0.01
45	<i>Heliotropium angiospermum</i>	0.0	33.3	16.6	p<0.01
46	<i>Ipomoea tiliacea</i>	11.0	20.0	15.5	NS
47	<i>Rottboellia cochinchinensis</i>	11.0	20.0	15.5	NS
48	<i>Spermoce latifolia</i>	11.0	20.0	15.5	NS
49	<i>Priva lappulaceae</i>	11.0	20.0	15.5	NS
50	<i>Cenchrus echinatus</i>	22.0	7.0	14.5	p<0.05
51	<i>Cynodon dactylon</i>	22.0	7.0	14.5	p<0.05
52	<i>Eleutheranthera ruderalis</i>	11.0	13.3	12.2	NS
53	<i>Pityrogramma calomelanos</i>	11.0	13.3	12.2	NS
54	<i>Lantana camara</i>	11.0	13.3	12.2	NS
55	<i>Trianthema portulacastrum</i>	0.0	20.0	10.0	p<0.01
56	<i>Vernonia cinerea</i>	0.0	20.0	10.0	p<0.01
57	<i>Cyperus kyllingia</i>	0.0	20.0	10.0	p<0.01
58	<i>Hypitis lanceolata</i>	0.0	20.0	10.0	p<0.01
59	<i>Sida rhombifolia</i>	0.0	20.0	10.0	p<0.01
60	<i>Clidemia hirta</i>	0.0	20.0	10.0	p<0.01
61	<i>Dactyloctenium aegyptium</i>	0.0	20.0	10.0	p<0.01
62	<i>Triumfetta semitriloba</i>	0.0	20.0	10.0	p<0.01
63	<i>Stachytarpheta cayennensis</i>	0.0	20.0	10.0	p<0.01
64	<i>Mikania micrantha</i>	0.0	20.0	10.0	p<0.01
65	<i>Parthenium hysterophorus</i>	11.0	7.0	9.0	NS
66	<i>Desmodium incanum</i>	11.0	7.0	9.0	NS
67	<i>Merremia aegyptia</i>	0.0	13.3	6.6	p<0.05
68	<i>Piper dilatatum</i>	0.0	13.3	6.6	p<0.05
69	<i>Diodia ocyimifolia</i>	0.0	13.3	6.6	p<0.05
70	<i>Cissus verticillata</i>	0.0	13.3	6.6	p<0.05
71	<i>Achyranthus aspera</i>	0.0	13.3	6.6	p<0.05
72	<i>Physalis angulata</i>	0.0	13.3	6.6	p<0.05
73	<i>Cyperus sphaacelatus</i>	11.0	0.0	5.5	NS
74	<i>Ruellia tuberosa</i>	0.0	7.0	3.5	NS
75	<i>Tridax procumbens</i>	0.0	7.0	3.5	NS
76	<i>Wedelia trilobata</i>	0.0	7.0	3.5	NS
77	<i>Leonotis nepetifolia</i>	0.0	7.0	3.5	NS
78	<i>Ludwigia octovalvis</i>	0.0	7.0	3.5	NS
79	<i>Digitaria horizontalis</i>	0.0	7.0	3.5	NS
80	<i>Paspalum conjugatum</i>	0.0	7.0	3.5	NS
81	<i>Melochia nudiflora</i>	0.0	7.0	3.5	NS
82	<i>Clerodendron philippinum</i>	0.0	7.0	3.5	NS
83	<i>Centratherum punctatum</i>	0.0	7.0	3.5	NS

the fact that in addition to weeds becoming naturalised to the shady conditions under the established banana environment, these orchards have not been rotated or tilled and herbicides are not usually used because of Fairtrade requirements. According to the overall mean frequency for irrigated and non-irrigated weeds in established orchards, fifteen weed species occurred in more than 50% of the banana orchards: *Commelina diffusa* > *Peperomia pellucida* > *Mormordica charantia* > *Ageratum conyzoides* > *Laportea aestuans* > *Drymaria cordata* > *Spigella anthelmia* > *Phyllanthus tenellus* > *Oxalis barrelieri* > *Portulaca oleraceae* > *Cyperus luzulae* > *Croton lobatus* > *Mimosa pudica* > *Cleome rutidosperma* > *Setaria barbata*. These species are all shade tolerant [7,8].

Although it is not known whether these weed species are competitive for nutrients, [9] pointed out that banana suffer little competition from broadleaved herbaceous weeds. However, it was [9] who recommended that *Commelina* species be managed to provide a beneficial soil cover in banana [10]. Kasasian [11] later noted *Commelina* species as a host of banana virus in Puerto Rico and of the reniform nematode (*Rotylenchulus*) in the Windward Islands and Feakin [12] reported it as harbouring the banana root nematode *Radopholus similis* in the Caribbean [13, 10].

Dry Matter (DM) Weights: The DM weights (g/m²) of each species in established banana orchards is shown in Table 3 and 4 where the species are ordered according to

Table 3: Population densities (plants/m²) of weeds in established orchards under each irrigation regime. Species are ordered according to their overall mean densities for irrigated and non-irrigated orchards. Last column gives the statistical significance of the difference (d) between the mean densities for irrigated and non-irrigated orchards. (T denotes >0 and <0.5 plants/m²)

Code and weed species	Irrigated field	Non-irrigated field	Overall mean	Signif. diff.
1 <i>Commelina diffusa</i>	65.0	121.0	93.0	p<0.01
6 <i>Drymaria cordata</i>	33.0	40.0	36.5	NS
5 <i>Laportea aestuans</i>	39.0	33.0	36.0	NS
3 <i>Mormordica charantia</i>	16.0	30.0	23.0	NS
2 <i>Peperomia pellucida</i>	12.0	28.0	20.0	NS
22 <i>Panicum trichoides</i>	0.0	35.0	17.5	p<0.01
18 <i>Hedyotis corymbosa</i>	31.0	4.0	17.5	p<0.01
16 <i>Amaranthus spinosus</i>	21.0	10.0	15.5	NS
10 <i>Portulaca oleracea</i>	22.0	9.0	15.5	p<0.05
35 <i>Phenax someratii</i>	1.0	30.0	15.5	p<0.05
15 <i>Setaria barbata</i>	8.0	20.0	14.0	p<0.05
12 <i>Croton lobatus</i>	23.0	4.0	13.5	p<0.05
47 <i>Rottboellia cochinchinensis</i>	1.0	25.0	13.0	p<0.05
31 <i>Chamaesyce hirta</i>	2.0	22.0	12.0	p<0.05
17 <i>Eleusine indica</i>	20.0	4.0	12.0	p<0.05
24 <i>Chamaesyce hyperifolia</i>	12.0	11.0	11.5	NS
4 <i>Ageratum conyzoides</i>	12.0	10.0	11.0	NS
21 <i>Boerhavia diffusa</i>	18.0	4.0	11.0	p<0.05
9 <i>Oxalis barrelieri</i>	6.0	15.0	10.5	p<0.05
14 <i>Cleome rutidosperma</i>	15.0	5.0	10.0	p<0.05
27 <i>Cyperus rotundus</i>	4.0	16.0	10.0	p<0.05
37 <i>Cyathula prostrata</i>	0.0	19.0	9.5	p<0.05
8 <i>Phyllanthus tenellus</i>	9.0	10.0	9.5	NS
7 <i>Spigelia anthelmia</i>	11.0	8.0	9.5	NS
40 <i>Euphorbia heterophylla</i>	1.0	17.0	9.0	p<0.05
23 <i>Synedrella nodiflora</i>	7.0	10.0	8.5	NS
20 <i>Emilia sonchifolia</i>	7.0	9.0	8.0	NS
39 <i>Eclipta prostrata</i>	3.0	12.0	7.5	p<0.05
13 <i>Mimosa pudica</i>	6.0	9.0	7.5	NS
11 <i>Cyperus luzulae</i>	8.0	6.0	7.0	NS
38 <i>Acalypha arvensis</i>	0.0	13.0	6.5	p<0.05
48 <i>Spermoce latifolia</i>	1.0	12.0	6.5	p<0.05
26 <i>Blechum pyramidatum</i>	1.0	11.0	6.0	p<0.05
28 <i>Ipomoea quamoclit</i>	9.0	3.0	6.0	NS
19 <i>Marsypicantes chamaedrys</i>	2.0	10.0	6.0	p<0.05
29 <i>Bidens pilosa</i>	6.0	5.0	5.5	NS
33 <i>Nautilocalyx melittifolius</i>	0.0	11.0	5.5	p<0.05
34 <i>Jacquemontia tamnifolia</i>	3.0	5.0	4.0	NS
42 <i>Pycnopus polystachys</i>	6.0	2.0	4.0	NS
30 <i>Lindernia diffusa</i>	5.0	3.0	4.0	NS
59 <i>Sida rhombifolia</i>	0.0	7.0	3.5	NS
25 <i>Microtea debilis</i>	4.0	3.0	3.5	NS
36 <i>Catharanthus roseus</i>	6.0	0.0	3.0	NS
32 <i>Centrosema pubescens</i>	2.0	4.0	3.0	NS
50 <i>Cenchrus echinatus</i>	5.0	1.0	3.0	NS
72 <i>Physalis angulata</i>	0.0	6.0	3.0	NS
44 <i>Alternanthera sessilis</i>	0.0	5.0	2.5	NS
45 <i>Heliotropium angiospermum</i>	0.0	5.0	2.5	NS
57 <i>Cyperus kylingia</i>	0.0	5.0	2.5	NS
43 <i>Tephrosia purpurea</i>	3.0	2.0	2.5	NS
61 <i>Dactyloctenium aegyptium</i>	0.0	5.0	2.5	NS
41 <i>Thelpteris dantata</i>	1.0	4.0	2.5	NS
64 <i>Mikania micrantha</i>	0.0	5.0	2.5	NS
55 <i>Trianthema portulacastrum</i>	0.0	4.0	2.0	NS
65 <i>Parthenium hysterophorus</i>	2.0	2.0	2.0	NS
46 <i>Ipomoea tiliacea</i>	1.0	3.0	2.0	NS
49 <i>Priva lappulaceae</i>	1.0	3.0	2.0	NS
52 <i>Eleutheranthera ruderalis</i>	1.0	2.0	1.5	NS
56 <i>Vernonia cinerea</i>	0.0	3.0	1.5	NS
67 <i>Merremia aegyptia</i>	0.0	3.0	1.5	NS
58 <i>Hyptis lanceolata</i>	0.0	3.0	1.5	NS
60 <i>Clidemia hirta</i>	0.0	3.0	1.5	NS
51 <i>Cynodon dactylon</i>	2.0	1.0	1.5	NS

Table 3: Continued

53	<i>Pityrogramma calomelanos</i>	1.0	2.0	1.5	NS
62	<i>Triumfetta semitriloba</i>	0.0	3.0	1.5	NS
54	<i>Lantana camara</i>	1.0	2.0	1.5	NS
63	<i>Stachytarpheta cayennensis</i>	0.0	3.0	1.5	NS
71	<i>Achyranthus aspera</i>	0.0	3.0	1.5	NS
76	<i>Wedelia trilobata</i>	0.0	2.0	1.0	NS
73	<i>Cyperus sphacelatus</i>	2.0	0.0	1.0	NS
66	<i>Desmodium incanum</i>	1.0	1.0	1.0	NS
68	<i>Piper dilatatum</i>	0.0	2.0	1.0	NS
80	<i>Paspalum conjugatum</i>	0.0	2.0	1.0	NS
69	<i>Diodia ocyimifolia</i>	0.0	2.0	1.0	NS
70	<i>Cissus verticillata</i>	0.0	2.0	1.0	NS
74	<i>Ruellia tuberosa</i>	0.0	1.0	T	NS
75	<i>Tridax procumbens</i>	0.0	1.0	T	NS
77	<i>Leonotis nepetifolia</i>	0.0	1.0	T	NS
78	<i>Ludwigia octovalvis</i>	0.0	1.0	T	NS
79	<i>Digitaria horizontalis</i>	0.0	1.0	T	NS
81	<i>Melochia nudiflora</i>	0.0	1.0	T	NS
82	<i>Clerodendron philippinum</i>	0.0	1.0	T	NS
83	<i>Centratherum punctatum</i>	0.0	1.0	T	NS
Total community density		414.0	641.0	527.5	p<0.05

Table 4: Dry matter weight (g/m²) of weeds in established orchards under each irrigation regime. Species are ordered according to their overall mean densities for irrigated and non-irrigated orchards. Last column gives the statistical significance of the difference (d) between the mean densities for irrigated and non-irrigated orchards. (T denotes >0 and <0.5 g/m²)

Code and weed species	Irrigated field	Non-irrigated field	Overall mean	Signif. diff.	
1	<i>Commelina diffusa</i>	140.2	262.8	201.5	NS
5	<i>Laportea aestuans</i>	47.4	21.5	34.5	NS
22	<i>Panicum trichoides</i>	0.0	43.4	21.7	p<0.01
37	<i>Cyathula prostrata</i>	0.0	30.7	15.4	p<0.01
35	<i>Phenax someratii</i>	1.1	16.9	9.0	p<0.01
10	<i>Portulaca oleraceae</i>	2.8	13.6	8.2	p<0.01
12	<i>Croton lobatus</i>	15.6	0.4	8.0	p<0.01
3	<i>Mormordica charantia</i>	4.4	10.4	7.4	p<0.05
11	<i>Cyperus luzulae</i>	8.8	4.9	6.9	NS
6	<i>Drymaria cordata</i>	1.1	10.6	5.8	p<0.01
16	<i>Amaranthus spinosus</i>	10.8	0.0	5.4	p<0.01
26	<i>Blechnum pyramidatum</i>	0.0	7.4	3.7	p<0.01
23	<i>Synedrella nodiflora</i>	6.3	0.7	3.5	p<0.05
28	<i>Ipomoea quamoclit</i>	6.2	0.0	3.1	p<0.05
14	<i>Cleome rutidosperma</i>	4.8	0.6	2.7	NS
33	<i>Nautilocalyx melittifolius</i>	0.0	5.3	2.7	NS
40	<i>Euphorbia heterophylla</i>	0.0	4.3	2.1	NS
9	<i>Oxalis barrelieri</i>	2.7	1.1	1.9	NS
59	<i>Sida rhombifolia</i>	0.0	3.8	1.9	NS
15	<i>Setaria barbata</i>	3.3	0.0	1.7	NS
25	<i>Microtea debilis</i>	3.2	0.0	1.6	NS
20	<i>Emilia sonchifolia</i>	2.8	0.0	1.4	NS
18	<i>Hedyotis corymbosa</i>	2.8	0.0	1.4	NS
51	<i>Cynodon dactylon</i>	2.5	0.0	1.3	NS
43	<i>Tephrosia purpurea</i>	1.4	1.1	1.2	NS
19	<i>Marsypicantes chamaedrys</i>	0.0	2.5	1.2	NS
4	<i>Ageratum conyzoides</i>	0.8	1.6	1.2	NS
8	<i>Phyllanthus tenellus</i>	1.5	0.7	1.1	NS
52	<i>Eleutheranthera ruderalis</i>	1.7	0.0	0.9	NS
30	<i>Lindernia diffusa</i>	1.2	0.5	0.8	NS
32	<i>Centrosema pubescens</i>	0.0	1.5	0.8	NS
13	<i>Mimosa pudica</i>	1.1	0.2	0.7	NS
18	<i>Eleusine indica</i>	1.3	0.0	0.7	NS
70	<i>Cissus verticillata</i>	0.0	1.1	0.6	NS
2	<i>Peperomia pellucida</i>	0.6	0.3	0.5	NS
61	<i>Dactyloctenium aegyptium</i>	0.9	0.0	0.5	NS
7	<i>Spigelia anthelmia</i>	0.5	0.2	0.4	NS
49	<i>Priva lappulaceae</i>	0.0	0.7	0.3	NS
21	<i>Boerhavia diffusa</i>	0.6	0.0	0.3	NS

Table 4: Continued

48	<i>Spermoce latifolia</i>	0.0	0.5	0.2	NS
34	<i>Jacquemontia tamnifolia</i>	0.0	0.4	0.2	NS
41	<i>Thelpteris dantata</i>	0.0	0.4	0.2	NS
31	<i>Chamaesyce hirta</i>	0.0	0.3	0.2	NS
50	<i>Cenchrus echinatus</i>	0.3	0.0	0.2	NS
27	<i>Cyperus rotundus</i>	0.0	0.3	0.1	NS
67	<i>Merremia aegyptia</i>	0.0	0.2	0.1	NS
36	<i>Catharanthus roseus</i>	0.2	0.0	0.1	NS
42	<i>Pycnus polystachys</i>	0.0	0.2	0.1	NS
64	<i>Mikania micrantha</i>	0.0	0.2	0.1	NS
66	<i>Desmodium incanum</i>	0.0	0.1	0.045	NS
Total dry matter (DM)		279.0	451.0	365.0	p<0.05

DM weight averaged over both irrigated and non-irrigated orchards. The species producing the most DM ($>10 \text{ g/m}^2$) were not necessarily the most frequent species: *Commelina diffusa* > *Laportea aestuans* > *Panicum trichoides* > *Cylathula prostrata* > *Phenax sonneratii* > *Portulaca oleraceae* > *Croton lobatus* > *Mormodica charantia* > *Cyperus luzulae* > *Drymaria cordata*. *Commelina diffusa* had the highest DM at both the irrigated (140.2 g/m^2) and non-irrigated (262.8 g/m^2) sites. Total weed DM was higher in non-irrigated than in irrigated banana orchards.

Species Diversity of Weed Communities: Based on the Shannon-Weiner diversity indices of the two communities, non-irrigated established banana orchards had more diverse communities (4.17) than irrigated orchards (3.61). It was determined that the diversity of the two types of orchards differ significantly in terms of the Shannon-Weiner diversity index at $p=0.05$; t_{obs} (6.14) is greater than t_{crit} (1.96). The difference although odd may be attributed to the different sampling areas. Irrigated areas were generally located in areas of dry sandy Soufriere cindery volcanic soils where water-holding capacity and organic carbon are low. Such soil types enable fewer weed species to grow hence the lowest species diversity index. In contrast, non-irrigated areas included moist clayey loam soils which are heavy textured and the water-holding capacity as well as the organic carbon contents were relatively high and sufficient to allow establishment of a more species rich weed community. Non-irrigated established orchards had a similar level of evenness ($E=0.95$) as irrigated orchards ($E=0.93$). The Steinhaus's similarity coefficient (S_s) was slightly higher (0.60) than the Jaccard similarity coefficient (S_j) which was 0.57. Values closer to 1 indicate complete similarity. Therefore the two weed communities had about 60% similarity. The Shannon-Weiner index was affected both by the number of species and their evenness i.e. high numbers and more even distribution both increase

diversity when determined by H. However, since E values were similar, it would seem that non-irrigated orchards had a greater richness than irrigated orchards.

Uses of Weeds Found in Banana Orchards in St. Vincent: Out of more than 93 weed species identified as weeds in banana orchards 50 weeds are recorded as having medicinal uses and more than 11 have other uses. Oudhia [14] clearly mentions that every plant on this earth is useful for human beings, animals and for other plants. Allelopathic, industrial and medicinal uses of many common problematic weeds have been reported in India [14]. However not many farmers indicate knowledge of the uses of these weeds in St. Vincent. Many farmers identified *Commelina diffusa* as a weed which is used for "cooling" or treatment of jaundice in babies.

The study indicated that there is scope of utilizing these useful weeds in banana orchards in order to provide additional income to Fairtrade farmers in the Windward Islands. The utilization of these unwanted plants cannot only make the field free from weeds but also help in generating employment opportunities for rural societies. Utilization of useful weeds after uprooting will check the heavy use of herbicides in banana orchards.

CONCLUSIONS

The weed flora of banana orchards in 2003-2004 in St. Vincent and the Grenadines consisted of more than 93 species representing more than 82 genera and 38 families. The most important families were Asteraceae and Poaceae. Annual life histories predominated over perennial life histories; although the most frequently occurring species was the perennial *Commelina diffusa*. Most species occurred quite infrequently however with variations between the irrigated and non-irrigated fields. In this regard the data indicated that fifteen weed species occurred in more than 50% of the non-irrigated banana orchards: *Commelina diffusa* > *Peperomia pellucida* >

Mormordica charantia > *Ageratum conyzoides* > *Laportea aestuans* > *Drymaria cordata* > *Spigella anthelmia* > *Phyllanthus tenellus* > *Oxalis barrelieri* > *Portulaca oleraceae* > *Cyperus luzulae* > *Croton lobatus* > *Mimosa pudica* > *Cleome rutidosperma* > *Setaria barbata*.

Commelina diffusa had the highest population density and *Cissus verticillata* being the lowest. The population densities with the five most frequent species occurring in irrigated banana fields include: *Commelina diffusa* > *Laportea aestuans* > *Drymaria cordata* > *Hedyotis corymbosa* > *Croton lobatus* and in non-irrigated banana fields: *Commelina* species > *Drymaria cordata* > *Panicum trichoides* > *Mormordica charantia* and *Phenax sonneratii*. Additionally weeds in non-irrigated banana fields outnumbered weeds found in irrigated banana fields probably reflecting differences in the varying soil types between locations rather than effects of irrigation. The species producing the most DM (>10 g/m²) were not necessarily the most frequent species: *Commelina diffusa* > *Laportea aestuans* > *Panicum trichoides* > *Cylathula prostrata* > *Phenax sonneratii* > *Portulaca oleraceae* > *Croton lobatus* > *Mormodica charantia* > *Cyperus luzulae* > *Drymaria cordata*. Weed biomass was generally higher in non-irrigated banana orchards than in irrigated orchards possibly also due to the differences in soil type.

The number of weed species per field varied from 5 to 15 and data revealed dominance of a single species, *Commelina diffusa*. The number of coexisting species in the weed communities of banana orchards and their relative densities are important considerations in weed management.

REFERENCES

- Hammerton, J.L., 1981. Weed Problems and Weed Control in the Commonwealth Caribbean. *Tropical Pest Management*, 27(3): 379-387.
- Froud-Williams, R.J., D.S.H. Drennen and R.J. Chancellor, 1983. Influence of cultivation regime on weed floras of arable cropping systems. *Journal of Applied Ecology*, 20: 187-197.
- Milberg, P., L. Anderson and K. Thompson, 2000. Large-seeded species are less dependent on light for germination than small seeded ones. *Seed Science Research*, 10: 99-104.
- Bourdôt, G.W., G.A. Hurrell and D.J. Saville, 1998. Weed flora of cereal crops in Canterbury, New Zealand. *New Zealand Journal of Crop and Horticultural Science*, 26: 233-247.
- Thomas, A.G., 1985. Weed survey system used in Saskatchewan for cereal and oilseed crops. *Weed Science*, 33: 34-43.
- Elliot, K.J., R.L.R. Boring and W.T. Swank. 1998. Changes in vegetation structure and diversity after grass to forest succession in a Southern Appalachian Watershed. *American Midland Naturalist*, 140(2): 219-232.
- Holm, L.G., J. Doll, E. Holm, J.V. Pancho and J.P. Herberger, 1997. *World Weeds, Natural Histories and Distribution*. New York, NY: JohnWiley and Sons.
- Holm, L.G., D.L. Pluknett, J.V. Pancho and J.P. Herberger, 1977. *The World's Worst Weeds: Distribution and Biology*. Honolulu, HI: The University Press.
- Simmonds, N.W., 1959. *Bananas*. London, U.K: Longmans.
- Terry, P.J., 1996. Weed Management in Bananas and Plantains. In *Weed Management for Developing Countries*, edited by R. Labrada, J.C. Caseley and C. Parker, FAO Plant Production and Protection Paper 120. pp: 311-315.
- Kasasian, L., 1971. *Weed Control in the Tropics*. London, U.K: Leonard Hill, pp: 307.
- Feakin, S.D., 1971. *Pest Control in Bananas*. PANS Manual No. 1. Centre for Overseas Pest Research. 2d ed. College House, UK: PANS.
- Queneherve, P., C. Chabrier, A. Auwerkerken, P. Topart, B. Martiny and S. Martie-Luce, 2006. Status of weeds as reservoirs of plant parasitic nematodes in banana fields in Martinique. *Crop Protection*, 25: 860-867.
- Oudhia, P., 1999. Medicinal weeds in rice fields of Chhattisgarh (India). *International Rice Research Notes*, 14(1): 40.