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EFFECT OF TWO SELECTED INTERCROPPING SYSTEMS ON THE YIELDS OF CARROTS IN ST. VINCENT

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ABSTRACT

A study was conducted, on five farms under carrots for the past five years, to test the effect of two selected intercropping systems on carrot yield. Root-knot nematode (**Meloidogyne incognita**) damage on carrots was compared with that on carrots grown in monoculture. Damage was estimated on a root gall index based on the number of galls and malformation of carrot roots which account for unmarketable yield. The chives-carrots and cabbage-carrots systems gave significantly lower unmarketable yield of carrot. The carrot monoculture gave the highest unmarketable yield. Total and marketable yields were not significant in the two intercropping systems as compared to carrot monoculture. When yields of carrot were adjusted for root gall index using covariance analysis it was found that the carrot monoculture had the highest unmarketable yield and root gall index (2.8).

INTRODUCTION

For many years, crop rotation has been demonstrated as an efficient means of controlling several important nematode pests (Hutton et al., 1982); Netscher, 1985). Intercropping or multiple cropping, as a menas of managing nematode pests, has attracted the attention of many researchers worldwide. In recent times, scientists have begun to investigate multiple cropping systems with the belief that these systems possess pest management properties (Adams et al., 1971). Trembath (1976) from Australia, produced the first evidence that nematodes and diseases may be impeded when both hosts and non-hosts are grown in mixtures. Several other workers (Brodie & Murphy, 1975; Mc Donald, 1985b) have shown that mixed cropping harboured significantly fewer nematodes than monoculture.

During 1976-1978, the decline in carrot production in St. Vincent was estimated to be between 55 and 60 per cent (Barker & Henderson, 1985). At the national level, this decline resulted in a reduction in foreign exchange earnings, and at the regional level, disrupted the production of a major producer. The fall in production consequently led to increased importation of carrots from sources outside the CARICOM area. Singh (1979) estimated the annual loss in St. Vincent to be over EC$500,000 during the period referred to by Barker & Henderson (1985). This loss was attributed to the root-knot nematode, **Meloidogyne incognita** (Kofoid and White) Chitwood, and to the fungal pathogen **Sclerotium rolfsii**. Singh (1982) further confirmed **M. incognita** as the major contributor to the decline in carrot yield in St. Vincent.

It is with this background that research began two years ago to identify intercropping systems with potential to manage root-knot nematode on carrot (**Daucus carota** L.). Reduction in damage to carrots, and the re-establishment of an important carrot production base in St. Vincent, could create an impact by reducing the import food bill in the CARICOM region. Generally, root-knot nematode damage on carrot is manifested in galling of the main and secondary roots, tap-root malformation and proliferation, poor yields and poor quality, resulting in a reduction in marketable yield and in a high proportion of unmarketable produce.

MATERIALS AND METHODS

The experiment was done on five farms, four of which were located in the Rosehall area (Bason and Schwartz) on the Leeward side of the island, while the other was in the Biabou district on the Windward side. The soil in the Rosehall area is classified as Belmont gravelly sand loam (Typic Hapludolls, loamy-skeletal mixed). The soil of Biabou is classified as Greggs loam and clay loam (Typic Dystrandepts - medial) (Ahmad, 1981). All five farms had been plagued with root-knot damage on carrots over the past five years.

The three cropping systems tested included carrot monoculture, and cabbage-carrots and chives-carrots intercropping. Plot size was 6.1 x 5.1 m with 60 cm separating each plot. There were five ridges per plot.

In the intercropping plots, each ridge was planted with two rows of carrots and one row of intercrop. The cabbage seedlings and chive setts were planted in single rows on the crown of the ridge two weeks prior to seeding the carrots. The carrot seeds were sown in rows along both sides of the intercrop with an inter-row spacing of 30 cm. After thinning, the intra-row spacing of carrots in all three cropping systems, including the monoculture, was 10 cm. Seeding of the carrots in both the monoculture and the intercropping systems at any one experimental site was done at the same time. In the monoculture, carrot was seeded in three rows per ridge. The cabbage seedlings were transplanted 45 cm apart while the chive setts had an intrarow spacing of 15 cm. Planting on the five farms was completed between late-November 1985 and mid-January 1986.

The treatments were arranged in a randomized complete block design replicated four times per farm. The crop management on all five farms was the same. Mixed fertilizer (NPK + Mg) of 15-7-21+2 was applied at the rate of 800 kg ha^{-1} in two splits. Hand-weeding was done thrice, and four fortnightly applications of Permethrin (at 0.003% a.i.) were made to control **Plutella xylostella** on cabbage. On two farms, it was necessary to apply tow weekly sprays of Trimiltox Forte at 0.31% a.i. to control Early Blight disease **(Alternaria dauci)** on carrots.

Data on total, marketable yield, unmarketable yield and root gall index were statistically analyzed (variance) and root gall index. Covariance analysis was used to adjust yields for root gall index. Correlation coefficients between marketable and unmarketable yields, marketable and total yields and between unmarketable and total yield were calculated. Correlations were also calculated between root gall index and marketable, unmarketable, and total yields.

RESULTS

There were highly significant differences (P = 0.05) among farms in marketable and unmarketable yields, both before and after covariance analysis to adjust for root gall index (Tables 1 and 2). Data on total yields are summarized in the following tabulation:

Farm	Tons/ha
1	11.19
2	17.36
3	15.30
4	14.11
5	8.89

The farm x treatment interactions were not significant, either for marketable or unmarketable yields or for total yields of carrot.

Treatment means were highly significant for unmarketable yield (Table 2). There were no significant differences between treatments in marketable yield (Table 1). The chives-carrots and cabbage-carrots intercropping systems gave 19.2 and 21.8 per cent unmarketable yields while the carrot monoculture produced 22.4 per cent (Table 3).

Mean root gall index (RGI) differed among the five farms (Table 4). Significant correlations were observed between RGI and unmarketable yield (r = + 0.47*). Root gall index was negatively correlated with marketable yield and with total yield, but the coefficients were not significant.

Marketable yield was negatively correlated with unmarketable yield (r = -0.57*), but positively correlated with total yield (r = 0.96**). Unmarketable yield and total yield were negatively correlated but the coefficient was not significant.

DISCUSSION

Highly significant differences among the five farms in marketable, unmarketable and total yield can be attributahle to soil types, soil moisture conditions, varying population densities of the root-knot nematode and to the different times of planting.

The non-significance of the farm x treatment interactions for marketable, unmarketable and total yield indicates that the treatments are apparently effective at different levels of yields. The varying levels of yields are in turn directly related, among other factors, to nematode populations.

The differences found in mean root gall index in the farms strongly suggest that the pre-plant population densities of the root-knot nematode varied in the five farms. Seinhorst (1965) first found that crop damage and yield losses are directly related to pre-plant nematode population densities. A high root gall index resulted in a high unmarketable yield.

Table 1. Effect of cropping systems on marketable carrot yield (t/ha) on five farms

Farm	Cropping System			Farm means1/
	Cabbage-carrots	Chives-carrots	Carrots alone	
1	7.00	7.67	10.33	8.33
2	14.33	16.00	17.67	15.63
3	12.67	13.33	13.67	13.22
4	11.00	11.00	13.33	11.78
5	4.00	3.00	4.67	3.89
Means2/	9.80	10.20	11.73	

1/ Farm means not significantly different.

2/ Treatment means not significantly different.
CV = 25.4%

Table 2. Effect of cropping systems on unmarketable carrot yield (t/ha) on five farms

Farm	Cropping System			Farm means1/
	Cabbage-carrots	Chives-carrots	Carrots alone	
1	12.00	8.67	13.33	11.33
2	6.67	6.00	8.33	7.00
3	7.67	8.00	9.67	8.44
4	9.00	8.33	12.00	9.78
5	19.00	17.33	24.66	20.33
Means2/	10.87	9.67	13.60	

1/ Farm means highly significantly different.

2/ Treatment means highly significantly different
CV = 26.1%

Table 3. Effect of cropping systems on yields and root galling of carrots

Cropping system	Yield of Carrots (t/ha)			Root galling index1/
	Total	Marketable	Unmarketable	
Cabbage-carrots	12.50	9.77	2.73 (21.8%)	2.1
Chives-carrots	12.53	10.12	2.41 (19.2%)	1.8
Carrots alone	15.17	11.77	2.29 (22.4%)	2.8
C.V. (%)	21.1	25.4	26.1	

1/ Mean root gall index based on: 0- no root infected; 1- hairy root with a few small galls; 2- root with many small galls; 3- root with a few large galls; 4- root with many large galls; 5- malformation, splitting and heavy galling of tap roots.

Table 4. Effect of cropping systems on mean root gall index of carrots on five farms

Farm	Cropping systems			Farm means
	Cabbage carrots	Chives-carrots	Carrot alone	
1	2.25	1.50	2.20	2.1
2	1.50	1.25	2.25	1.7
3	1.75	1.00	3.00	1.9
4	2.00	3.00	3.50	2.8
5	2.75	2.25	2.75	2.6
Means	2.1	1.8	2.8	

1/ Mean root gall index based on: 0 = no root damage;
1 = hairy root with a few small galls;
3 = root with a few large galls;
4 = Root with many large galls;
5 = malformation; splitting and heavy galling of tap roots.

The chives-carrots and cabbage-carrots systems significantly reduced the root-knot damage on carrots. The chives-carrots system had the lowest unmarketable yield with, correspondingly the lowest root gall index. Similar results were obtained by Mc Donald (1985b) wherein chives-carrots and cabbage-carrots reduced root-knot damage and increased marketable yield. He also showed that the two intercropping systems favoured the reduction in population densities of **M. incognita.**

In Nigeria, Egunjobi (1985) showed, in her multiple cropping studies, that **Meloidogyne javanica** populations in the soil and roots of cowpea were significantly reduced under cowpea and maize intercropping in comparison with monoculture cowpea. Several reports (Nusbaum and Ferris, 1973; Trembath, 1976) substantiate the significance of cropping systems in the management of nematode pests of crops.

The investigation herein reported is one of several recent studies world-wide researching multiple cropping, intercropping or mixed cropping as a means of exploiting the innate mechanisms of these less disturbed ecosystems to manage pests, including plant parasitic nematodes (Adams et al., 1971; Perrin, 1977). The cropping systems approach to the management of nematode pests of crops has been intensified even more recently. It has been realized that this alternative management strategy has great advantages over chemical control and even over the breeding of varieties for resistance to specific nematode pests (Sasser, 1985). Moe (1985) has begun to further develop the research methodology for analytic optimization of cropping systems designed to minimize losses due to plant parasitic nematodes.

The economic advantages of multi-cropping have been adequately extolled by Egunjobi (1985). These include the value of mixed cropping as an insurance against total crop loss in times of pest epidemics selective for crop species, or drastic declines in the prices of particular crops. Also the maximization of returns in the peasant farmer's small and usually unmechanized holdings as well as harvesting at different times ensures the survival of the farm family especially where transportation and storage facilities are inadequate.

The next logical step in the present research is to demonstrate the economic viability of the chives-carrots and cabbage-carrots intercropping systems vis-a-vis the carrot monoculture by applying Land Equivalent Ratio (LER) and Income Equivalent Ratio (IER). The technology also needs to be transferred to the carrot farmers of the Eastern Caribbean, the majority of whom are small farmers who can benefit the most.

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