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STUDIES TO IMPROVE GINGER (*ZINGIBER OFFICINALE* ROSCOE) PRODUCTIVITY AND QUALITY

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ABSTRACT

Poor quality and low productivity of ginger rhizomes made the product uncompetitive on the extra-regional market. This study tested the components that could produce rhizomes of similar quality to the Hawaiian grade. Three field experiments were carried out to evaluate fertilizer formulations, fertilizer rates with organic manures and system of cultivation, and system of cultivation and plant density. Organic manure increased overall yield by 25% and exportable grade ginger by 500%. Closer intra-row spacing produced higher yields in both systems of cultivation. Furrow cultivation maximized total rhizome yield and exportable grade ginger with a 50% reduction in fertilizer requirement of 500 kg. ha^{-1}). Furrow cultivation improved the exportable grade yield of ginger but not overall yield. The addition of phosphate to the 15-08-24 NPK did not improve yields. A combined technology of 25 cm intra row spacing, organic manure, furrow cultivation and NPK fertilizer (15-08-24) at 500 kg. ha^{-1} was compared to the existing technology on 2000 m^2 plots. Exportable grade ginger increased by 300%, and cost of production fell from EC $1.31 kg to EC $0.57kg^{-1} (US $1.00 = EC $2.70).

INTRODUCTION

Ginger was identified in 1991 by the Agricultural Diversification Unit (ADCU) as a suitable candidate in the diversification process, is uncompetitive on the extra-regional market due to the generally poor quality of rhizomes (length and thickness), unreliable supplies and the high farm gate prices (OECS/ADCU, 1992).

Medlicott (1990) described the quality requirements of ginger rhizomes of the extra regional market as a minimum length and thickness of 20 cm and 3 cm respectively and a hand weight of not less than 200 g. Ginger of this standard received premium prices on the extra regional market where the prices are set by Hawaiian grade ginger.

The existing technology in St Vincent is planting in flat plowed lands with a spacing of 0.36 m^2 per plant. This cultivation method produces yields of 8 to 12 t. ha^{-1}. Stephenson (1989) reported that ginger quality similar to the Hawaiian grade ginger was produced in Dominica through furrow cultivation combined with organic manure application (10 t. ha^{-1}) and high rates of fertilizer (1.2 t. ha^{-1} of a 24-24-30 NPK).

This study focused on evaluating the effectiveness of organic manure addition, fertilizer formulation and rates, system of cultivation and plant density on productivity, quality and cost of production. This work was done during 1989 to 1992 at three sites in St Vincent.

MATERIAL AND METHODS

Experiment 1

Evaluation of the effect of different fertilizer formulations on exportable grade ginger.

Four fertilizer formulations 15-08-21 (Banana), 18-18-05 (ORD), 21-00-00 (Sulphate of Ammonia) and 15-18-21 (enriched TSP) were tested at three sites, Vermont, Tourama and Belmont.

The soil and climate data for these areas are presented in Table 1. The experiment was laid down in a 4 x 4 latin square design at each site. The spacing used was 0.36 m^2. The rhizome pieces (setts) 50 +10 g were planted in land prepared by the existing method of cultivation (flat plowed). The fertilizer was applied in a split application of 500 kg. ha^{-1} at planting and again and at 6 weeks after emergence. Weeds were controlled manually.

Marketable yields were taken and exportable grade determined by technicians working with the Caribbean Agricultural Trading Company (CATCO) packing plant in St Vincent and the Grenadines. The cultivar was the St. Vincent large.

Experiment 2

Evaluation of different fertilizer rates required for both the existing system and the introduced technology from Dominica.

All treatment combinations of two levels of pen manure (0 and 10 t. ha^{-1}), two systems of land preparation,(furrow and flat) and four rates of Banana fertilizer, 400, 800, 1200 and 1600 kg.ha^{-1} were laid out in a split plot design. The main plots were cultivation systems by manure and fertilizer rates were the sub-plots. The fertilizer was banded around each plant. Main plots were replicated twice at each site, Akers and at Perseverance. The harvested area per sub-plot was 5 m^2. Flat cultivation was normal farmer's practice that is, hoe plowed, chip and plant. Furrow cultivation required trenches 15 cm wide and 30 to 40 cm in depth. The furrows were laid down 60 cm apart. The setts (50 +10 g) were planted 30 cm apart in the furrow. Pen manure was broadcasted at a rate of 10 t ha^{-1} in the furrow and tilled into the soil. The cultivar was the same as in experiment 1. Exportable grade was determined similarly as in experiment 1.

Experiment 3

The effect of reduced intra row spacing and system of cultivation on the exportable yield of ginger.

Six spacings of 15, 25, 35, 45, 55 and 65 cm within the row and an inter-row spacing of 60 cm were combined with two systems of land preparation, flat and furrow, as described previously. The experiment was laid down at two sites in a split-plot design with three blocks at each site. The main plot was land preparation systems with spacing being the sub-plot. The same St Vincent Large ginger cultivar was used. The exportable grade ginger was evaluated similarly as in experiment 1.

RESULTS AND DISCUSSION

Experiment 1

There was a significant interaction effect ($p<0.05$) of fertilizer formulation by sites (Fig. 1). The three areas produced the highest exportable yields from applications of 15-18-24 NPK and the yields were similar from the application of 15-08-24 NPK. Tourama district was noted for a lower annual rainfall (under 2000 mm) than the other two areas and produced a lower yield for all types of fertilizer (Table 1). Although sulphate of ammonia produced yields similar to 15-08-24 and 15-18-24 applications at Belmont, this fertilizer application resulted in significantly lower yields at both Toruma and Vermont. Except at Torouma, 18-18-05 applications resulted in lower yields. The nutrient potassium apparently affected production at Vermont and Belmont. The Vermont and Belmont soils belong to the group of old volcanic soils and fixed the phosphate before the plant could access the nutrient. This was due to the allophanic nature of the soil (Visser, 1991).

From the results, it can be cautiously recommended that farmers in Belmont or in similar eco-zones could use either sulphate of ammonia or 15-08-24. Farmers in the Tourama and Vermont area and other areas with soils of recent volcanic origin should use an NPK fertilizer such as the 15-08-24 or enriched phosphate 15-18-24 in preference to sulphate of ammonia. The most favorable area for growing ginger appeared to be Belmont, an area normally cultivated to this crop, followed by Vermont. In Tourama an area prone to rapid soil desiccation, mulching might be necessary. The potential for achieving more than 20 t. ha^{-1} of marketable ginger was demonstrated at all sites.

Experiment 2

Significant differences ($p<0.001$) were observed for the interaction of fertilizer rates and system of cultivation (Fig. 2) on exportable grade ginger. The increased rates showed improved yield of exportable grade ginger in flat cultivation, however the yield decreased for the higher application rates of fertilizer in furrow cultivation. The optimum rate in flat cultivation appears to be at 1.2 t. ha^{-1} and 0.4 t. ha^{-1} for furrow cultivation. Possibly the furrow (unplowed) treatment held the fertilizer for a longer period thus preventing any leaching that may have occurred in flat cultivation (plowed). Lee and Asher (1981), Lee et al (1981a) and Lee et al (1981b), reported that in Australia, little plant development took place in the first 50 days of growth. They also reported that farmers averaged yields around 26 to 37 t. ha^{-1} and these yields required only 40 kg to 110 kg. ha^{-1} of nitrogen. Therefore rates of 200 kg. ha^{-1} of N presently used was excessive in relation to plant needs. The observed higher soil moisture in the furrow probably assisted in fertilizer utilization by the plant. The response to increased rates of fertilizer on the flat gave the maximum exportable yield of 7 t. ha^{-1} compared to over 25 t. ha^{-1} for furrow cultivation at the lowest fertilizer rate. The combined yield of marketable and unmarketable rhizomes for both systems of cultivation were similar (Fig. 3) at the higher rates of fertilizer. However, at the lower rates of 0.4 t. ha^{-1} furrow cultivation produced significantly higher total rhizome yields.

The main reason for farmer rejection of the flat-cultivated ginger was the excessive branching of the rhizome, shortness of the rhizome piece and small size of hands. Breakage during harvest occurred more often with furrow cultivated than with flat cultivated ginger. However, in order to clean the flat cultivated ginger adequately, the rhizome had to be broken into small pieces. The furrow cultivated ginger required careful packing both in field and packing plant in boxes and not in bags. This type of ginger is not presently suitable for the regional trade where packaging for transport is in bags.

The interaction of system of cultivation by pen manure applications on exportable yields was highly ($p<0.01$) significant (Fig. 4). The increase in exportable yields in furrow cultivation was about 5 times as high as that obtained from flat cultivation (Fig. 4). Note that grading was done to meet the standards suggested by Medlicott (1990) and not necessarily the existing market demands. Pen manure gave a further 25% boost to total yields generally for both systems of cultivation (Fig. 5). Several workers have recommended the use of organic manure in ginger cultivation (Stephenson, 1989; Paliwal, 1988). The requirement of high humus levels in the soil is also documented by both Ridley (1912) and Purseglove (1981). The observed yield responses were therefore expected. However, it is important to note the contribution of pen manure to improved quality. Every effort should be made to use organic manure. The producer could be well rewarded depending on the cost of finding, transporting and applying the organic manure.

Experiment 3

Reduction in the intra-row spacing of ginger from 60 cm to 15 cm produced significantly ($p<0.01$) higher exportable yields of more than 20 t. ha^{-1} (Fig. 6). The existing spacing of 60 cm intra-row produced averaged yields of 10 t. ha^{-1} and was similar to reported yields on farmers holdings. Although reports show that spacing in India was 225 cm^2 (Ridley, 1912; Purseglove, 1981)) yet the space remained at 3600 cm^2 per plant. Closer spacing improved yields on both flat and furrow cultivation.

The interaction of cultivation system and intra-row spacing showed no significant effect on either exportable grade ginger or total rhizome yields. Farmers can therefore reduce their intra-row nearer to 15 cm irrespective of the system of cultivation chosen. Flat cultivation had an overall significantly ($p<0.01$) lower exportable grade ginger at all spacings. The rhizome yields of furrow cultivation produced significantly higher yields (exportable and total) at all spacings compared to flat cultivation.

ECONOMIC ASSESSMENT

The combined results from the three experiments were made into an alternate technology compared to the existing cultivation system. The alternate technology consisted of a spacing at 25 cm intra-row by 60 cm inter-row, organic manure at 10 t. ha^{-1}, furrow cultivation, fertilizer NPK 15-08-18 at the rate of 500 kg. ha^{-1} in two split applications at 60 DAP and 120 DAP. This was compared to the existing technology to compute cost of production, each plot being approximately 2000 m^2. The alternate technology had a higher cost for crop establishment and maintenance (Table 2). This higher cost per hectare was offset by reduced cost per kg from EC $1.31 kg^{-1} to EC $0.57 kg^{-1} with the improved technology of spacing, furrow cultivation, fertilizers and manures. At a farm-gate price of EC $0.88 kg^{-1} the net return for the improved technology is EC $12,000.00 ha^{-1}. At a lower price of EC $0.66 kg^{-1} the net return is EC $3,600.00 ha^{-1}. The existing technology only showed profitability when no wages were paid for family labor.

CONCLUSIONS

The existing fertilizer formulation (15-08-24 NPK) is suitable at all locations and added phosphate showed only slight improvement in Vermont Valley.

Furrow cultivation not only required a lower rate of fertilizer but also improved yields and quality.

Organic manure is important and can increase exportable grade by 500% and overall yields by 25%.

Closer intra-row spacing produced higher yields and still gave enough room for crop management (e.g. moulding).

The combination of closer spacing, furrow cultivation with pen manure produces a profit in ginger production with the farmgate price at EC $0.66 kg^{-1}. At this farmgate price, the existing traditional cultivation system results in a net loss to the producer.

The observation that furrow cultivated ginger is more easily broken because of the length of individual rhizomes should be noted. Harvest and post-harvest handling becomes more important with this method of cultivation. This method of cultivation depends on the market availability.

Table 1. Some characteristics of the soils where experiment 1 on ginger was carried out during 1990/91.

Characteristics	Tourama	Belmont valley	Vermont
pH	5.8	5.3	5.5
Nitrogen (NO_3)(ppm)	34	34	31
Phosphorus (P_2O_5)(ppm)	17.3	20.5	6.5
Potassium (K_2O)(ppm)	315	200	105
AEZ	IVa	111	111
Elevation (m)	60	120	60
Slope	15°	10°	10°
Rainfall(mm)	<2000	2000 to 2500	2000 to 2500
Soil Type	Recent volcanic ash	Yellow earth recent volcanic ash	High level yellow earth

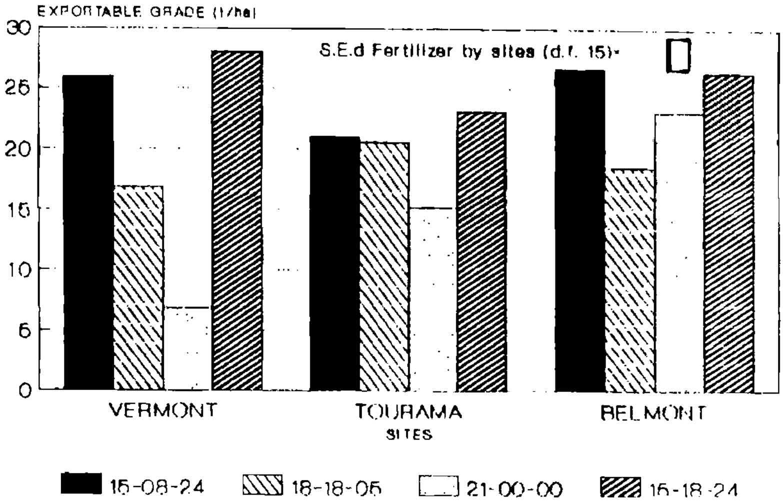
Source: CARDI, 1992. Annual Technical Report, St Vincent and the Grenadines.

Table 2. Economics of production for ginger grown under farmers condition and with improved cultivation techniques

Item/Technology	Farmer	Improved
Establishment ($/ha)*	7766	10332
Maintenance ($/ha)	4029	4729
Harvest ($/ha)	1699	3664
Post Harvest ($/ha)	1321	2850
Total Cost ($/ha)	**14814**	**21575**
Yields (kg/ha)	11322	38157
Cost/kg	**1.31**	**0.57**
Gross Income ($.88/kg)	9963	33578
Net Income ($.88/kg)	**(4851)**	**12003**
Gross Income ($.66/kg)	7473	25184
Net Income ($.66/kg)	**(7341)**	**3609**

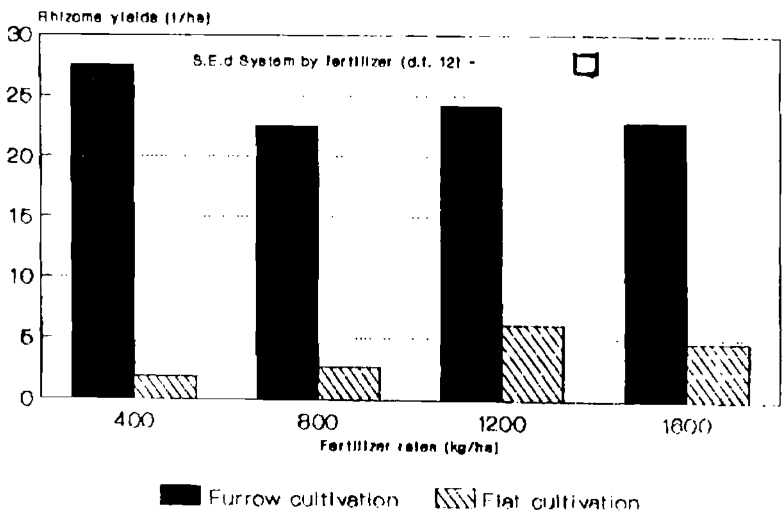
* US $1.00 = EC $2.70.

Figure 1. Effect of site by fertilizer formulation on the exportable grade yield of ginger



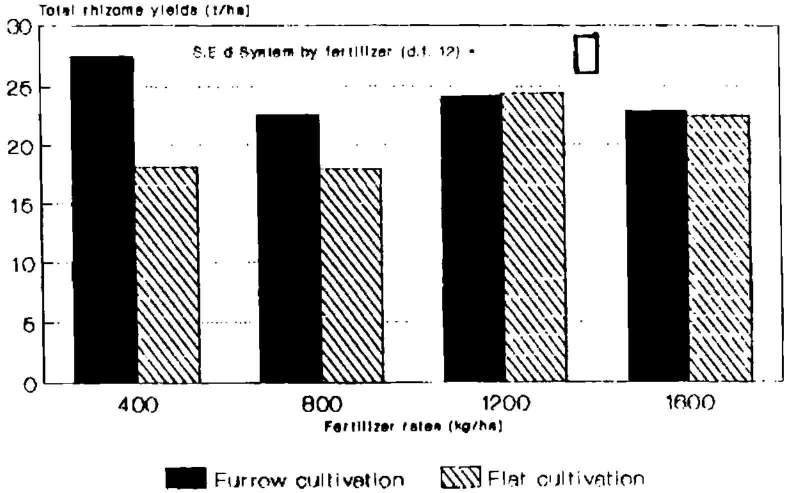
SITE: (3) IN ST VINCENT; 1990/91

Figure 2. Effect of cultivation system and fertilizer rates on the yield of exportable grade ginger



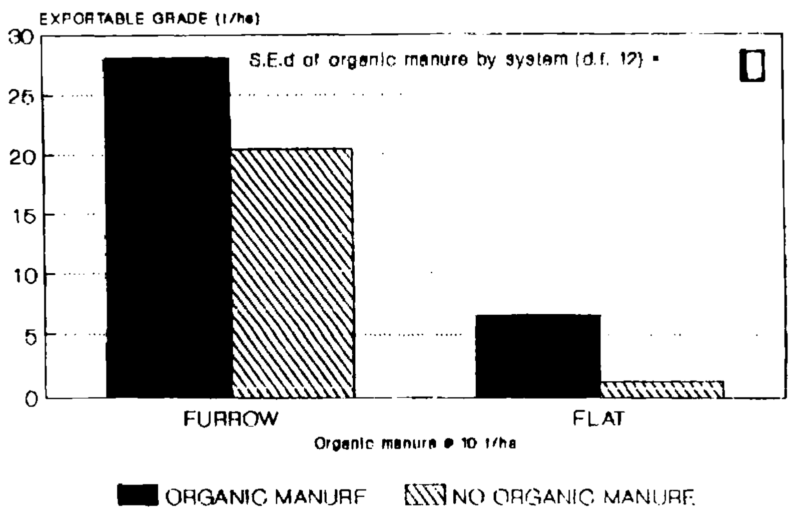
SITE: AKERS, ST VINCENT; 1990/91

Figure 3. Effect of cultivation system and fertilizer rates on the total yield of ginger fresh rhizomes



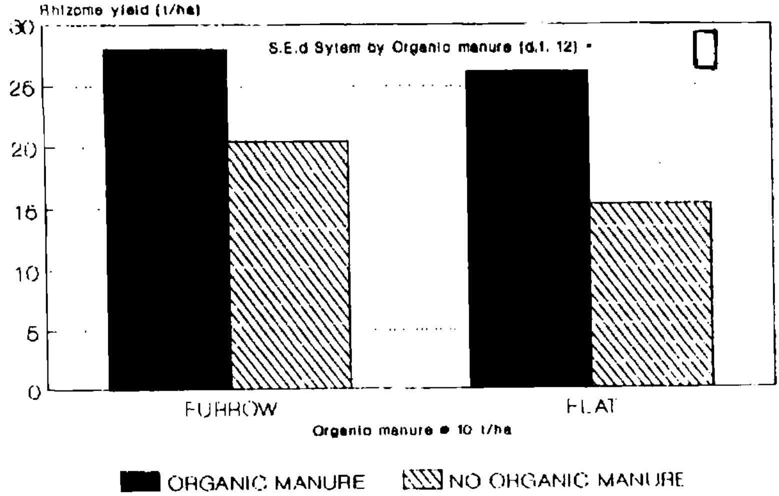
SITE: AKERS, ST VINCENT; 1990/91

Figure 4. Effect of organic manure and system of cultivation on the exportable grade yield of ginger



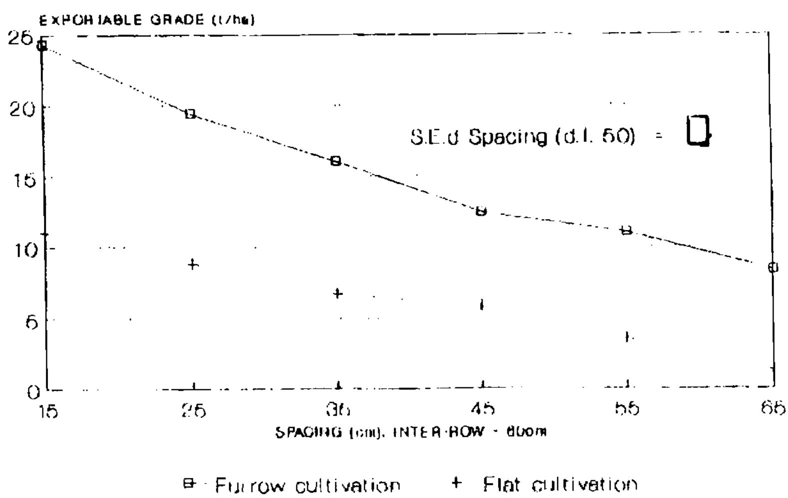
SITE:AKERS, ST VINCENT; 1990/91

Figure 5. Effect of organic manure and system of cultivation on the total fresh rhizome yield of ginger



SITE AKERS, ST VINCENT; 1990/91

Figure 6. Effect of reduced intra-row spacing and cultivation systems on exportable grade yield of ginger



SITE. QUEENS DRIVE, ST VINCENT; 1990/91

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