Original scientific paper
10.7251/AGRENG1803031V
UDC 633.61:631.147(963)

ORGANIC SUGARCANE CULTIVATION IN TAHITI

Marotea VITRAC[1*], Taivini TEAI[1], François-Régis GOEBEL[2], Ines SHILI-TOUZI[3]

[1]Research mixt unity about Insular ecosystems in Oceania (UMR 241 EIO), University of French Polynesia (UPF), Punaauia, French Polynesia
[2]Agroecology and sustainable Intensification of annual crops (AÏDA) department,CIRAD, Agricultural research for development, Montpellier, France
[3]Higher International Agro-development School of Engineer, ISTOM, Angers, France
*Corresponding author: maroteav@gmail.com

ABSTRACT

Organic sugarcane has a strong economic potential in Tahiti. However, there is no model for small-scale organic cultivation, and the rules enforced by the applicable standards don't always respect the agroecological principles. To determine whether a small organic sugarcane farming system is profitable or not, especially in terms of productivity, control of bioagressors (weeds, rats and pests) and human resource costs, a 1ha field of sugarcane was planted in 2015, with nine different varieties, in a machineable context under European organic standards. After two years, the cultivars used showed yields from 40 up to 100 tons/ha of cane. Regarding the control of bioagressors results were the following: 1) manual removing of weeds required 4 to 6 months after planting or after the first ratoon; 2) study of rat attacks during the maturation period showed that in a dirty field, for early varieties (18° Brix at ten months of cultivation), the cane stalks can be entirely damaged, and these attacks can even occur on canes with sugar content lower than 10%. Finally, the hand labor hoeing represented around 75% of the production costs. This result demonstrates that such organic cultivation is possible even when facing pest and weed problems. In further investigations, to improve hand labor efficiency, we will first focus on weed control using small mechanized treatments; secondly, we will aim at reducing rat infestations by the use of some unique early maturated varieties to attract and treat them locally.

Keywords: *Organic cultivation, agroecology, sugarcane, French Polynesia, Tahiti.*

INTRODUCTION

Sugarcane (Poaceae family) has been developed from decades firstly to produce sugar and secondly ethanol, paper, energy and rum. It is a multiannual crop which grows under tropical climates, producing biomass during the rainy season and sugars (mainly sucrose) during the dry season (Fauconnier, 1991).In 2016 the areas

under cultivation worldwide were about 26,77 million of hectares (ha) representing1,89 billion tons with an average yield about 70 t/ha (FAO statistic division, 2017). The areas under organic sugarcane cultivation were about 44 467 ha in 2011 (Willer & Lernoud, 2013) and increased up to 91 734ha in 2015 (Willer & Lernoud, 2017) representing 0,38% of the global world amount. Based on the IFOAM (International Federation of Organic Agriculture Movements) statistics, the certified organic producers in French Polynesia grown from21 in 2012 with 2,5 ha, up to 270 in 2015 with 167 ha, showing a great interest for this type of agriculture in these islands. In the French tropical island of Tahiti, some distilleries decided in 2015 to plant some sugarcane in order to produce high valuable rums. One of them decided to do it under full organic standards. Such a farming system has a strong potential to grow due to (1) the quick evolution of all the sugarcane cultivated surfaces from 1ha in 2015 up to 25ha in 2018 (industrial data from distilleries); (2) the high interest regarding organic productions in the world and particularly in French Polynesian; (3) the prohibition of the glyphosate herbicide which will happen in the very next year following European regulations and (4) the advantages offered by the finish product : a good shelf life, a low space storage and a high selling price. However, there is no model for small-scale organic farming systems, and the rules enforced by both European and Pacific NOAB (in French: Norme Océanienne d'Agriculture Biologique) applicable standards don't always respect the agroecological principles. There is also a big gap between the organic agriculture practiced for sugar industry and the possibilities offered by the island of Tahiti in terms of topography and land availability, the machineable lands being located mostly on ferralitic soils (Jamet, 1987). Such a gap is also regulatory and technical because (1) some of organic productions can be IFOAM certified even using destructive methods such as flame burnings to remove weeds (Ascard, 1990); (2) no sugarcane farming systems, organic fertilizers or inputs are available to start a sugarcane production in Tahiti. Contrary to the agroecological principle of proximity, almost all the goods are imported by boat from abroad and far from several thousand kilometers. Fortunately, it was quite easy to find some canes in the gardens of the Polynesians to collect the cuttings. They are different by each other regarding their morphology, but all containing good amounts of sugar. In fact we found in the bibliography (Fahrasmane & Ganou-Parfait, 1997; Artschwager & Brandes, 1958) that the Otahiti cane is a very special variety of *Saccharum officinarum* which was cultivated when Bougainville arrived in 1768. It is furthermore a good commercial argument associated to organic standard production for a high value-product. On the other hand, we didn't found technical references as how to cultivate sugarcane in Tahiti or relative to fertilization and only one reference regarding bioagressors (Hammes *et al*., 1989). To identify the varieties we found old literature (Cuzent, 1860; Henry, 1928) and some interesting data regarding the areas cultivated and the sucrose yields (Toullelan, 1986) but nothing technical to help us. We then chose to be close to agroecological improvements carried out in the island of La Réunion where some organizations such as CIRAD (in French: Centre de Coopération International en Recherche

Agronomique pour le Développement) and eRcane (private company working on sugarcane development) are developing research programs around organic fundamentals. For example, Chabalier *et al*. (2012) proposed manual weed removing on a first ratoon after hand harvesting. In this study, even if herbicides are still used they also evaluated the efficiency of natural covering following an agroecological management. The first issue is actually weed development as it is the first bioagressor regarding sugarcane growth (Marnotte *et al*., 2008). This issue was also treated by considering mechanical weed control as a very effective process (Bond & Grundy, 2000). In a second time, when the sugar content increases in the stalks, the rats could be the main problem (unpublished data from Coulis M., 2015; Hood *et al*., 1970). Such information convinces us to run a local organic production based on local varieties without using any chemicals and inputs plus a technical management proven from abroad.

MATERIAL AND METHODS

Under European and NOAB organic standards, a field about1 ha was planted in a machineable context in December 2014. A plot of about 2 835 m² was delimited to evaluates even varieties (315m² each) in 2015, and nine in 2016. Eight varieties were found around the island of Tahiti, and one was located in Taha'a in the same archipelago (Society Islands). Harvesting in private gardens produced 3,125 tons in 2015. The experiment began (without irrigation) at the end of the dry season, to harvest the first canes 12 months later (December 2015) and first ratoon 24 months later (December 2016). A specific design using stripes was organized with one variety per stripe (composed of three rows) perpendicularly to a slope of about 3%. Before planting, original vegetation composed mostly of ferns was cut. Organic fertilization was then produced to correct the desaturated soil by spreading vinasse from the distillery (20t/ha), composted equine manure (5t/ha) and dolomite (2 t/ha). Minimum soil tillage was conducted (15cm deep) before creating furrows. Manual planting using "one eye" cuttings was done in paired rows with a distance between the plants of about 50cm and 1,6m (interrows), representing 20 000 cutting stalks/ha. Weed removing was conducted manually by using a tiny hand hoe in the row and using a 4WD micro-tractor of about 16 horsepower (1,1m width) with a rotative disposer for the inter-row. Yields were estimated on 3 x 100 kg of fresh full hand-harvested canes by stripe, to get a range of data in this agricultural context. These canes were crushed one time (hand feeding three rolls 1t/h crusher), and the weight of juice was measured for each sample of 100kg (giving us the crushing yield) and also for each whole stripe plot about 315m². The Brix degree was also measured for each group (5 canes: bottom, top, and middle) with a portable visual refractometer. We then deducted the production of biomass of sugarcane per stripe. Regarding rat control, we used plastic PVC pipes placed in the stripes (2 for each group) as traps containing the rodenticide (brodifacoum 0,005%). We then counted and weighed the total amount of stalks damaged just after the shootings occurred. Finally, we added the weight of sugarcane produced and the weight of stalks damaged to get the global amount of sugarcane produced

per stripe to calculate the total yield in t/ha. The cultivation calendar for agricultural operations in the years of 2015 and 2016 is shown in table 1.The global costs for such a cultivation method were then established, separating hand labor from mechanization and inputs.

Table 1. Monthly cultural operations from plantation to the first ratoon.

	jan	**feb**	**march**	**april**	**may**	**june**	**july**	**aug**	**sept**	**oct**	**nov**
2015	G+H1	G+H1	G+H1		G+H1	R	G+H1		H2+R		H2+S
2016	G+H1		G+H1			B	G+H1 R- B	B	H2+R	H2+S	

G: rotative disposer (1 people – 1 day); R: rat treatment
S: straw removing; B: Brix degree during growth
H1: hand hoeing (5 people - 5 days) before cane inter-row closure
H2: hand hoeing (5 people – 5 days) after cane inter-row closure

RESULTS AND DISCUSSION

No competition with weeds was observed at the plantation as the field was just prepared once planting the one eye cuttings. But after only 3 to 4 weeks of culture, they started to grow again. Even if one eye cuttings are more expensive, they allow a quick plant development and may give more resistance to isolated drought which can occur in the rainy season (Gonthier, 2012). Moreover, such a technique used fewer cuttings than the conventional one, which was necessary in our context. Regarding cane production after harvest, the average yields were69,0 ton/ha in 2015 and 60,9 ton/ha in 2016. The yield difference between varieties were very high from 34,7 to 111,1 ton/ha (Table 2)with excellent reliability in 2015, which was not the case in 2016 because of the massive rat attacks occurred during the early winter. We didn't maintain the field at all during three months between April and June, creating perfect conditions for rapid rat development inside the trial even if the Brix values were less than 10° at this period (light greyed out cases in Table 3). In Hawaii Hood (1970) showed that the highest populations of rats occurred in late summer and early winter, which is in accordance with our situation. At the same time, the best sugarcane yields are usually obtained in the first ratoon (Fauconnier, 1991). It was not the case for us even adding the damaged cane to the global sugarcane weight (Table 2). It is probably due to the heavy weed pressure during the first three months without any husbandry. This result showed the importance to keep the field clean in anytime.

Table 2.Production data and yields obtained from 2015 and 2016 trials. Yields in sugarcane per stripe (t/ha). Modern varieties are the 6,7 and 8.The others are noble sugarcanes.

	juice vol. / stripe (l)		Juice yield (%)		Cane weight/stripe (kg) (1)		Number of damaged stalks		Weight of damaged stalks (kg)(2)		Cane weight/ stripe (kg) (1+2)		Cane yield (t/ha)	
	2015	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
1	1686	897	69%	60%	2 443	1 495		199		467	2 443	1 962	77,6	62,3
2	1012	122	68%	48%	1 488	254	66	408	165	995	1 554	1 249	49,3	39,7
3	586	120	75%	50%	781	240	313	385	781	860	1 094	1 100	34,7	34,9
4	1210	524	68%	50%	1 779	1 048		291		625	1 779	1 673	56,5	53,1
5	1050	225	70%	55%	1 500	409		382		795	1 500	1 204	47,6	38,2
6	2100	1173	60%	55%	3 500	2 133		366		790	3 500	2 923	111,1	92,8
7	2000	1360	60%	50%	3 333	2 720					3 333	2 720	105,8	86,3
8		1400		60%		2 333						2 333		74,1
9		675		60%		1 125		450		963		2 088		66,3

Table 3. Brix data for each variety between the 6th of June and 1st of August 2016. SD : Standard deviation.

	June 6th		June 27th		July 11th		Aug. 1st	
	average	**SD**	**average**	**SD**	**average**	**SD**	**average**	**SD**
1	9,54	1,72	11,30	1,75	11,71	1,48	14,52	0,90
2	14,67	2,92	14,21	1,22	15,24	2,06	15,56	0,69
3	12,47	1,12	9,69	2,02	12,71	0,68	16,05	0,37
4	9,19	1,51	9,63	2,43	9,49	0,75	13,78	0,39
5	12,00	2,53	12,51	1,87	12,65	1,27	14,59	0,99
6	14,09	1,45	15,43	3,44	14,82	1,80	14,89	0,69
7	16,37	1,82	15,39	1,69	16,63	0,96	15,91	0,29
8	10,64	3,07	10,21	1,69	11,33	2,51	15,71	0,62
9	9,37	2,62	10,29	1,95	11,42	0,93	12,58	1,84

We noticed that standard deviation decreased month after month, due to reversal amount of sugars from the bottom to the top, the sign of over-maturation (Fauconnier, 1991). Some varieties seemed to be mature around 25th of July at eight months after the first harvest (greyed out cases). In the tables 2 and 3, regarding varieties (2, 6 and 7), Brix degrees were quite high (up to 14) since June after only six months of growth. The highest yields were obtained for varieties 6 and 7 with more than 100 t/ha. This means that we probably found some modern varieties. It is very different for the variety 2 which had yield lower than 50 t/ha where rat attacks were also very high even in 2015 and 2016. This observation is of particular interest because this variety could be used as trap for rats in and around sugarcane plantations. In term of method, it is important to first observe if the ratoons are good (4 or 5 at least) before any further investigations to identify a variety with good agricultural potential. Similarly, the variety 3 only reached a Brix about 16 in August and suffered from hefty losses regarding rat attacks. This variety could also be used as trap crop for rats, with the particularity of a different attractive period. An association with service plants could be beneficial to keep some vegetation to shelter the rats but at the same time allowing the sugarcane growth (Antoir *et al*., 2016 and non published data from a seminar on service plants, CIRAD, 2018).We also observed two groups in Table 2, separated by their yields: the varieties with yields of more than 70 t/ha (6, 7, 8) and those with less (1, 2, 3, 4, 5, 9). This result was reinforced regarding Brix degree which is still very high for 6, 7 and 8 contrary to the others. We suppose that the Otahiti canes (the noble *Saccharum officinarum*) constitute the group with the lower yields and the lower Brix. We consider that the high desaturated ferralitic soil is a limiting factor for their development as opposed to the modern varieties with can produce good yields even under bad conditions of soil fertility. To separate the *Saccharum officinarum* noble canes (which could be the Otahiti ones) from the modern varieties, some samples of each variety should be examined using cytogenetic techniques and molecular biology genotyping to compare them as Schenck *et al*. (2004) did with Hawaiian varieties. However, apart from the canes supposedly to be modern cultivars, some cultivars seem to have a good potential (1 and 4) because (1) they seem to be manageable if the calendar cultivation is correctly followed (see no rat attacks in 2015);(2) their yields are above 50 t/ha with good Brix levels, and a good sucrose yield in the early period for the variety number 1 and a little late period for the variety number 4.It means the cultivation methods used allow producing and harvesting good amounts of sugarcane. To improve them investigations should be conducted with different mechanization ways using, for example, fake seedling techniques and other tools like a cover crop to reduce weed development(Bond & Grundy, 2001), human labor and finally the production costs. We could associate it with some natural covers using the residue produced after cane crushing (bagasse) thereby reducing the needs of fertilizer inputs and at the same time fighting against weed development (Quénéhervé *et al*., 2005).On the other hand, we need to get more information about the bioagressors, to adjust the future techniques. We could also propose new chemicals (or alternative ways) to

treat rat attacks (Quénéhervé *et al*., 2005). For example, they could be made locally (to avoid the increase of inputs from abroad and the use of a synthetic product), from the bark extract of *Gliricidia sepium* as a vitamin K inhibitor like described by Berkelaar (2011).

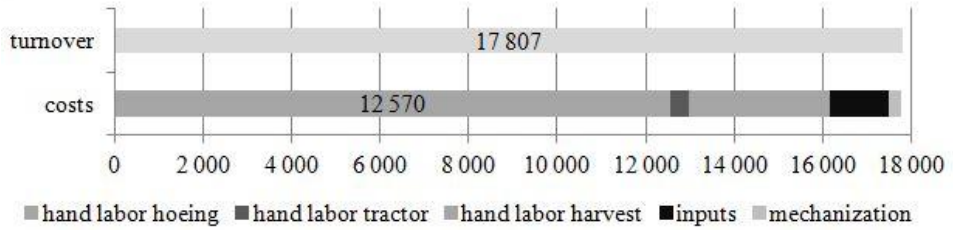

Figure 1. Turnover and production costs by category in Euros (€) / ha in 2015. Financial Balance is obtained even if hand labor hoeing represents 70,6% of the turnover.

Even if the cane closed the inter-rows between May and July (6 to 8 months after plantation or 1st ratoon), weed removing was needed until the harvest to keep the field clean to avoid rat development and make the crop easier to process. So, in Figure 1 we can easily see that the hand labor was the primary cost. It represented 90,8% of the turnover and 91,0% of the production costs. Such a result is encouraging us to continue because of the expensive selling price of the sugarcane: 500 €/t in this context of a highly valueorganic rum production.

CONCLUSIONS

We succeeded in producing a plot of organic sugarcane found locally under agroecological methods and principles. The purpose of such a farming system is to feed a highly valuable network. The first results encourage us for further investigations, improving yields and lowering costs using innovative systems.

REFERENCES

Antoir J., Goebel F. R., Le Bellec F., Esther J. J., Maillary L., Mansuy A., Marion D., Marnotte P., Martin J., Rossolin G., Vincenot D. (2016). Les bonnes pratiques de désherbage de la canne à sucre – Ile de La Réunion 2016. Chambre d'agriculture de La Réunion, 86 pages.

Artschwager E., Brandes E. W. (1958). "Sugarcane (*Saccharum officinarum L.*) Origin classification characteristics and descriptions of representative clones", Agriculture Handbook n°122, 307 p,

Ascard J. (1990). Thermal weed control with flaming in onions. Proceedings 3rd International Conference IFOAM, Non-Chemical Weed Control, Linz, Austria, 175-188.

Berkelaar D. (2011). Recette de *Gliricidiasepium* pour le contrôle des rats. Notes de développement d'ECHO, avril 2011. 17391 Durrance Rd NorthFt., Myers FL 33917, USA. n° 111, pp 11-12.

Bond W., Grundy A. C. (2001). Non-chemical weed management in organic farming systems. Weed research 2001 41, 383-405

Chabalier M., Marion D., Martin J.,Arhiman E., Lambert A., Esther J.-J., Chiroleu F. (2012). Essais de désherbage d'une repousse de canne à sucre après une coupe manuelle à La Réunion. Congrès sucrier ARTAS / AFCAS 2012, La Réunion.

Cuzent M. G. (1860). Tahiti, recherches sur les principales productions végétales de l'île. Imprimerie Ch. Thèze, Rocherfort, 123 p.

Fauconnier R. (1991). La canne à sucre, Maisonneuve & Larose, Paris, 165 p.

Fahrasmane L. et Ganou-Parfait B. (1997). De la canne au rhum. Millau: Edition Quae. 104p.

Food and Agriculture Organization of the United Nations.(2017). FAO statistics at http://www.fao.org/faostat/en/#data/QC

Gonthier J.-Y. (2012). One eye ou "bouture 1 oeil", opportunité de la production. Congrès sucrier ARTAS / AFCAS 2012, La Réunion.

Hammes C., Chant H., Mu L. (1989). Entomologie agricole. Notes et documents n°3. ORSTOM, Chambre d'Agriculture et d'Elevage, TAHITI – Polynésie française.

Henry T. (1928). Ancient Tahiti. Bernice P. Bishop Museum Bulletin, No. 48, 323-335

Hood G. A., Nass R. D., Lindsey G. D. (1970). The rat in Hawaiian sugarcane. Proceedings of the 4th Vertebrate Pest Conference. p11.

Jamet R., (1987). Les sols et leurs aptitudes culturales. Paris : République française, ORSTOM. 70 route d'Aulnay F-93140 BONDY. 128 p.

Marnotte P., Esther J.-J., Martiné J.-F., Jeannette M. R. (2008). Nuisibilité de l'enherbement sur une culture de canne à sucre : rapports d'essais, campagnes sucrières 2005-2006 et 2006-2007.Montpellier, CIRAD-PERSYST, 60p.

NOAB.(2008). Secretariat of the Pacific Community, 2008. Pacific organic standards, Australia.

Quénéhervé P., Dao J.-C., Ducelier D., Langlais C., Lassoudière A., Lhoste P., Mbolidi-Baron H., Soler A., Taupier-Letage B., Toribio A. (2005). Faisabilité technique de l'agriculture biologique à la Martinique : productions pp 166-181 *In* : Agriculture Biologique en Martinique, expertise collégiale IRD, Paris, 2005.

Schenk S., Crepeau M. W., Wu K. K., Moore P. H., Yu Q., Ming R. "Genetic Diversity and Relationships in Native Hawaiian *Saccharum officinarum* Sugarcane", *Journal of Heredity*, pp 327-331, 2004.

Toullelan P. Y. (1986). « Plantations sans planteurs : les cultures spéculatives dans les Etablissements Français de l'Océanie », Journal de la Société des Océanistes n°82-83, tome 42, pp 139-151.

Willer H., Lernoud J. (2013).The world of organic agriculture. Statistics and Emerging Trends.FiBL& IFOAM – Organics International (2013): Frick and Bonn, 2013-02. 340p.

Willer H., Lernoud J. (2017).The world of organic agriculture. Statistics and Emerging Trends.FiBL& IFOAM – Organics International (2017): Frick and Bonn, 2017-02. 332 p.