CARDI

# Review

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## FOREWORD

This is the first edition of CARDI Review which is intended to disseminate information on completed research conducted by the Caribbean Agricultural Research and Development Institute (CARDI).

CARDI Review will be published at least twice a year and will be posted on the CARDI Website (**http://www.cardi.org**). A limited number of hard printed copies of each edition will be made, but the major dissemination medium will be electronic.

Articles that are published would have been screened through a process of internal peer review. This ensures that the quality of research and published articles is of the same standard as recognised scientific journals.

At present, CARDI research programmes cover mostly non traditional crops and livestock. However, there are also projects in the traditional Caribbean export crops of coffee, sugar and bananas. Thematic areas of research are fairly wide ranging and include (not necessarily in order of importance) IPM, organic farming, production systems, plant genetic resources, feeding systems, environment, marketing, post-harvest and socio-economics.

CARDI Review sees research and development as a holistic activity encompassing all stages from pre planting to production, post-production, processing, and marketing. Each article in CARDI Review will be from researched areas in one or several parts of the commodity chain.

Therefore the articles published in CARDI Review will be varied, wide-ranging and, I hope, interesting and informative.

Bruce Lauckner
**Editor, CARDI Review**
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# Characterisation of feeding systems of goat farmers in the central region of Jamaica

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## Abstract

**Static diagnosis data for 165 goat farmers in three parishes (St Elizabeth, Manchester and Clarendon) in central Jamaica were analysed in order to characterise the feeding systems. Categorical data analysis was used to fit Y by X where Y (dependent variables) were main feed type, forage type, forage delivery method and supplement type, and X (independent variables) were parish, educational level, age, land for goat production and herd size. The Likelihood Ratio chi-square test was used to evaluate the Y by X relationships. Main feed types were significantly affected by parish (P=0.001), education (P=0.007), and marginally significantly affected by age (P=0.087) and herd size (P=0.104). About 36% of farmers in St Elizabeth did not supplement forages compared with 13% in Manchester and 5% in Clarendon. Thirty-one per cent of farmers with primary education depended only on forages whereas, on average, only 12% with post-primary education used forages alone. About 25% of farmers over 42 years did not use supplementation compared with 3% of those below 42 years of age. Some 25% of farmers with less than 32 head of goats used forages only while 93% of those with herd size more than 32 supplemented the forage. A higher proportion of farmers in Manchester (87%) and Clarendon (74%) than in St Elizabeth (56%) used improved forages. Forage delivery method was significantly (P=0.028) influenced by land size only. Over 90% of farmers with less than 1.9 ha of land used grazing and cut-and-carry system compared with about 65% of those with more than 1.9 ha of land. Corn/soy meal concentrate was the major supplement used by farmers but in Clarendon 68% used by-products. It was concluded that there are good prospects for developing feeding systems for sheep and goats using agro and industrial by-products and high-yielding fodder grasses and multipurpose trees that can fit into intensive production systems**

*Keywords*: Sheep and goats; feeding systems; forages; supplements; by-products

## Introduction

It is believed that the Spaniards introduced small ruminants, especially goats into the islands in the Caribbean Sea in the 15th and 16th centuries (Fielding and Reid 1994). In Jamaica sheep and goats remained a small-, low-resource farmer and hobbyist activity until between the 1950s and 1970s when focused research in breeding and management began. During the past 15 years programmes have been initiated to increase goat production and productivity with the view to promoting commercial production. Studies and consultations in the Caribbean have concluded that the development of feeding systems technologies based on indigenous feed resources will contribute immensely towards the development of economical production systems and facilitate the desired increased production and productivity for ruminant livestock in general (CARDI and SFC 1983; CTA 1990) and sheep and goats in particular (Martinez and Quijandra 1989; CARDI 1993). Several researchers in other regions of the world (Thompson and Cross 1978; Thomas et al. 1982; Hadjipanayiotou 1985; Chaudhry et al. 1996) have demonstrated both the biological and economic viability of indigenous feeds and feeding systems for small ruminant production. Similar observations have been made in the Caribbean for sheep production (Lallo et al. 1991a; Lallo et al. 1991b; Lallo and Garcia 1994; Thomas 1997) but these systems were more oriented towards production on research stations and institutional farms. Hence it will be necessary to develop systems with broader appeal for both institutions and farmers. But in order to develop successfully such feeding systems it will be useful to ascertain the existing feeding systems of farmers and identify opportunities for improving upon them or developing alternatives. Several studies have been undertaken to characterise small ruminant farming and production systems in the region (Osuji et al. 1988; Robertson 1991; Lutchman et al. 1993; McIntosh et al. 1993; CARDI 1994) however, none of the results made specific recommendations on feeding systems. Therefore this study was undertaken as a reference point for the development of feeding systems for sheep and goats farmers in the Caribbean by examining the characteristics and feeding systems of farmers in the central region of Jamaica. Jamaica has the largest population of goats in the English-speaking Caribbean (FAO 1997) and three of the 13 parishes (St Elizabeth, Manchester and Clarendon) located in the central part of the island account for about 40% of the national production (308,000 head, STATIN 1998). The characteristics and feeding systems of this sub-group should therefore approximate what obtains in the entire island.

## Materials and methods

A database of 220 goat farmers in the parishes of St Elizabeth, Manchester and Clarendon in the central region of Jamaica was used as the sampling frame. The database was constructed from *ex-ante* static diagnosis of farmers who participated in the CARDI/EDF Technology Transfer and Applied Research Project (TTARP) and the wider CARDI small ruminant programme between 1992 and 1997. The sample size was determined on the basis of numbers of breeding does. The range of breeding does in the sampling frame was summarised by descriptive statistics (mean, 21 (SEM, 2.3), median, 15 and mode, 9) and the mode was used as the cut off point for inclusion in the sample. In order words farmers who were deemed to have the potential for producing goats on a commercial basis were used for the study. This short list produced a sample size of 172 farmers. A random stratified (by parish) sample of 165 was then chosen for analysis.

The data sets compiled for the analysis included farmer age, educational background, land area used for goat production, total herd size, number of breeding does, area of improved pasture, main feed type, forage type, forage delivery method and supplement type and amount. The data were analysed using JMP® statistical discovery software (SAS 1997). The characteristics of the farmers in the three parishes for the continuous variables age, land area for goat production, area under improved pastures, total herd size, number of breeding does and supplement amount were first analysed. Then categorical analysing was performed by fitting Y by X according to the model when both variables have nominal values. Parish, educational level, age, land for goats and herd size were used as the independent (X) variables, while main feed type, forage type, forage delivery method and supplement type were the dependent (Y) variables. For the quantitative data: age, land for goats and herd size, the median (50%) values were first determined and the samples grouped into two (< and > 50%) before fitting Y by X. The Likelihood Ratio chi-square test was used to evaluate the Y by X relationships.

## Results

The basic characteristics of the farmers in the three parishes are shown in Table 1 and Figure 1. The average age of the sample goat farmers in the three parishes was 45 years. Each farmer, on average, had about 4 ha of land devoted to goat production of which 1.4 ha were under improved forages, although Manchester farmers had a significantly (P=0.015) larger area of improved forages than St Elizabeth and Clarendon farmers (Table 1). About 38% of St Elizabeth farmers had only primary education compared with 25% for Manchester and 19% for Clarendon (Figure 1). St Elizabeth farmers had significantly smaller herd sizes than those in Manchester and Clarendon (Table 1) but the differences were not significant (P=0.115, total herd and P=0.096, breeding does) as there was considerable farm to farm variation. The amount of concentrate supplement fed per doe per year was similar but the amount of by-products supplement used was highest in Clarendon followed by Manchester and then St Elizabeth.

Table 1 Comparison of the characteristics of goat farmers in the three parishes in the central region of Jamaica

| Parish | Age (yr) | Land for goats (ha) | Area of improved forage (ha) | Total herd (head) | Breeding does (head) | Conc per doe (kg/yr) | By-prod per doe (kg/yr) | Total supplement per doe (kg/yr) |
|---|---|---|---|---|---|---|---|---|
| St Elizabeth | 45.8 | 2.34 | 0.61 | 31.4 | 13.6 | 63.6 | 22.0 | 85.6 |
| Manchester | 48.1 | 5.77 | 2.51 | 45.3 | 24.6 | 56.2 | 102.4 | 158.6 |
| Clarendon | 41.7 | 3.51 | 1.12 | 54.2 | 23.7 | 89.9 | 203.1 | 292.9 |
| Mean | 45.2 | 3.87 | 1.41 | 43.6 | 20.7 | 71.6 | 103.2 | 193.5 |
| SEM | 1.79 | 0.829 | 0.285 | 4.54 | 2.31 | 14.07 | 29.62 | 30.50 |
| df | 162 | 162 | 162 | 162 | 162 | 135 | 135 | 135 |
| P | 0.347 | 0.233 | 0.015 | 0.115 | 0.096 | 0.218 | 0.043 | 0.015 |
| Median | 42.5 | 1.9 | 0.8 | 32 | 15 | 60.0 | 173.3 | 135.7 |

Tables 2 to 6 show the effects of parish, educational level, age, land for goat production and herd size on feeding systems of goat farmers in the central region of Jamaica. There were significant effects of parish on main feed (P=0.001), and supplement (P=0.035) types used by farmers (Table 2) but the effect of parish on forage type (P=0.092) was marginally significant. About 36% of farmers in St Elizabeth used only forages for goat production compared with 13% in Manchester and 5% in Clarendon. Conversely 95%, 87% and 64% of farmers in Clarendon, Manchester and St Elizabeth, respectively provided supplements for their animals. A higher proportion of farmers in Manchester (87%) and Clarendon (74%) than in St Elizabeth (56%) used improved forages which included African Star grass (*Cynodon nlemfuensis*), pangola (*Digitaria decumbens*), Guinea grass (*Panicum maximum*) and Napier/elephant grass (*Pennisetum purpureum*). Wild tamarind (indigenous leucaena) was also common. Corn/soy meal concentrate was the major supplement used by farmers, particularly in St Elizabeth and Manchester (Table 2).

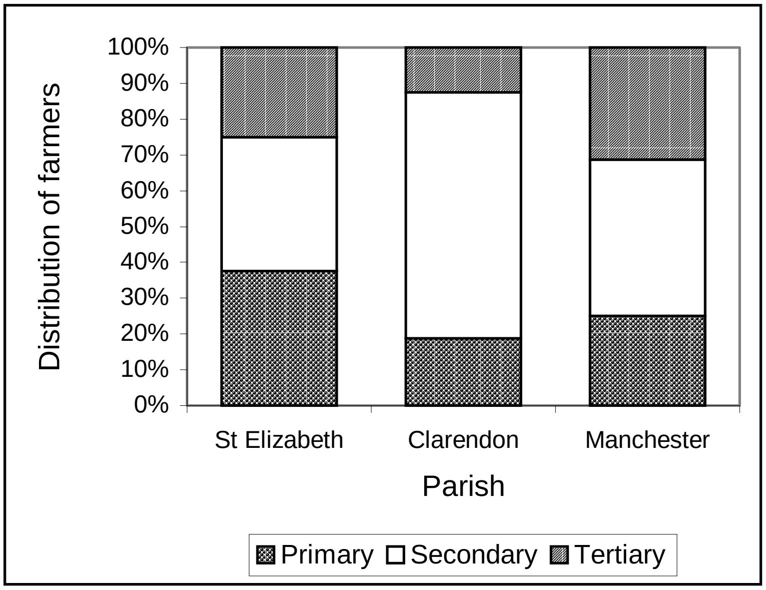


Figure 1 Level of education of goat farmers in the central parishes of Jamaica

The level of education also significantly influenced main feed (P=0.007), and forage (P=0.012) and supplement (P=0.077) types used by farmers (Table 3). The association between level of education and supplement was marginally significant (P=0.077). Thirty-one per cent of farmers with primary education depended only on forages whereas, on average, only 12% of those with secondary and tertiary education used forages alone. On average the use of improved forages was 20, 71 and 82% for farmers with primary, secondary and tertiary education respectively. Again proprietary concentrate was used most often, with the percentage of farmers ranging from 80 for primary level achievers to 25 for those with tertiary education.

Table 4 shows that age did not generally affect feeding systems with only a marginally significant effect (P=0.087) on main feed used. Twenty-four per cent of farmers over 42 years used forages only, compared with 3% of those below 42 years of age.

The size of land available for goat production had significant effect on forage delivery method only (P=0.028, Table5). Over 90% of farmers with less than 1.9 ha of land used grazing and cut-and-carry systems compared with about 65% of those with more than 1.9 ha of land.

Herd size had no significant effect on the feeding systems used by farmers (Table 6).

Table 2 Effect of parish on feeding systems of goat farmers in the central region of Jamaica

| | Main feed | | Forage type | | | Forage delivery system | | Supplement type | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | FO* | F+S | N | I | N & I | G | G & C | Conc | By-P | Conc & By-P |
| St. Elizabeth | 20 | 35 | 20 | 10 | 21 | 17 | 38 | 34 | 3 | 0 |
| Manchester | 7 | 48 | 7 | 10 | 38 | 10 | 45 | 24 | 3 | 17 |
| Clarendon | 3 | 52 | 14 | 17 | 24 | 7 | 48 | 18 | 4 | 35 |
| Likelihood Ratio | 9.02 | | 8.01 | | | 1.75 | | 12.89 | | |
| Prob.> ChiSq | 0.001 | | 0.092 | | | 0.416 | | 0.035 | | |

* FO, forage only; F+S, forage + supplement; N, native; I, improved; N & I, native and improved; G, grazing; G & C, grazing and cut fodder; Conc, corn/soy meal concentrate; By-P, by-products

Table 3 Effect of education on feeding systems of goat farmers in the central region of Jamaica

| | Main feed | | Forage type | | | Forage delivery system | | Supplement type | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | FO* | F+S | N | I | N & I | G | G & C | Conc | By-P | Conc & By-P |
| Primary | 14 | 31 | 24 | 0 | 6 | 15 | 31 | 24 | 3 | 3 |
| Secondary | 7 | 76 | 7 | 5 | 12 | 17 | 65 | 45 | 7 | 28 |
| Tertiary | 6 | 31 | 2 | 6 | 3 | 3 | 34 | 7 | 0 | 21 |
| Likelihood Ratio | 3.01 | | 12.88 | | | 1.81 | | 8.42 | | |
| Prob.> ChiSq | 0.007 | | 0.012 | | | 0.404 | | 0.077 | | |

* FO, forage only; F+S, forage + supplement; N, native; I, improved; N & I, native and improved; G, grazing; G & C, grazing and cut fodder; Conc, corn/soy meal concentrate; By-P, by-products

## Discussion

Surveys conducted in the Caribbean (for example Osuji et al. 1988; Lutchman et al. 1993) have shown that most sheep and goat farmers fell within the age group of 36-50 years. Lutchman et al. (1993) noted also that over 80% of the farmers in their sample (sample size 67) had at least primary education which augured well for easier extension work in terms of breaking barriers and extending adoptive technology. In the present study goat farmers in the parishes of St Elizabeth, Manchester and Clarendon in the central region of Jamaica who were deemed to have the potential for commercial production were mainly quadragenarians and had attained high levels of education, especially those in Manchester and Clarendon. Therefore they might be receptive to and, at least, assimilate ideas on new feeding systems technologies. The other observed characteristics of the farmers were that they owned herds that were twice the national average (20 head) for this category of farmers (Ministry of Agriculture, 1991). The ratio of breeding does to total herd (1:2) was also higher than the 1:3 ratio typical for goat herd composition in Jamaica. However, the unit land utilised for goat production was small, and of this, only about 36% had been developed as improved pastures (Table 1), suggesting that there could be an opportunity for the promotion of appropriate improved pastures.

Table 4 Effect of age on feeding systems of goat farmers in the central region of Jamaica

| | Main feed | | Forage type | | | Forage delivery system | | Supplement type | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | FO* | F+S | N | I | N & I | G | G & C | Conc | By-P | Conc & By-P |
| <42 yr | 2 | 58 | 7 | 24 | 31 | 6 | 55 | 38 | 3 | 24 |
| >42 yr | 25 | 80 | 31 | 31 | 41 | 28 | 76 | 38 | 7 | 28 |
| Likelihood Ratio | 2.93 | | 2.47 | | | 1.77 | | 0.19 | | |
| Prob.> ChiSq | 0.087 | | 0.291 | | | 0.183 | | 0.912 | | |

* FO, forage only; F+S, forage + supplement; N, native; I, improved; N & I, native and improved; G, grazing; G & C, grazing and cut fodder; Conc, corn/soy meal concentrate; By-P, by-products

The use of forages only or forages with supplementation differed among the parishes and was related to age and educational level. More St Elizabeth farmers than those in Manchester and Clarendon used forages only. Robertson (1991) made similar observations on St Elizabeth farmers. The provision of supplements is a regular husbandry practice in sheep and goat production in the Caribbean (McIntosh et al. 1993; Lutchman et al. 1993). In the current study 64%, 87% and 95% of farmers in St Elizabeth, Manchester and Clarendon respectively used supplements (Table 2) which is consistent with the regional pattern. More relatively young farmers used supplements too which indicates that they are aware of the benefits of supplementary feeding. The fact that St Elizabeth farmers were more inclined to use less supplementation might have been due to the small size of the herds. The tendency for goat farmers with small herds on small parcels of land to use only forages for production was also noted by Alexandre and Borel (1990).

Table 5 Effect of land size on feeding systems of goat farmers in the central region of Jamaica

| | Main feed | | Forage type | | | Forage delivery system | | Supplement type | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | FO* | F+S | N | I | N & I | G | G & C | Conc | By-P | Conc & By-P |
| <1.9 ha | 14 | 69 | 28 | 28 | 28 | 6 | 76 | 38 | 3 | 28 |
| >1.9 ha | 13 | 69 | 8 | 28 | 45 | 28 | 55 | 38 | 7 | 24 |
| Likelihood Ratio | 0.24 | | 3.56 | | | 4.81 | | 2.86 | | |
| Prob.> ChiSq | 0.876 | | 0.169 | | | 0.028 | | 0.381 | | |

* FO, forage only; F+S, forage + supplement; N, native; I, improved; N & I, native and improved; G, grazing; G & C, grazing and cut fodder; Conc, corn/soy meal concentrate; By-P, by-products

Table 6 Effect of herd size on feeding systems of goat farmers in the central region of Jamaica

| | Main feed | | Forage type | | | Forage delivery system | | Supplement type | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | FO* | F+S | N | I | N & I | G | G & C | Conc | By-P | Conc & By-P |
| <32 head | 21 | 62 | 17 | 24 | 41 | 13 | 69 | 35 | 3 | 18 |
| >32 head | 6 | 76 | 21 | 31 | 31 | 21 | 62 | 41 | 7 | 34 |
| Likelihood Ratio | 2.48 | | 0.77 | | | 0.51 | | 1.09 | | |
| Prob.> ChiSq | 0.104 | | 0.679 | | | 0.476 | | 0.581 | | |

* FO, forage only; F+S, forage + supplement; N, native; I, improved; N & I, native and improved; G, grazing; G & C, grazing and cut fodder; Conc, corn/soy meal concentrate; By-P, by-products

Jamaican farmers generally tend to depend upon native forages for goat production (Muschette et al. 1989) and this appears to be particularly true for those in St Elizabeth (Robertson 1991). The high usage of unimproved forages by St Elizabeth farmers compared to Manchester and Clarendon farmers could be related to the higher level of education, and hence greater exposure in the latter parishes than the former. Also it could be due partly to culture and the economic value placed on certain improved forages. Bauxite is mined in all three parishes. African Star grass is normally used to reclaim the mined-out lands some of which are then leased to farmers, including goat farmers. Therefore, the farmers were exposed to at least one improved grass species. But in south St Elizabeth where most of the goat rearing occurs, dry land farming for vegetable production is the principal activity. In this area Guinea grass is grown as cash crop and sold for mulching rather than as feed for livestock. The results of this study, nevertheless, have implications for all three parishes. Feeding systems research and development can build on the awareness and use of improved forages in Manchester and Clarendon by introducing tested new improved forages. For St Elizabeth the new improved forages might have to be introduced in parallel with training and education on the merits of such forage resources for goat production.

Method of forage usage was the least responsive dependent variable. On average 80% of farmers across parishes, age, level of education and herd sizes grazed and also cut forage for the goats. The practice of combining grazing with cut-and-carry is not surprising. Goats are normally penned/housed in the evenings because of fear of praedial larceny and dog predation and cut forage provides some of the feed needs until the following morning. The practice obtains in other parts of the Caribbean too (for example Lutchman et al. 1993). It is also understandable that farmers with small parcels of land would tend to supplement forage at the farmstead with cut forage from outside the farm (Table 5). These observations present opportunities for incorporating banks of high-yielding fodder grasses and multipurpose trees for cut-and-carry in the feeding systems of sheep and goat farmers.

Across parishes between 59% (alone) and 93% (with by-products feed) of the farmers used corn/soy meal concentrates for supplementation. The use of corn/soy meal concentrates was more pronounced in St Elizabeth while by-products were used more frequently and in greater amounts in Clarendon (Tables 1 and 2). Clarendon is located to the immediate west of the parish of St Catherine where there are citrus processing plants. This provides an opportunity for the utilisation of citrus pulp in by-product feeds, since it is readily available in this area. In addition there is a commercial by-products feed manufacturer in St Catherine. Clarendon is also a major broiler-producing parish and broiler litter is readily available. These reasons might have accounted for the high usage of by-products feed in Clarendon. On the other hand St Elizabeth is furthest removed from the centres of agro and industrial by-products and hence producers there might not have been aware of the potential of these by-products.

Land availability and herd size did not influence the use of supplements. The median values for land area and herd size (Table 1) indicated that at a stocking rate of 0.4 ha per Tropical Animal Unit (400 kg) and average mature body weight of 35 kg for the goats involved in the study there were adequate land and improved forage resources for the farmers sampled. These facts might suggest that forage insufficiency was not the motive for supplementation. Rather supplementation might have been prompted by a perceived inadequacy of nutrients from the forages. If that is true then feeding systems research and development strategies aimed at addressing the problem will have to include the accentuation of the positive practices currently existing while at the same time developing appropriate new technologies. The positive existing practices include the use of by-product feeds which are 30%-50% cheaper than comparable corn/soy meal concentrates. Therefore rations from readily available agro and industrial by-products will be formulated and tested on farms. For appropriate new technologies high-yielding forage crops with high nutrient contents, especially protein, will be evaluated for suitability as the basal feed.

## Conclusions

The study has highlighted positive existing feeding systems components including the awareness and use of improved forages in Manchester and Clarendon, entrenched system of cut-and-carry and the use of by-product feeds especially in Clarendon. The study also confirmed the observation that sheep and goats were reared on small parcels of land and that only about 36% of farmers' lands had been developed for cultivation of improved forages. Therefore, it is concluded that there are good prospects for developing feeding systems for sheep and goats using agro and industrial by-products and high-yielding fodder grasses and multipurpose trees that can fit into intensive production systems.

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# Management of Root Knot nematode (*Meloidogyne spp*) in tomato production

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## Abstract

**Root knot nematode (*Meloidogyne spp*) populations in soils must be reduced to allow profitable tomato production. Tomato varieties UWI(H), Capitan, Calypso and Heatwave were grown in soils amended with neem-seed meal (400 kg/ha), sheep pen manure (40,000 kg/ha), and Furadan (8 kg a.i./ha) to determine the effects in managing root knot and other nematode population densities associated with tomato (*Lycopersicon esculentum*). Results indicated that Furadan was superior to the other soil amendments. UWI(H) variety performed best. This variety demonstrated tolerance to *Meloidogyne spp*. The other varieties did not yield as much fruit and plant biomass as UWI(H) in the presence of bacterial wilt (Ralstonia solanacearum) and root knot infections.**

*Keywords:* Nematodes and neem; Penmanure and nematodes; Furadan; Soil amendments; Tomato varieties; Bacterial wilt resistance

## Introduction

The cause of potato yield reduction in Long Island, New York (Mai 1985), has been clarified and the yield reduction attributed to nematode build up in soils. However, farmers and agricultural technicians still overlook the importance of this group of plant pathogens. Like most pathogens nematodes are microscopic and cause a variety of symptoms to be manifested in plants, and the common idea that only ‘galls on roots’ are symptoms of nematode problems, must be dispelled. *Meloidogyne* is a gall-forming genus from among the diverse genera of nematodes. This genus is commonly known as root-knot nematode and is one of the most important genera of nematodes.

Globally, an annual crop loss of 10% from nematode infections is normal (cited in Sasser 1989). Effective nematode control is often achieved through the use of integrated management strategies involving nematicides, use of resistant varieties, crop rotation and other cultural practices (Sarah 2000, Stoner et al. 1986). In St Lucia nematicide imports peaked at 1.1 million kilograms between 1999 and 2000 (Pesticide Control Board, St Lucia, 2000) but the use of resistant varieties is also a widely accepted management strategy for nematode diseases. Resistant varieties employ mechanisms that prevent the nematodes from multiplying. The inoculum density is thereby reduced sufficiently to allow subsequent plantings of other more nematode susceptible crops.

In tomatoes, the well-known VFN variety label is testimony to the efforts that have been put into the development of varieties of tomatoes that are specifically resistant to root- knot nematode (*Meloidogyne sp*). Other strategies such as the use of soil amendments are constantly being evaluated.

The objective of this experiment was to determine the relative tolerance of four varieties of tomato (*Lycopersicon esculentum*) to root knot nematode infection, while comparing organic soil amendments with a chemical nematicide for their relative efficacy in reducing the population densities of root knot and other nematodes.

## Materials and methods

The field plot used in the experiment measured 31.1 m x 8.5 m and was previously planted with ochro, (*Hibiscus esculentum*) that was heavily infected with root knot nematode, (*Meloidogyne sp*). The plot was located on the CARDI Demonstration and Training Centre (CARDI-DTC) at La Ressource, Dennery, St Lucia. The selected area was divided into three blocks each measuring 10.3 m x 8.5 m. The experimental design was a split plot, with four soil amendments in the major plots and four tomato varieties in the minor plots.

The soil amendments used in the major plots were: neem-seed meal, organic matter (pen manure), and Furadan. There was an untreated control (Table 1). The amendments were incorporated in the soil four weeks prior to crop establishment. Each major plot measured 10.3 m x 2.1 m and was sub-divided into minor plots in which the tomato varieties were planted. The tomato varieties used were Heatwave, Calypso, Capitan and UWI(H). The UWI (H) variety was obtained from L. O'Garro of the University of the West Indies, Cave Hill, Barbados. The other varieties were obtained from commercial sources in St Lucia. All varieties are known to have the same maturity time. The UWI(H) variety was previously reported as having high tolerance to bacterial spot (*Xanthomonas campestris lycopersici*). (CARDI 2000)

Nine seedlings of each variety comprised a treatment. Variety UWI(H) was planted twice in each major plot. Seedlings were spaced 0.76 m x 0.76 m. The experiment was established on 6 April 2000 and was supplied on 18 April 2000. The plants were individually staked 30 days after planting (DAP). Fifty grams of fertilizer (NPK) were applied to each plant 14 DAP. A further 70 g were applied per plant at 42 DAP. Weed management was conducted manually and the entire experiment was sprayed with insecticide (Diazinon 3.5 ml/L) to control insects.

Data were collected on transplant mortality, disease incidence, yield, root biomass, plant height and biomass, nematode population densities from root and soil extractions and root-gall index. Root-gall index progressively rated the level of root infection by root-knot nematodes on a scale from zero to ten**.** Nematodes were extracted 86 days after planting, from 100 $cm^3$ soil and 25 g of roots by the Baermann Pan technique (Barker 1985). Data were statistically analysed for significant differences among the treatments.

Table 1 Main plot treatments used in management of root-knot nematodes in tomato production at CARDI, St Lucia

| Main plot treatments | Rates | Amount used /plot |
|---|---|---|
| Control | 0 | 0 |
| Neem-seed meal | 400 kg/ha | 1,025 g |
| Organic matter* | 40,000 kg/ha | 102 kg |
| Furadan | 8 kg a.i./ha | 205 g (10G) |

***** Organic matter consisted of manure from sheep pens.

## Results and discussion

### Transplant mortality

The major cause of transplant mortality was cutworm damage, which differed across the soil amendment treatments. The lowest incidence of transplant mortality occurred in Furadan amended plots, while pen manure and neem amended plots had the highest incidences (Table 2). The nematicide/insecticide, Furadan, repelled activity of this insect. The plots amended with organic matter tended to favour infestation. Contrary to what was anticipated, neem seed meal at the rates used did not seem to have any repelling effect on cutworm activity.

Table 2 The incidence of cutworm damage in tomato, 6 days after being planted in amended and un-amended soils at CARDI, St Lucia

| Soil amendment treatments | Damage (%) |
|---|---|
| Control | 19 |
| Neem-seed meal | 28 |
| Organic matter(pen manure) | 27 |
| Furadan | 6 |

### Disease incidence

The dominant disease was bacterial wilt (*Ralstonia solanacearum*). This disease was first observed 30 DAP and increased in incidence as the crop progressed (Figure 1). Bacterial wilt incidence was lowest in variety UWI(H) throughout the experiment and the performance was significantly different ($P<0.001$) from the other varieties. These data tend to show the superior tolerance of variety UWI(H) to bacterial wilt (Table 3). It is also amply demonstrated that under appropriate conditions a susceptible crop can be rapidly destroyed as a result of infection by this disease. There was no significant ($P>0.05$) effect of the soil amendment treatments on the incidence of the disease, nor were any significant ($P>0.05$) interaction effects detected.

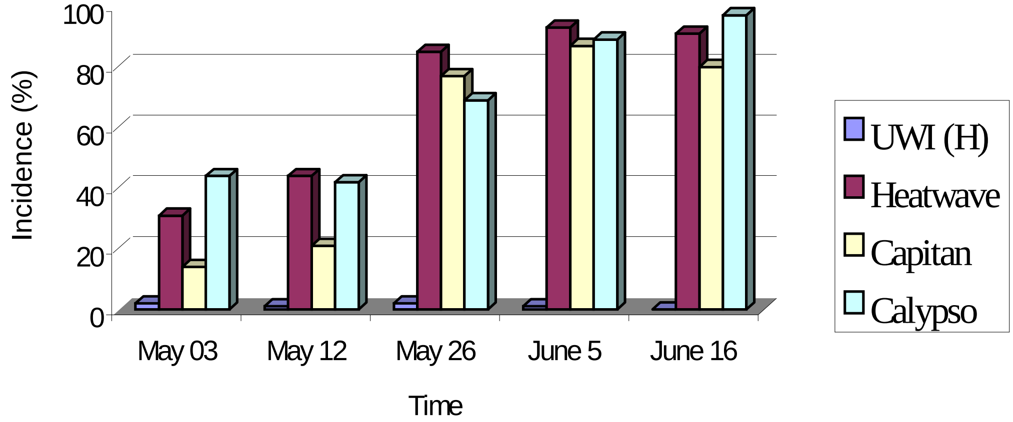


Figure 1. Incidence over time (May/June 2000) of bacterial wilt *(Ralstona solanacearum)* in four tomato varieties grown in amended and un-amended soils at CARDI, DTC, St Lucia

## Yields

The yield figures represent a single harvest that was done 86 days after planting. There were significant differences ($P<0.001$) in the yield of the varieties and these differences were not affected by soil amendments. The variety UWI(H) produced the highest yields compared to the others, Calypso, Capitan and Heatwave (Table 4). This superior performance of the UWI(H) variety is as a result of the adaptability shown by the variety to growth conditions, especially its high tolerance to the bacterial wilt pathogen.

## Plant growth parameters

Plant height, plant biomass and root weight analyses are used to demonstrate how well the varieties utilized existing conditions for vegetative growth. In all three of these parameters there were significant difference ($P<0.001$) among the varieties. Plant biomass figures are quoted in Table 5 to represent these parameters. Again the variety UWI(H) was far superior to the other varieties, and the performance was consistent across all the major treatments (Soil amendments). This performance is significant in light of the high incidence of bacterial wilt shown in the other varieties (Table 3).

Table 3. Overall mean incidences of bacterial wilt disease observed in four tomato varieties after 30 days growth in amended and un-amended soils at CARDI-DTC, St Lucia. The data was transformed from percentages to angles- (Y = ARCSIN(SQRT(X/100)). Back-transformed means (%) are in parentheses

| | Calypso | Capitan | Heatwave | UWI(H) | Means |
|---|---|---|---|---|---|
| Control | 20.7 (13) | 19.7 (11) | 29.1 (24) | 3.7 (0.4) | 15.4 (7) |
| Furadan | 59.7 (75) | 19.7 (11) | 43.7 (47) | 3.2 (0.3) | 25.9 (19) |
| Pen manure | 24.4 (17) | 21.2 (13) | 30.1 (25) | 3.2 (0.3) | 16.4 (8) |
| Neem meal | 58.1 (72) | 10.0 (3) | 30.9 (26) | 0.0 (0.0) | 19.8 (12) |
| Means | 40.7 (43) | 17.7 (9) | 33.4 (30) | 2.5 (0.2) | |

| | | |
|---|---|---|
| SEM (24 df) | UWI(H) variety | = 3.7 |
| SEM (24 df) | Other varieties | = 5.2 |
| SEM (6 df) | Soil amendments | = 4.5 |
| SEM (24 df) | UWI(H) x soil amendments | = 7.4 |
| SEM (24 df) | Other varieties x soil amendments | =10.5 |

The mean plant biomass of variety UWI(H) was at least three times that of Capitan, the nearest competing variety. The tolerance of the UWI(H) variety to bacterial wilt is also indicated by its superior performance across the soil amendment treatments (Table 5).

The genera of plant parasitic nematodes recovered from extractions were: *Meloidogyne*, *Helicotylenchus* and *Rotylenchulus*. The highest population densities were associated with Capitan with significant differences (P=0.018) among the varieties (Table 6). If the plant biomass analysis and the yield analysis are considered in conjunction with the analysis of nematode population densities, the correlation allows the conclusion that the variety UWI(H) can tolerate a high population density of parasitic nematodes. In addition the variety grows luxuriantly and out yields the other varieties.

Table 4. Mean yields of tomato varieties after 86 days growth in amended and un-amended soils, at CARDI - St Lucia. Data were square root transformed (Y=SQRT(X+1)). Back transformed means (kg) are in parentheses

| | Calypso | Capitan | Heatwave | UWI(H) | Mean yield (kg) |
|---|---|---|---|---|---|
| Control | 1.09 (0.18) | 1.44 (1.07) | 1.22 (0.49) | 1.84 (2.38) | 1.49 (1.21) |
| Furadan | 1.00 (0.00) | 1.24 (0.55) | 1.03 (0.07) | 1.65 (1.62) | 1.30 (0.33) |
| Pen manure | 1.00 (0.00) | 1.22 (0.48) | 1.05 (0.09) | 1.83 (2.33) | 1.38 (0.91) |
| Neem meal | 1.03 (0.07) | 1.26 (0.59) | 1.06 (0.13) | 1.67 (1.78) | 1.34 (0.79) |
| Means | 1.03 (0.07) | 1.29 (0.66) | 1.09 (0.19) | 1.74 (2.02) | |

SEM (24 df) UWI(H) variety = 0.038
SEM (24 df) Other varieties = 0.054
SEM (6 df) Soil amendments = 0.041
SEM (24 df) UWI(H) x soil amendments = 0.076
SEM (24 df) Other varieties x soil amendments = 0.108

Table 5. Mean plant biomass (plant weight) of tomato varieties grown in amended and un-amended soils at CARDI , St. Lucia. Data were square root transformed (Y = SQRT(X)). Back transformed means (g) are in parentheses

| | Calypso | Capitan | Heatwave | UWI(H) | Mean biomass |
|---|---|---|---|---|---|
| Control | 16.1 (259) | 21.8 (475) | 21.6 (467) | 29.6 (876) | 23.7 (562) |
| Furadan | 0.0 (0.0) | 15.6 (243) | 8.4 (71) | 29.6 (876) | 16.6 (276) |
| Pen manure | 10.8 (117) | 20.8 (433) | 14.1 (199) | 35.2 (1239) | 23.2 (538) |
| Neem meal | 7.5 (56) | 17.4 (303) | 9.8 (96) | 49.8 (2480) | 26.9 (724) |
| Means | 8.6 (74) | 18.9 (357) | 13.5 (182) | 36.0 (1296) | |

SEM (24 df) UWI(H) variety = 2.79
SEM (24 df) Other varieties = 3.95
SEM (6 df) Soil amendments = 3.84
SEM (24 df) UWI(H) x soil amendments = 5.59
SEM (24 df) Other varieties x soil amendments = 7.90

## Nematode population densities from soil extractions.

Low nematode population densities were associated with Calypso. This variety is susceptible to *Meloidogyne spp* and does not allow development of high root biomass to support high nematode populations. The biomass analysis previously discussed, supports this finding. Heatwave variety had a low plant biomass. The high bacterial wilt incidence in this variety would have contributed to the unthrifty condition of the plants and the low nematode population density.

Table 6. Overall mean population densities of plant parasitic nematodes extracted from 100 $cm^3$ of soil in which four tomato varieties were grown at CARDI - St Lucia

| Varieties | Population densities (Transformed Y=LN(X+1)) | Back transformed means |
|---|---|---|
| Calypso | 5.05 | 155 |
| Capitan | 7.32 | 1509 |
| Heatwave | 5.00 | 147 |
| UWI(H) | 6.71 | 819 |
| SEM (24 df) | UWI(H) 0.432 | |
| SEM (24 df) | Other varieties 0.611 | |

There was a less significant (P=0.084) variation in plant parasitic nematode population densities among the soil amendments. The lowest nematode population densities were detected in plots treated with Furadan while the highest population densities were present in the control plots (Table 7). Pen manure treatment provided some measure of control and warrants further investigation, particularly as it relates to the new trend of organic banana farming. Furadan was far superior to the other treatments. The mean nematode population density in Furadan treated plots was 65% lower than population densities in the control plots.

## Nematode population densities from root extractions

Data on nematode population densities associated with extractions from roots of tomato plants indicate a similar variation as for soil extractions. There was no significant (P>0.05) difference among the population densities associated with the soil amendments, though Furadan and Neem treatments had the lowest mean population densities of 35.9 and 35.2 nematodes respectively, from 25 g of roots. Pen manure treatments yielded a mean population density of 67.7 and the control 145.9 (Table 8). The data on the nematode population densities associated with the roots of the varieties (Table 9) indicate similar results as from soil extractions (Table 6).

Table 7. Overall mean population densities of plant parasitic nematodes extracted from 100 $cm^3$ aliquots of treated and un-treated soil in which tomato varieties were grown at CARDI - St Lucia

| Soil amendments | Population densities (Transformed Y=LN(X+1)) | Back transformed means |
|---|---|---|
| Control | 6.57 | 712 |
| Furadan | 5.56 | 252 |
| Pen manure | 6.14 | 463 |
| Neem meal | 6.37 | 583 |
| SEM (6 df) | 0.228 | |

Table 8. Overall mean population densities of plant parasitic nematodes extracted from 25 g of root tissue taken from tomato varieties grown in treated and un-treated soils at CARDI - St Lucia

| Soil amendments | Population densities (Transformed Y=LN(X+1)) | Back transformed means |
|---|---|---|
| Control | 4.99 | 146 |
| Furadan | 3.61 | 36 |
| Pen manure | 4.23 | 68 |
| Neem meal | 3.59 | 35 |
| SEM (6 df) | 0.789 | |

## Root gall index

Gall index figures (0 – 10) reflect the level of infestation of plant roots by root knot nematodes as depicted by number and size of galls on roots. Zero reflects no visible galls on roots while 10 depicts roots that are heavily infested with galls.

There were no significant effects ($P>0.05$) of soil treatments on the root gall index, however the varieties again showed very significant differences ($P=0.018$) in their responses. (Table 10)

Table 9**.** Overall mean population densities of plant parasitic nematodes extracted from 25 g of root tissue taken from four tomato varieties grown at CARDI - St Lucia

| Varieties | Population densities (Transformed Y=LN(X+1)) | Back transformed means |
|---|---|---|
| Calypso | 2.83 | 16 |
| Capitan | 5.78 | 323 |
| Heatwave | 2.74 | 15 |
| UWI(H) | 4.59 | 98 |
| SEM (24 df) UWI(H) | 0.469 | |
| SEM (24 df) Other varieties | 0.664 | |

Table 10**.** Mean root gall index for four tomato varieties grown on treated and un-treated soils at CARDI - St Lucia

| | **Calypso** | **Capitan** | **Heatwave** | **UWI(H)** | Mean gall index |
|---|---|---|---|---|---|
| Control | 1.00 | 2.00 | 1.79 | 2.83 | 2.09 |
| Furadan | 2.53 | 3.33 | 1.61 | 3.50 | 2.90 |
| Pen manure | 2.28 | 2.33 | 1.78 | 4.50 | 3.08 |
| Neem meal | 4.23 | 3.67 | 2.23 | 3.50 | 3.42 |
| Means | 2.51 | 2.83 | 1.85 | 3.58 | |

SEM (14 df) UWI(H) variety = 0.279
SEM (14 df) Other varieties = 0.395
SEM (6 df) Soil amendments = 0.374
SEM (14 df) UWI(H) x soil amendments = 0.558
SEM (14 df) Other varieties x soil amendments = 0.789

Variety UWI(H) displayed the highest mean root gall index (3.58), yet this variety was the best performer in all areas of assessment. The low root gall index in Heatwave must be assessed with the high level of bacterial wilt, which would have contributed to rotting and low root knot nematode activity.

## Conclusions

Variety UWI(H) has shown a high level of tolerance to bacterial wilt (*Ralstonia solanacearum)* and root knot nematode *(Meloidogyne spp)* infections.

In soils infected with the bacterial wilt and root knot pathogens, variety UWI(H) is likely to perform better than the varieties Calypso, Capitan, or Heatwave, hence giving greater financial rewards to farmers.

## Recommendations

The performance of variety UWI(H), a small-fruited “cherry” tomato should be validated by tomato farmers who have a history of bacterial wilt, root knot or bacterial spot problems.

The marketing unit of the Ministry of Agriculture St. Lucia should initiate a marketing programme for this small-fruited “cherry” tomato.

Niche markets for UWI(H) should be identified and information passed on to farmers.

The agronomy department of the Ministry of Agriculture or CARDI should develop a production system for UWI(H). The system in use in Barbados can be instructive.

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