October 2006 OCCASIONAL PAPER No. 39

MAURITIUS SUGAR INDUSTRY
RESEARCH INSTITUTE

ALTERNATIVE CROPS FOR SMALL-SCALE CANE GROWERS: TWO CASE STUDIES

by

N. GOVINDEN

October 2006 OCCASIONAL PAPER No. 39

MAURITIUS SUGAR INDUSTRY
RESEARCH INSTITUTE

ALTERNATIVE CROPS FOR SMALL-SCALE CANE GROWERS: TWO CASE STUDIES

by

N. GOVINDEN

ISBN 99903-24-23-9

National Library (Republic of Mauritius) Cataloguing-in-Publication Data

Govinden, Noël
Alternative crops for small-scale cane growers: two case studies / Noël Govinden
- Réduit: Mauritius Sugar Industry Research Institute, 2006.
9 p; 30 cm. - (Mauritius Sugar Industry Research Institute Occasional Paper; No. 39).
ISBN 99903-24-23-9
1. Sugarcane – Mauritius – Case studies
2. Peach palm – Mauritius – Case studies
3. Cactus – Mauritius – Case studies
4. Alternative agriculture – Mauritius – Case studies
I. Title 06-00013
633.61'09'6982 dc 22

CONTENTS

Suggested citation: GOVINDEN, N. (2006). Alternative crops for small-scale cane growers: two case studies. Réduit: Mauritius Sugar Industry Research Institute. 9 p. (*Occ. Pap. Maurit. Sug. Ind. Res. Inst.*; 39) (Available at http://www.web-merchand.com.msiri/pdf/peach_palm_dragon_fruit.pdf)

ALTERNATIVE CROPS FOR SMALL-SCALE CANE GROWERS: TWO CASE STUDIES

1. Introduction

Most stakeholders in the sugar industry now agree that with the reduction in price of sugar, sugar cane will not be viable on part of the land currently under the crop (e.g Tonta and Ramasamy, 2006). The exact area is not known; it may occupy up to 12 000 hectares (Anon, 2005). While some small-scale planters are hoping for support measures in order to continue growing sugar cane, others are looking for alternatives. Likewise, some operators in the corporate sector and some large-scale growers are also thinking of alternatives, at least for part of their land.

Alternatives comprise agricultural and non-agricultural options. Some of the non-agricultural ones include urban and property development, ecotourism and productive forestry (Ministry of Housing and Lands, 2003). On the first two, which appear more interesting financially, there may be restrictions imposed by planning and environmental considerations. The other two may not be financially attractive.

The agricultural alternatives have not been studied yet in any detail. Options proposed for part of the land in the superhumid zone include mixed cropping of vegetables and fruit production (AREU, 2006). None of them has been validated yet. And on a very small-scale, there is the additional option of protected culture of selected flowers, ornamentals and vegetables.

In this discussion paper the characteristics of acceptable alternative crops are first defined and then, two cases studies are presented. The objective of this paper is to initiate discussions on alternatives so as to choose priorities for research and development.

2. Characteristics of an acceptable alternative crop

2.1 *It should be financially viable*. It must provide acceptable net revenue levels for a family. Either self and family labour are sufficient (250 md/year at 5 h/day), or the cost of contract labour can be covered easily. To-day, the minimum acceptable net revenue probably varies from about MUR 7000/month for a small family of three to about MUR 10 000/month for a larger family. Therefore, if the annual net revenue is less than about MUR 84 000 to MUR 120 000, the alternative is not likely to appeal to anybody, probably not even to the unemployed, and it should be discarded.

2.2 *Its production should be sustainable*. That is, it should provide the acceptable net revenue for a minimum number of years, which probably varies from 15 years for an operator being recycled from sugar cane production to 25 years for a new entrant. To be sustainable, yield should not decrease as a result of soil erosion and other problems. Net revenue should not decrease too much with increasing labour and other input costs, depreciation of the rupee and increasing competition from abroad. Thus, it should not be too labour intensive. In the subhumid zone, it should not require irrigation, which is not likely to be available. It should require minimum external inputs such as fuel, fertilizers and other agrochemicals. It should also have either a large and increasing domestic market or a large and increasing prospective export market or, better still, both.

2.3 *It should be resilient in the face of climatic and business risks*. With respect to climate, either the alternative should not be too susceptible to cyclones or management options must be available to minimize risks due to cyclones. In rainfed areas, performance should not be too dependent on rainfall. That is, there should be a reasonable level of production even if rainfall were to decrease by 25% in the subhumid zone or to increase by 25% in the superhumid zone.

With respect to business risks, either the initial outlay should not be excessive (MUR 100 000/ha?) or the time lag to recoup initial investment should be short (2-3 years maximum) or loans at preferential rates should be easily available or, better still, all three conditions should hold. If the selling price of the product is uncertain, then the enterprise should yield positive returns in all except the worse price scenarios.

Internal rates of returns should exceed the discount rate by at least 10% in the case of low risk enterprises and probably by up to 30% in the case of high risk ones.

3. First case study: pejibaye (*Bactris gasipaes*) palm cabbage production (Govinden, 2004 a & b)

3.1 Main agro-ecological requirements

Production should be limited to the superhumid belt with between 2000 and 3000 mm of annual rainfall, because below the lower limit and above the upper limit, performance drops.

Very adverse soils, that is, very shallow, or very acidic (pH < 4.5), or waterlogged ones should be avoided. Other adverse soil conditions can probably be amended without excessive costs. Thus, very rocky soils do not matter. At land preparation time, drains can

be dug to improve external drainage; acidity can be corrected with lime and, inherently poor fertility can be restored through the use of chicken manure or factory filter mud.

Except in small fields near residences where dogs will keep hares away, the fields have to be fenced to avoid hare damage to seedlings. Since the fences have to be left in place for 1½ years, they can be re-used only once.

Wind breaks should be planted except in well-protected areas. Giant bamboo (*Dendrocalamus giganteus*) can be used in large fields and sang dragon (*Pterocarpus indicus*) in smaller ones. The shoots of the former can provide some additional revenues. The latter can also serve as a live fence post.

Well-developed seedlings should be transplanted early in the rainy season, in January if possible, to ensure good establishment.

After a couple of manual weedings, a herbicide should be used to reduce the cost of weeding. On some fields where there are no obstacles, a mechanical mower can be used. In due course, an improved system would be to grow a cover crop to control soil erosion. None has been tested yet.

Fertilizers should be applied regularly or, if chicken manure or factory filter mud are available, they should be preferred.

3.2 Advantages of the pejibaye palm (Govinden, 2004b)

It is adapted to the superhumid zone.

It grows very fast. In the superhumid zone, it can be expected to reach harvest size in 2 to 2 ½ years after transplanting, depending on soil fertility and management.

It regrows from suckers. The suckers reach harvest size in just 2 years. Extra suckers which should be removed could be pickled for additional revenue.

It has no pest or disease of importance. Thus, pesticides are not required. In due course, if a suitable cover crop can be found to obviate the need for herbicides, organic production could be attempted.

The palm cabbage quality is excellent. Since it does not oxidize, it lends itself to packaging for the convenience of supermarket customers.

3.3 Drawbacks of pejibaye

It is very susceptible to hare attacks. Currently, the preferred solution is a good fencing.

It is more susceptible to cyclone damage than most other palms (Govinden *et al*, 2004). Three ways to minimize this risk are, firstly, to plant deeper than other palms to improve anchorage; secondly, to grow windbreaks; and thirdly, every year to harvest all tall shoots before December so as to leave only suckers during the cyclonic season. Tall shoots could be uprooted in a cyclone, but the suckers could lose their leaves without the stem breaking.

On slopes, there is a risk of soil erosion at planting. A good option on sugar cane lands would be to prepare furrows and to plant the pejibaye directly in the old cane without further land preparation.

3.4 Considerations for a business plan for pejibaye

3.4.1 Financial viability

Although 2500 seedlings are planted per hectare, one should bank on harvesting 2000 after 2 to 2 ½ years. The current average farmgate price of one shoot is MUR 250 (range 225-275). With the projected increase in production, it could drop to MUR 200. A safe working hypothesis would be MUR 150. Thus, gross returns would amount to MUR 300 000 after 2 to 2 ½ years, or MUR 120 000 to 150 000 per annum. Thereafter, with the suckers, MUR 300 000 would accrue every two years or MUR 150 000 per annum.

To initiate plantation, a loan may be necessary. It could be repaid over four years after a moratorium of three years. Over seven years, the grower would have grossed about MUR 900 000 and spent about MUR 140 000. This gives an average net return of MUR 108 000/annum for the first seven years. Thereafter, it increases to MUR 120 000/annum because the loan will have been cleared. Thus, on this first count, in the first seven years, pejibaye will give net returns far better than sugar cane. A grower could earn a living on a single hectare.

3.4.2 Sustainability

The duration of a pejibaye plantation is not known. There are cases of 25 years or more in Costa Rica, but cyclones are rare there. Here, with cyclones, the best may be 14 years, which may be adequate for recycled cane growers. The new entrants may have to plan to replant once.

The increase in net returns after seven years can compensate for adverse changes in business environment, such as increased costs, depreciation of the rupee and drop in prices.

The size of the domestic market is unknown. Currently, the supply is inadequate. The export market has not been prospected. Mauritius is unlikely to be competitive on the market for canned palm hearts. Niche markets for the fresh product should be sought.

3.4.3 Resilience

Cyclones are unavoidable. The risk of damage should be minimized as explained in 3.3. In the superhumid zone to which pejibaye is adapted, there is little risk of the plant suffering from drought except in the first year. For this reason, early planting has been recommended. However, in the wetter part of the zone (3000 mm), there is a risk of excess water. For this reason, it has been recommended to avoid soils with poor internal drainage and to establish a proper external drainage system.

The pejibaye is one of the fastest perennial crops to yield returns. Nevertheless, a grower will be without revenue for the first 2 to 2 ½ years. Moreover, the grower would need to finance the plantation and maintenance costs. Thus, a loan is unavoidable. The terms assumed in 3.4.1 should be checked with loan agencies.

3.4.4 Marketing and value-addition

Currently, growers sell whole palm shoots in the field. Prospective buyers transport them to the main customers – hotels and restaurants. It has been assumed that the current system will continue. Improvements further down the chain, such as extracting the palm heart from the shoot and packaging it for sale to supermarkets would not improve growers' revenue, but they would open up new markets. Likewise, processing the palm hearts into spicy pickles (*achard*) and palm hearts in brine add value and enlarge and stabilize the market. They also reduce the risk of a drop in price, create further employment opportunities and reinforce the pejibaye palm heart cluster. A separate business case could be made in future for developing the industry as a cluster, especially if export is envisaged.

Another interesting future development which should be tested is the possibility of harvesting the suckers annually when they are still too small for the local market but quite appropriate for pickling. The risk of cyclone damage would disappear and cash flow would be improved, but net returns may not be higher.

3.4.5 Conclusion

Pejibaye appears to be a good candidate alternative crop. There are some risks which should be minimized and some uncertainties on, for instance, market size and loan conditions which have to be settled. The crop also offers interesting development prospects with improved marketing and with processing. A research project on these would be justified.

4. Second case study: pitaya or dragon fruit (*Hylocereus undatus*)

4.1 Main agro-ecological requirements (Govinden, 2006)

In contrast to pejibaye, pitaya prefers a dry climate. It does best with less than 1500 mm annual rainfall. It can also grow in regions with up to 2000 mm, but flowering and fruit production may be affected.

It grows on all soil types from sand to heavy clays, but it cannot withstand waterlogging. Pitaya is a climbing plant and must therefore be provided with a support. It is best grown on a trellis (Anon, 2006).

It is grown from stem cuttings, which strike roots readily. At planting, some inorganic fertilizers may be used, but organic sources of nutrients, such as manure, compost and factory filter mud are preferable.

Pitaya does not have pests and diseases of importance, but it is very susceptible to snail attacks, especially when it is young.

Pitaya must be hand cross-pollinated; otherwise, it does not produce fruits. Therefore, it is essential to plant two cross-compatible clones.

4.2 Advantages of pitaya

Pitaya is adapted to practically the whole of the humid and subhumid zones of Mauritius and the whole of Rodrigues.

It grows very fast and can produce the first fruits within a year of plantation and achieve a stable yield after three years.

There is no need to purchase plants for new plantations or for extension of plantations because it can be grown very easily from cuttings.

There is no need to control pests and diseases except snails in the first year.

The fruit is exceptionally attractive, in high demand, fetches a very high price and keeps well.

4.3 Drawbacks of pitaya

It is not adapted to the Central Plateau where it is too rainy and cool.

Pitaya has to be cross-pollinated and this requires much labour on only a few days per year.

It requires a support which is costly.

On slopes, precautions must be taken at planting to prevent soil erosion. As with pejibaye, it may be preferable to leave the old sugar cane *in situ* and to plant the pitaya in furrows without any further land preparation.

4.4 Considerations for a business plan for pitaya

4.4.1 Financial viability

Currently, the retail price in Europe and the USA is about MUR 200 per kg or about MUR 100 per fruit of normal size. Here, a farm gate price of MUR 25 per fruit has been assumed, leaving a large margin for the retailer and a good deal for the customer. High density planting of 5000 plants per hectare at the rate of 2 plants per hill has been recommended. After one year, one should not expect to harvest much more than about 10 000 fruits worth MUR 250 000 at the farm gate. This should help defray initial costs. In the second year, the target should be 50 000 fruits worth MUR 1 250 000 and, in the third year, a stable production of 75 000 fruits worth MUR 1 875 000.

Costs are not well known. Main items include construction of a trellis and labour for pollination. Total costs during the first five years have been estimated to amount to MUR 250 000. The very high returns starting from the second year after plantation should make pitaya attractive financially.

4.4.2 Sustainability

Pitaya is a perennial. As from the third year, it should be pruned to a stable size as a function of the spacing. Otherwise, it will grow wild and there would not be space to cross-pollinate. Its reaction to cyclones is not known, which is why a solid structure, regular pruning and the use of wooden posts to lead the roots into the soil have been recommended. Thus, even if the posts were to snap in heavy wind, the plants could be straightened up again. In any case, new shoots would come out fast to replace broken ones. Moreover, because pitaya flowers in flushes, all the fruits present on the plants could be lost during a cyclone, and more flowers would come out soon afterwards. Nevertheless, a wind-break would be helpful to minimize cyclone damage.

The net returns are so high that business risks should be well covered.

The size of the domestic market is unknown, and the export market has not been prospected.

4.4.3 Resilience

Methods have been proposed in 4.4.2 to minimize the risk of cyclone damage. Drought should not be a problem because the plant is tolerant to drought. Heavy rains can reduce yields in the superhumid region, which is why pitaya has not been recommended for the zone. Poor soils should not be a problem either. All that pitaya needs is some organic fertilizer every year.

Pitaya is even faster than pejibaye in yielding returns. This should help pay for establishment costs.

4.4.4 Marketing and value-addition

Fresh pitaya is such a high-value crop that there may not be any need to process it for value-addition. Low-grade fruits – bruised, undersized and split – can be processed into jam. Pitaya has not yet been marketed locally, but it has been present on export markets in Europe and USA for several years. Those who have tasted the fresh fruit here contend that it should sell itself. It should simply be wrapped in cling film and presented in super markets. If it is chilled, it will keep for two weeks at least.

4.4.5 Conclusion

Pitaya is undoubtedly an excellent candidate alternative crop. The only major risk is that of saturating the domestic market. This implies checking the export market right away and looking for ways to extend the production season.

Pitaya has a few very high peak labour demands for cross-pollination every year. The use of casual labour should be envisaged. A good research project would be to seek a self-compatible clone which would be pollinated by bees.

5. General conclusion

In this paper, the characteristics of a good alternative crop to substitute for sugar cane in small-scale growers' fields on marginal lands have been defined. The characteristics show that perennials should be favoured because they minimize the need to replant. This is particularly relevant on sloping land susceptible to soil erosion. Annuals may be financially more attractive, but they would cause soil erosion on the slopes and hence, their production would not be sustainable. With the two crops there is a risk of soil erosion on slopes at planting. Fortunately, they do not have to be replanted and some simple methods can be adopted to minimize this risk.

The land which is most likely to go out of cane is marginal. Some are on steep slopes, some are in areas which are too wet or too dry. The two case studies show that, on one hand, pejibaye may be appropriate for very humid regions while, on the other hand, pitaya could be grown in the dry regions. In this sense, the two crops are complementary.

As with all other crops in Mauritius, both alternatives are susceptible to cyclones, with which growers must learn to live and whose damage they must attempt to minimize by appropriate management.

The elements which should be considered in business plans have been discussed. Of course, the business plans themselves must be made on a case by case basis since each potential grower may have land in particular areas, may be financially endowed differently, may have family labour or may not, may be willing to take risks to different extents and may have different revenue needs and expectations. In addition, few small-scale cane growers have experience with the management of alternative crops and, consequently, the management requirements should also be considered in the business plans.

6. References

Anon. 2005. *A roadmap for the Mauritius sugar cane industry for the 21st century*. 15 pp. Port Louis, Government of Mauritius.

Anon. 2006. Growing pitaya: I. Guidelines for plant establishment. Recomm. Sheet 157 (May 2006): 2 pp. Réduit, Mauritius Sugar Industry Research Institute.

AREU. 2006. *Land suitability at Midlands*. P Hanoomanjee (pers. Comm.) Mimeo doc. Quatre Bornes, Agricultural Research and Extension Unit.

Govinden, N. 2004a. *Guide de la production de coeurs de palmiers à Maurice*. Adv. Bull., 8 : 22 pp. Réduit, Mauritius Sugar Industry Research Institute.

Govinden, N. 2004b. Prospects of palmito production from pejibaye-revisited. Occ. Paper 38 : 8 pp. Réduit, Mauritius Sugar Industry Research Institute.

Govinden, N, Wong Yen Cheong, K and D'Espagnac, L. 2004. Cyclone damage to eight species of palms at different growth stages. In Lalouette, J A, Bachraz, D Y and Bheenick, K J (eds). *Proceedings of sixth meeting of agricultural scientists*, pp 311-318. Réduit, Food and Agricultural Research Council.

Govinden, N. 2006. *La pitaya ou fruit du dragon: un atout pour le développement fruitier à Maurice*. Presented at MSIRI, March 3, 2006. Mimeo (unpublished): 26 pp, Réduit, Mauritius Sugar Industry Research Institute.

Ministry of Housing and Lands. 2003. *National development strategy. Vol 1, development strategy and policies*. 212 pp + Appen. Port Louis, Government of Mauritius.

Tonta, J A and Ramasamy, S. 2006. *Agro-economic study of difficult areas under sugar cane*. Occ. Rep. 32:39 pp + Appen, (In Press). Réduit, Mauritius Sugar Industry Research Institute.

22. * PARISH, D.H. *and* FEILLAFE, S.M. Notes on the 1 : 100 000 soil map of Mauritius. August, 1965; 43 p.; 4 figs.; 5 col. pl.; 2 tbls.; 1 map [Map : D.O.S. (Misc.) 317. Published by Directorate of Overseas Surveys. Printed by the Ordnance Survey, U.K. (2,500/8/ 62/1374/OS)]. Reprinted September 1998.

23. HALAIS, P. *and* DAVY, E.G. Notes on the 1 : 100 000 agro-climatic map of Mauritius, compiled by the Mauritius Sugar Industry Research Institute and the Mauritius Meteorological Services. June 1969; 27 p.; 3 figs., 6 tbls., 5 maps. [Map : D.O.S. (Misc.) 446. Published by Directorate of Overseas Surveys. 1967. Printed by the Ordnance Survey, U.K. (3,500/5/67/3522/OS)]

24. WILLIAMS, J.R. The position of the spear guiding ring in *Xiphinema* species. November, 1966. *Nematologica* 12 (1966) : 467-469, 1 fig.; 2 tbls.

25. WILLIAMS, J.R. Observations on parasitic protozoa in plant-parasitic and free living nematodes. December, 1967. *Nematologica* 13 (1967) : 336-342, 5 figs. (including 4 pl.), 2 tbls.

26. * WILLIAMS, J.R. Studies on the biology, ecology and economic importance of the sugar cane scale insect, *Aulacaspis tegalensis* (Zhnt.) (Diaspididae) in Mauritius. December 1970. *Bull. ent. Res.* 60 (1970) : 61-95, 15 figs.; 5 pl.; 9 tbls.

27. WILLIAMS, J.R. The biology of *Physcus seminotus* Silv. and *P. subflavus* Annecke & Insley (Aphelinidae) parasites of the sugar cane scale insect *Aulacaspis tegalensis* (Zhnt.) Diaspididae) June, 1972. *Bull. ent. Res.* 61 (1972); 463-484, 7 figs.; 1 pl.; 4 tbls.

28. * WILLIAMS, J.R. (*comp*.) Entomological parasite-host records from Mauritius. June, 1974. 33 p.

29. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS *and* MAURITIUS SUGAR INDUSTRY RESEARCH INSTITUTE. Notes on the land resources and agricultural suitability map of Mauritius 1 : 50 000, by E.Z. ARLIDGE *and* Y. WONG YOU CHEONG. 1975; 138 p.; 7 figs.; 4 pl.; 15 tbls.
[Map in two parts accompanied by legend. Printed by Litografia Artistica Cartografica, Firenze, Italy 1973]

30. WILLIAMS, J.R. *and* LUC, M. The species of *Xiphinema* Cobb, 1913 (Nematoda : Longidoridae) in the sugar cane fields of Mauritius. October, 1977; 19 p.; 8 figs.; 6 tbls.

31. WILLIAMS, J.R. An annotated check list of the invertebrates (insects, mites, nematodes) of sugar cane in Mauritius. October, 1978. 22 p. (Rev. and enl. ed. of No. 8, 1962).

32. WILLIAMS, J.R. *(comp.)* Entomological parasite-host records from Mauritius. March, 1980. 39 p. (Rev. and enl. ed. of No. 28, 1974).

33. OFFICE DE LA RECHERCHE SCIENTIFIQUE ET TECHNIQUE OUTRE-MER *and* MAURITIUS SUGAR INDUSTRY RESEARCH INSTITUTE. Carte pédologique de l'île Maurice 1 : 50 000, dressée par P. WILLAIME, pédologue à l'ORSTOM, accompagnée d'une *Notice explicative simplifiée.* Avril 1984; 24 p. incl. of 2 annexes and map in 3 sheets.

34. INSTITUT FRANCAIS DE RECHERCHE SCIENTIFIQUE POUR LE DEVELOPPEMENT EN COOPERATION *and* MAURITIUS SUGAR INDUSTRY RESEARCH INSTITUTE. Carte pédologique de l'Ile Rodrigues à 1 : 20 000, dressée par P. DE BLIC, pédologue à l'ORSTOM. 1985. [Note : the map was published as MSIRI *Occasional Paper* No. 34 (1985), while the explanatory notes were published as MSIRI *Technical Circular* (N.S.) No. 3 (1986)].[Please see under *Technical Circular* (New Series)].

35. MAMET, J.R. *and* WILLIAMS, J.R. The recorded foodplants of Mauritian insects. December, 1993. 202 p.

36. GANESHAN, S. and WILLIAMS, J. R.Entomological parasitoid-host records from Mauritius. December 2000. 45 p. (2^{nd} rev. ed. of no. 32) (ISBN 99903 24 15 8).

37. JHOTY, I., RAMASAMY, S., GOVINDEN, N., (comps.) Suitability of sugar cane lands for potato and tomato: notes and maps 1: 150 000 scale. 2001. 12 p.: 5 tbls, 2 maps.

38. GOVINDEN, N. Prospects of Palmito production from Pejibaye – revisited. 2004. 8 p.

**** publication out of print***

OCCASIONAL PAPERS

1. WILLIAMS, J.R. Studies on the nematode soil fauna of sugar cane fields in Mauritius. 1. The genus *Mononchus* (Trilobidae, Enoplida). October, 1958; 13 p.; 32 figs.

2. WILLIAMS, J.R. Studies on the nematode soil fauna of sugar cane fields in Mauritius. 2. Belondiridae (Dorylaimoidea, Enoplida) November, 1958; 9 p.; 8 fig.

3. WILLIAMS, J.R. Studies on the nematode soil fauna of sugar cane fields in Mauritius. 3. Dorylaimidae (Dorylaimoidea, Enoplida) February, 1959; 28 p.; 29 figs.

4. * WILLIAMS, J.R. Studies on the nematode soil fauna of sugar cane fields in Mauritius. 4. Tylenchoidea *(partim)* January, 1960; 30 p., 13 figs., 2 pl.

5. ROCHECOUSTE, E. Botanical and agricultural characters of sugar cane varieties of Mauritius. 1. Ebène 1/37 and M 147/44. August 1961, 7 p.; 7 figs. (including 2 col. pl.)

6. * WILLIAMS, J.R. Studies on the nematode soil fauna of sugar cane fields in Mauritius. 5.Notes upon a parasite of root-knot nematodes. September, 1961. N*ematologica* 5, (1960) : 37-42, 3 figs.

7. WILLIAMS, J.R., *(comp.)* A bibliography of sugar cane nematology. January, 1962; 12 p.

8. * WILLIAMS, J.R. *and* MAMET, J.R. The insects and other invertebrates of sugar cane in Mauritius and Réunion. January, 1962. (Rev. & enl. ed. of *Bull. Dep. Agric. Maurit.* No. 89, 1954). 23 p.

9. GEORGE, E.F. An experiment to compare the selection of sugar cane varieties from seedlings bunch planted in two different ways and from others singly planted. February, 1962; 35 p.; 7 figs., 21 tbls.

10. * ROCHECOUSTE, E. Studies on the biotypes of *Cynodon dactylon* (L.) Pers. 1. Botanical investigations. March, 1962. *Weed Res.* 2 (1962) : 1-23, 7 figs., 2 pl., 3 tbls.

11. * ROCHECOUSTE, E. Studies on the biotypes of *Cynodon dactylon* (L.) Pers. 2. Growth response to trichloroacetic and 2,2-dichloropropionic acids. June, 1962. *Weed Res.* 2 (1962) : 136-145, 4 tbls.

12. SENTENAC, R. Recherches d'eau souterraine à l'Ile Maurice. 1. Généralités. Juillet, 1962; 27 p.; 12 figs.

13. HAYWARD, A.C. Studies on bacterial pathogens of sugar cane.
    1. Differentiation of isolates *Xanthomonas vasculorum*, with notes on an undescribed *Xanthomonas* sp. from sugar cane in Natal and Trinidad. 3 tbls.
    2. Differentiation, taxonomy and nomenclature of the bacteria causing red stripe and mottled stripe diseases. October, 1962; 27 p.; 4 pl.; 4 tbls.

14. * WILLIAMS, J.R. A new genus and species of Nygolaimidae (Enoplida). December, 1962. *Nematologica* 8, (1962) : 225-228, 1 fig.

15. SENTENAC, R. Recherches d'eau souterraine à l'Ile Maurice. 2. Secteurs de Pamplemousses, Rivière du Rempart, Plaine des Roches, Nouvelle Découverte. Octobre, 1963; 28 p.; 9 figs.

16. SENTENAC, R. Recherches d'eau souterraine à l'Ile Maurice. 3. Secteurs de Flacq, Grand Port. Novembre, 1963; 29 p.; 10 figs.

17. SENTENAC, R. Recherches d'eau souterraine à l'Ile Maurice. 4. Secteurs de Plaines Wilhems, Rivière Noire, Chamarel. Conclusion générale. Décembre 1963; 24 p.; 5 figs.

18. ROCHECOUSTE, E. Botanical and agricultural characters of sugar cane varieties of Mauritius. 2. M 202/46, M 93/48, M 253/48 and Ebène 50/47. August, 1964; 18 p.; 13 figs. (incl. 4 col. pl.).

19. GEORGE, E.F. Physiological growth attributes of *Saccharum* clones and their progenies. January, 1965. *Ann. Bot.* 29 (1965) : 153-165, 2 figs., 7 tbls.

20. WILLIAMS, J.R. Studies on the nematode soil fauna of sugar cane fields in Mauritius. 6. *Eudorylaimus sundarus* N. sp. (Dorylaimidae) February, 1965. *Nematologica* 10 (1964) : 319-322, 1 fig.

21. WILLIAMS, J.R. Studies on the nematode soil fauna of sugar cane fields in Mauritius. 7. Species of *Thornenema* (Dorylaimidae). February, 1965. *Nematologica* 10 (1964) : 345-352, 3 figs.

ISBN 99903-24-23-9
continued on inside back cover