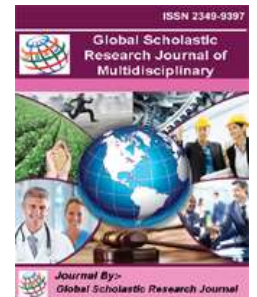




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**A PROTOCOL FOR THE PLANTING, MANAGING AND COST OF  
ESTABLISHING A FRUIT ORCHARD IN THE INTERMEDIATE SAVANNAHS OF  
GUYANA**

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**Abstract**

A mixed fruit crop orchard containing avocado, citrus, guava, soursop and golden apple was established in the Intermediate Savannas of Guyana, mainly to augment the production of fruit crop seeds for the national programme, and to investigate suitability of the infertile soils for orchard production. These savannas are characterized by the low inherent fertility in both surface and subsoil. These soils are classified as well drained and Ultisols, Oxisols and Entisols predominate. The common feature of these soils is their relatively low pH, ranging from 4.3 to 5.9 within profiles and among types. The Cation Exchange Capacity and base saturation are typically low with high Al saturation. Tree crop production in these soils are oftentimes challenging because although the rainfall of 2250 mm could be described as adequate for row crop production, 40 -60 percent of the total rain occurs from mid-April to mid-August. The protocol used in establishing the plants include animal manure as well as low grade rock phosphate in the planting pit. The growth and survivability of the plants were positive in both the wet and dry months and the percentage change in plant growth from the initial to the final height ranged from 190-500%. Floral initiation and fruiting occurred in two of the fruit types at 14 months after planting. The costs related to the establishing and maintaining of the orchard for a year was also determined.

**Key words:** Intermediate savannas, avocado, soursop, guava, animal manure, infertile soils

## 1.1 Introduction

In Guyana there is an unusually high demand for orchard plants; this demand has resulted in the Orchard Crop Programme of the National Agricultural Research and Extension Institute producing and making available for sale approximately G\$12M annually. It is felt that the amount of revenue and consequently the number of plants sold could be increased, however a short supply of critical seed material for the important and/or high demand crops has resulted in the Institute not being in a position to meet the increasing demand.

This increased demand for orchard crops was therefore the catalyst for the establishment of a mixed fruit crop orchard at the Ebini Research Station which is located in the Intermediate Savannas of Guyana. Additionally, it is expected that there would be an increased demand for orchard plants in the Intermediate Savannas, as well as the Berbice River districts, as the demand for fruit to supply the emerging processing sector is increased.

In this regard, the establishment of the orchard at Ebini became a necessity, provided the opportunity for the development and refinement of a protocol for the establishment of orchard crops in the Intermediate Savannas.

It is important to highlight, that in the not too distant past two fruit orchards were successfully established in the Intermediate Savannas, both of which used a protocol for establishment based on the use of leaf litter as an organic matter source and inorganic fertilizers in the planting pit in the establishment phase. The unique feature of the orchard at Ebini, as against those that were previously established in the Intermediate Savannas, was as a result of the availability of an abundant supply of animal manure at the Ebini location. The use of animal manure (sheep manure) in the planting pit was promoted. Additionally, the plants identified for propagation at Ebini, were those from which there is a high demand, as well as those plants with unique nutritional value.

The concept of this long term coordinated research project with orchard crops particularly as it relates to the establishment and management of these orchards were aimed at moving fruit crop production levels to a new baseline peak and perhaps with incremental increases.

Attempt to keep pace with consumer demands and needs for increased income generation in hinterland as well as rural communities, by initially utilizing higher nutrient levels at crop establishment. The crop/livestock integrated system was improved by utilizing animal manure as an important component in the establishment phase and testing this concept over

time. Additionally, the development of a technological package that would provide useful information, as well as comparisons with other proven methods of fruit crop propagation in the Intermediate Savannas and on similar soil types was one of the primary aims of this study.

## **2.1 Methodology**

### **2.11 Location**

The Intermediate Savannas of Guyana which exceeds 2700 km<sup>2</sup> are located 58° W and 5° N in the north-eastern quadrant of Guyana, and lie immediately south of the coastal plains, east and west of the Berbice river.

### **2.12 Climate**

Climate is tropical humid with a mean annual rainfall of 2250 mm distributed bimodally. The long rainy season accounts for 40 -60 percent from mid-April to mid-August while about 20 percent of the total comes in the highly unpredictable short rainy season from mid-November to January. Mean annual temperature is 26<sup>0</sup>C. Highest temperatures are recorded from August to November and peaking in excess of 34<sup>0</sup>C. The early months of the year are coolest with a mean minimum of about 21<sup>0</sup>C. The climatic pattern permits two rain-fed cropping seasons per year. However, the short rainy season is considered too unreliable for any large-scale cropping activity without irrigation. Seventy percent of the natural vegetation comprises primarily forest and shrub with only 25 percent being grassland type vegetation in association with marsh and swamp plants.

### **2.13 Soils**

Well drained Ultisols, Oxisols and Entisols predominate. They are all coarse to medium textured, ranging from pure white quartz sand to yellowish red sandy loams. The common feature of these soils is their relatively low pH, ranging from 4.3 to 5.9 within profiles and among types. They are of low inherent fertility in both surface and subsoil. The Cation Exchange Capacity (CEC) and base saturation are typically low with high Al saturation. Available P is low and is considered a major limiting nutrient. Organic matter content of these soils is negligible.

### 2.14 Project Site

The Ebini Research Station, located in the Ebini Savannahs (part of the wider Intermediate Savannahs) is the selected location for the fruit orchard and testing project. The station is located on the eastern bank of the Berbice River, and approximately 146 km up the river.

### 2.15 Implementation

The land preparation for the orchard was started in December 2013. Site selection was based on the proximity to the main work site. Approximately 5.0 hectares of land was identified for the project. The initial plantings were done during the short rainy season of December 2013 to March 2014.

### 2.16 Planting

The plant site was prepared by digging a pit about 50 cm deep and 50 cm x 50 cm square. The planting hole was then filled with approximately 4-5 kg of well weathered animal manure (at Ebini sheep/goat manure was used). Additionally, at each planting site 250g of low grade rock phosphate was well incorporated into the manure and soil mixture, no inorganic fertilizer was used at planting.

The plants were then placed in the prepared pit, the inter and intra row spacing was 9 metres. Planting only occurred during the rainy season, as this allowed the plants the required moisture and time to become properly established.

**Table 1:** Type of plants in the collection

Scientific name	Common or local name
<i>Persea americana</i>	Avocado
<i>Citrus jambhiri.</i>	Rough lemon
<i>Psidium guajava</i>	Guava
<i>Annona muricata</i>	Soursop
<i>Spondias dulcis</i>	Dwarf Golden Apple

## **2.2 Crop management**

### **2.21 Fertilization**

Inorganic fertilizer with the ratio of 12-12-17-2 was used for the first time six months after planting (June 2014) and at subsequent six month intervals ( December 2014) during the establishing year, the amount of fertilizer applied was 250 g per plant. The fertilizer was applied around the drip line of each plant. Organic manure was also applied twice during the establishment period, the additional applications of manure acted as a mulch during the dry period.

### **2.22 Irrigation**

Irrigation was done manually; water was applied to individual plant at a rate of between 9-18 litres per plant, depending on the size of the plant. This activity was only conducted during the dry season and it was done 2-3 times per week depending on the prevailing weather conditions and the soil moisture content.

### **2.23 Pest control**

A pest control programme was instituted and this programme involved the routine spraying of the plants to control, aphids, mealy bug, sooty mold, leaf minor, white flies and other pests of economic importance. No major disease incident was observed

### **2.24 Weed Management**

The programme to control weeds involved the plants being circle weeded manually at two week intervals. The inter and intra row control for weeds was done at a five week interval using either a Rota Slasher and/or a tractor drawn brush cutter. These time intervals could vary depending on the weather conditions as well as the weed growth rate, and availability of resources to conduct these activities.

## **2.3 Data Collection and Analysis**

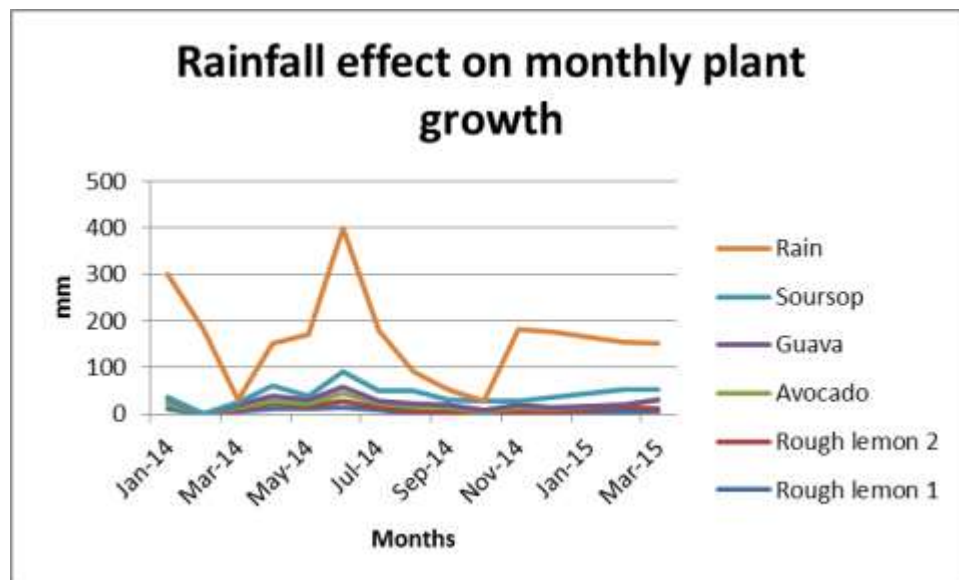
Plant height in centimetres were recorded monthly, these data were used to ascertain the growth habit and growth pattern of the plants during the establishment period. These data were collected for a period of 14 months, ideally to allow for the plants to encounter two dry and two wet periods. Additionally, the plants were observed for any other growth characteristic, as well as insect and other pest infestation and damage.

### 3.1 Results and Discussion

The diversity of fruit types planted in the orchard collection at Ebini provided for information to be ascertained on growth characteristics but more importantly on the range of pests and types of pests and other pertinent information that may be useful and could have an effect on establishment of fruits in the Intermediate Savannahs. Additionally, as a result of the planting of the orchard, a better comprehension of the effect of weather and perhaps the use of organic matter, fertilizer and limestone on the establishment phase of fruit plants in the Intermediate Savannahs were ascertained.

#### 3.11 The Growth Indices

The growth indices for the plants in the collection were acquired by physically measuring each plant in the collection every 28 days for a period of 14 months. These indices therefore were an average of the individual height of the plants of a particular species. These measurements were taken from the ground level to the top most point of the plant. The index did not take into account any measurement for the spread of the plant, the number of branches or the girth of the plants. The growth indices of the plants in the collection as well as a comparison of the growth index and rainfall are presented in Figure 1.



**Figure 1.** A comparison of the growth indices and rainfall for selected fruit plants in the Intermediate Savannahs over a 14 month period.

The growth indices were positive for all species during each month of the establishment phase, Figure 1, plants generally respond positively to moisture and even through the dry

periods of the establishment phase which were recorded as March 2014, and during the period from August-October 2014, the plants exhibited positive growth, however, the best growth indices for all species were observed during the month of June 2014, incidentally during this month the highest rainfall, (309.8 mm) was also recorded, overall the total rainfall during the period of January 2014-March 2015 was 1797.3 mm.

The lowest growth indices varied throughout the year but were mostly observed during the period October 2014-January 2015, Table 2. The plants were fertilized at the end of June and the beginning of December 2014; apparently the fertilizer application did not result in any significant increase of height of the plants during the corresponding month, but may have resulted in an increase of the overall nutritional status of the plants.

Water deficits affect almost every aspect of plant growth and development (Pallardy, 2008), water deficits are nearly always associated with drought condition. In order therefore to reduce the effects of the drought conditions, irrigation was provided to the plants. Water was provided to individual plant at a rate of between 9-18 litres per plant depending on the size of the plant. This activity was conducted through the duration of the dry season, and it was done 2-3 times per week. Water deficits are regarded as the major causes of failure of newly planted trees resulting in loss of leaf turgor, stomatal closure, decreased photosynthesis and reduced metabolic functions.

**Table 2.** High and low growth indices in (cms) for some selected fruit plants compared to rainfall during the establishment phase.

Parameters	Rough lemon 1	Rough lemon 2	Avocado	Guava	Soursop
Highest growth rate	14.7 cms	12.5 cms	17.7 cms	14.2 cms	32 cms
Month	June 2014	June 2014	June 2014	June 2014	June 2014
Rainfall	309.1 mm	309.1 mm	309.1 mm	309.1 mm	309.1 mm
Lowest growth rate	0.1 cms	0.1 cms	1.7 cms	2.7 cms	2.6 cms
Month	Nov. 2014	Dec. 2014	Jan. 2015	Oct. 2014	Jan. 2015
Rainfall	156.2 mm	140.7 mm	263.3 mm	Not available	263.3 mm

Also during the dry months, in addition to irrigation being provided, grass mulch was also used; mulching is an essential component to reduce plant transplant losses. Benefits of mulches are numerous and these include minimising fluctuations of soil temperature and soil moisture; weed suppression; soil nutritional enrichment; the regulation of pH and CEC; pathogen suppression; increasing soil microbial activity and improving aeration.

### **3.12 Fertilization effects**

Inorganic fertilizer with the ratio of 12-12-17-2 was used for the first time approximately six months after planting (June 2014) and the next application was six months after the first application. The amount of fertilizer applied at each application was 250 g per plant; the fertilizer was applied around the drip line of each plant. Two fruit types' avocado as well as soursop exhibited the lowest growth indices in January 2015, following the application of fertilizer in December 2014. (Table 2)

### **3.13 Plant height increase**

The percentage change of the plants from the initial heights which were taken in February 2014 and the final heights which were taken in March 2015 showed that the guava plants recorded the highest percentage change of 536% over the initial height, while the avocado had the lowest percentage change of 195%. Because fruit orchards are perennials and tree roots remain practically restricted to the same soil space for many years, it is important to incorporate homogeneous amounts of limestone to deep levels before planting so that the root system can develop adequately for efficient uptake of water and nutrients.

It is the opinion of the authors that the use of lime at planting may have enhanced the development and nutritional status of the plants with less need for fertilizers, thus improving the growth rate and perhaps boosting the plant productivity.

The natural soils of the Intermediate Savannahs are acid with high aluminium saturation, lime therefore must be used to neutralize the toxic Al in the surface layers, and therefore enable a more intense proliferation of roots, which are reported to have a positive effect on plant growth. (William Natale et al 2011).



**Table 3:** Initial plant height, difference in growth and percentage change of some selected plants

Plant type	Initial Average Plant height (cm) February 2014	Average Plant Height (cm) March 2015	Difference in growth (cm)	Average monthly growth (cm)	Percent change in growth
Rough lemon (Row 1)	42.1	128.1	86	6.1	204.2
Rough Lemon (Row 2)	42	126.6	84.6	6.04	201.4
Avocado	57.2	168.72	111.52	7.76	194.9
Guava	28	178.2	150.2	10.72	536.4
Soursop	60.1	291.8	231.7	16.55	385.5

The same authors further suggested that it is important to incorporate the limestone thoroughly into the soil at the time of planting perennial crops because surface application alone acts slowly on the deeper soil layers and a soil insufficiently corrected at the establishment of the orchard can impair crop productivity.

The pH of the soil of the orchard when measured during the establishment phase ranges between 5.10-5.27; this pH was well within the desirable pH range for most fruit crop species. The importance of the root system is obvious because there is a close dependency between root development and the above ground portion of the plant.

### 3.14 The measure of the survivability

In estimating or attempting to ascertain the ability of fruit trees to niche within a particular ecozone, Hirons and Percival (2011) suggested that it is important to consider the factor they refer to as crop ecophysiology, because it considers the genetic potential of the plant to be

established in a given environment and species characteristics which may reduce the impact of a particular stress.

Planting and post-planting practices are fundamental to establishment success; hence all seedlings were planted into an enhanced environment which was aimed at changing the physical structure of the typical savannah soil. The plants were placed in planting pits of approximately 50 cm deep and 50 cm x 50 cm square, the environment was enhanced by the utilization of between 4-5 kg of well weathered animal manure per planting site, also, 250g of low grade rock phosphate was incorporated in the animal manure at each individual planting site. The rooting environment is critical in ensuring future resource availability and anchorage. Failure to give full consideration to any one of these factors increases the likelihood of a high mortality rate in any planting scheme. Additionally, the quality of the planting material is essential in any planting programme, the material used in this orchard was principally collected from the NAREI nursery.

de Queiroz Pinto (2011) suggested that for the acidic soils of the Cerrados of Brazil, when planting soursop, 21.6 L of cured bovine manure or 5.4 L poultry manure; 216 g lime (PRNT 100%); 151 g P<sub>2</sub>O<sub>5</sub> (367 g of triple superphosphate); 1.0 g B; 0.5 g Cu; 1.0 g Mn; 0.05 g Mo and 5.0 g Zn, were recommended to be applied at each planting site or pit, he further suggested that N and K, at 20 g/plant, should be applied around the plant in three portions at intervals of 30 days between each application and if micronutrients is to be used the recommended practice is 100 g/pit of F.T.E. formula BR-12.

Table 4, shows the overall survivability of the various fruit types that were monitored in the orchard collection; the rough lemon as well as the soursop had a 100% survival rate when planted in the orchard collection. The grafted avocado had an overall survival rate of 33%. The overall survivability of the plants monitored was 88% and the individual survivability of the different species ranged from a low of 33% to a high of 100%.

**Table 4:** Percentage survivability of plants monitored in the orchard

<b>Crop type</b>	<b>Number planted</b>	<b>Number of Plants died</b>	<b>% survival</b>
Citrus (Rough Lemon)	48	0	100
Guava	24	7	70.8
Avocado (Seedling)	24	2	91.6
Soupsop (Mon Repos)	24	0	100
Soursop (Ebini)	7	1	85.7
Dwarf golden apple	8	1	87.5
Grafted avocado	9	6	33.3
Total	144	17	88%

### 3.15 Floral Initiation and Fruiting

Three fruit types exhibited floral initiation during the establishment period; these include the dwarf golden apple, the soursop and the guava plants. Dwarf golden apple plants tend to initiate the floral stimulus very early and in some instances at about 4-5 months after planting. At the Ebini orchard the flowers were removed thus preventing these plants from fruiting.

Love and Paull 2011, reported that the soursop plants bear fruit between 3-5 years from seedling planted in Hawaii, they further observed that the plant flower most months of the year and the peak flowering is during the months of May and June, with the fruits ripen in November and December. At the Ebini orchard floral initiation was observed on some of the plants (in March 2015) as early as 15 months after planting and of the 24 plants observed 50% had initiated fruiting, and flowering was observed on 18 of the plants.

Similarly of the 17 guava plants in the orchard collection, 14 initiated fruiting in March 2015, some 15 months after planting, Mossler and Crane 2015, suggested that properly propagated and cultured guava trees may start to bear within 2 to 4 years, and a mature tree will produce from 60 to 100 kg fruit per year.

#### 4.1 Cost of Production of the Ebini Mixed Fruit Orchard

The cost of production of an agricultural venture or project is critical to its long term survivability and it also gives a fair indication of the viability of the project. More so if the project is located in a rural or hinterland community of Guyana, where the cost of supplying inputs as well as the cost of inputs could be more expensive than those of other locations.

In this exercise the establishment as well as the maintenance cost of the plants at the mixed fruit crop orchard at Ebini were determined, because of the age and plants, only the establishment and operating variables for the first year of operation were taken into account. Based on the expected yields of the plants in the orchard as well as the cost of the produce, it appears that the venture may be a financial success.

##### Establishment Costs

	Units	\$/unit	\$/plant	\$/plant/year	Total Cost
Land Preparation	Ha	\$30,000.00	\$521.00	\$521.00	\$75,000.00
Digging pits Manual	144 pits	6 man days @ \$2000.00/day	\$83.00	\$83.00	\$12,000.00
Planting	144 pits	6 man days @ \$2000.00/day	\$83.00	\$83.00	\$12,000.00
Lime	250g/plant	\$1500.00/45 kg	\$8.00	\$8.00	\$1,152.00
Cost of plant	1. 24 x \$200 2. 9 x \$260 3. 48 x \$200 4. 24 x \$100 5. 31 x \$100 6. 8 x \$500	\$26,240.00	\$182.00	\$182.00	\$26,240.00
1. Avocado \$200					
2. Avocado \$260					
3. R. Lemon \$200					
4. Guava \$100					
5. Soursop \$100					
6. Go .apple \$500					

Manure	5 kg/plant	\$500/ 20 kg bag	\$125.00	\$125.00	\$18,000.00
<b>Establishment Total</b>			<b>\$1002.00</b>	<b>\$1002.00</b>	<b>\$144,392.00</b>
<b>Operating cost</b>					
Manure	5 kg/plant/2 times/year	\$500/20 kg bag	\$125.00	\$250.00	\$36,000.00
Weeding	Entire orchard 2 times/month	\$30,000.00/ month	\$208.00	\$2,500.00	\$360,000.00
Pest control	Twice/month	\$3,000/litre	\$7.00	\$83.00	\$12,000.00
Circle weeding	Each plant once /month	2 man days@ \$2,000.00/day	\$333.00	\$4,000.00	\$48,000.00
Fertilizer 12-12-17-2	250g/plant/ twice /year	\$7500.00/45kg	\$42.00	\$84.00	\$12,000.00
Lime application	250g/plant/ twice /year	\$1500.00/45 kg	\$8.00	\$16.00	\$2,304.00
Irrigation	3800 L/month only in dry	\$30,000.00	\$208.00	\$625.00	\$90,000.00
Pruning etc.	2 times/year	\$10,000.00	\$69.00	\$139.00	\$20,000.00
Applying water to plants	3 times per week for 12 weeks	1 man day @\$2000.00/day	\$14.00	\$500.00	\$72,000.00
<b>Operating Total</b>			<b>\$1,014.00</b>	<b>\$8,197.00</b>	<b>\$652,304.00</b>
<b>Total Cost</b>			<b>\$2,016.00</b>	<b>\$9,199.00</b>	<b>\$796,696.00</b>

1. All costs are in G\$, an exchange rate of G\$200 is equivalent to US\$1

The cost of capital items were not taken into consideration, however the cost of providing the input and the labour cost for the inputs were taken into account.

### 5.1 Conclusion

The mixed fruit orchard which was established on the low fertility soils of the Intermediate Savannahs of Guyana continue to provide some unexpected results, clearly from the performance of the plants based on the planting and management method developed as well as the cost of production of a plant per year of approximately \$9,200, there are indications that a fruit orchard if properly managed could be a profitable venture. While it is important to admit that we are judging the performance of the venture on the establishment phase we are confident that with the continued development and maintenance of the orchard the fruiting phases would yield an adequate amount of fruit to make the overall venture a success.

## References

- Crane, J.H. and C.F. Balerdi (2005). Guava Growing in the Florida Home Landscape. Horticultural Sciences Department document HS4. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.
- de Queiroz Pinto. (2011) Soursop, Embrapa Cerrados, BR 020 km 18 Rodovia Brasilia/Fortaleza.
- Hirons A. D. and G. C. Percival. ( 2013) Fundamentals of tree establishment: a review in Trees, people and the built environment. Myerscough College, Lancashire, UK R.A. Bartlett Tree Research Laboratory, University of Reading UK
- Love K. and R. E. Paull. (2011) Hawaii Tropical Fruit Growers, College of Tropical Agriculture and Human Resources, Hawaii, Department of Tropical Plant and Soil Sciences
- Mossler M. A. and J. Crane. ( 2015) Florida Crop/Pest Management profile: Guava and Wax Jumbu. Horticultural Sciences Department document CIR 1415. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.
- Natale W., D. E. Rozane, S. Étienne Parent and L. Etienne Parent. (2011) Soil Acidity and Liming in Tropical Fruit Orchards, Ch. 7. Universidade Estadual Paulista, Campus Jaboticabal, Via de Acesso Paulo D. Donato Castelane, Jaboticabal, São Paulo, Brazil.
- Pallardy, S.G. (2008). Physiology of Woody Plants. Academic Press.