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Vermiculture for Sustainable Organic Agriculture in Madagascar

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Abstract: Despite the possession of arable land, Malagasy farmers do not have sufficient access to capital and equipment and invest little to improve their low agricultural productivity in Madagascar. Vermicomposting is the result of research on the culture of earthworms to overcome problems with fertilization and provide benefits to farmers, including improvement in crop performance and yield, and preservation of the environment. Each farmer can practice vermicomposting because of its simple technology. Our concern has been how to develop the production and use of vermicompost at the household level in rural areas in order to solve problems of soil fertility, improve agricultural productivity, and increase farmers' incomes with this organic technique. Thus, the objective of this research was to propose a model for the development of production and use of vermicompost in rural areas in order to minimize the costs of agricultural inputs, improve soil fertility and increase long-term household incomes. A typology of operators was carried out according to defined factors of production and activities performed, followed by a socio-economic analysis and a comparative analysis based on the types obtained. It will be essential to clearly define a national policy on organic farming by supporting private sector groups, NGOs or associations, and encouraging farmers to produce their own fertilizer. Technical and financial support will be needed for the development of concrete visual references which can demonstrate the technical and economic value that organic farming brings using vermicompost.

Keywords: vermicompost; household income; sustainable agriculture

1. Introduction

Malagasy farmers do not have sufficient access to materials and capital, despite the possession of arable land. They use very few modern inputs, such as fertilizers and improved seeds, or modern technologies. They engage in few activities for improvement of agricultural land: 16% of cultivated land is fertilized, 2% with mineral fertilizers and 14% with organic manure [1]. Vermicompost is a fertilizer that farmers can produce themselves by using their land and recycling household waste. Its use is considered organic, and greatly reduces inputs excluding expenditures for synthetic chemicals [2]. However, the number of farmers who currently use vermicompost is very small. In the Rural Municipality of Ambohimanambola with 2228 farmers, 0.85% use vermicompost, while others use either chemical fertilizers (NPK, urea), animal manure (cattle, rabbits, poultry), or ash, and only in small quantities. Development of vermicomposting in this community has been led by the

association Tanora Andrin'ny tontolo Ambanivohitra, or TATA. TATA is a peasant association created in December 1997 and legalized in 2004, and is ranked among the first producers of vermicompost in Madagascar. The goals of TATA have been to support achieving sustainable improvements in agricultural productivity and increase the income of rural households in the community.

The overall objective of this research was to propose a developmental model of manufacture and use of vermicompost to minimize spending on agricultural inputs, improve the fertility of the soil in the long term, and increase household incomes. The corresponding specific objectives were (i) to characterize the agricultural practices of farmers in the Rural Municipality of Ambohimanambola; (ii) to determine the socio-economic benefits of using vermicompost; and (iii) to determine the conditions for developing the use of vermicompost among farmers.

The hypotheses to be tested were: (i) farmers using vermicompost have better crop production than by fertilization with other modes; (ii) the use of vermicompost reduces spending on agricultural inputs and increase farmers' incomes; and (iii) the lack of information and awareness of farmers inhibits further developing the use of vermicompost.

2. Experimental Section

2.1. Materials

2.1.1. Study Area

The research was carried out in the Rural Municipality of Ambohimanambola, the District of Antananarivo Avaradrano, Analamanga Region, Madagascar. It included 2228 households that are in 10 villages, each having their own characteristics. The majority of people (85%) are devoted mainly to agriculture. The leading producers of vermicompost in Madagascar are in this area, grouped in the TATA association, whose headquarters is located in this rural municipality.

2.1.2. Data Collection

The documentation collected revolved around the following themes: (i) analysis of farmers' fertilization practices; (ii) all work addressing the practice of vermicomposting; and (iii) all of the work already carried out on the use of vermicompost. Interviews were conducted with: (i) the President and the trainers of the TATA association; (ii) the authorities responsible for the Rural Municipality of Ambohimanambola; and (iii) 5 leaders of the respondents in each village. A survey of farmers produced all of the data for the study through a questionnaire. It was conducted among 60 of 928 households in 5 villages of the 10 selected according to their fertilization practices. A focus group was also conducted with households who are members of the TATA association. It was designed to obtain information about their opinions, attitudes and experiences or to explain their expectations about the intervention.

2.2. Methods

2.2.1. Typology

A typology of farms was used to identify and differentiate them, using data from the surveyed farms about their practices and procedures. Successful differentiation criteria were based on the production system, inputs, production activities, and non-agricultural activities. The results of the questionnaire from the 60 households were used to perform a multivariate analysis with XLSTAT software (Addinsoft, Paris, France). Four methods of analysis were selected: Agglomerative Hierarchical Clustering (AHC), k-means clustering, Discriminant Analysis (DA) with an analysis of variance, and Multiple Correspondence Analysis (MCA).

2.2.2. Identification of Socio-Economic Performance of Rural Vermicomposting

The profitability of fertilizer use was analyzed in two stages. First, a socio-economic analysis of the production of vermicompost focused on evaluation of the time required for making vermicompost, assuming that farmers made their own. It was important to identify the cost in Malagasy ariary (1$ = 2000 ariary (2012 average)) per kg vermicompost, and the Internal Rate of Return, or IRR, of investment using a Simulation Test, or TSIM, in XLSTAT. Second, a comparative analysis between the treatment group, composed of farmers using vermicompost, and other types of fertilization and/or other modes was performed. In the Discriminant Analysis, a Wilks' Lambda test was done to determine if the averages of the types statistically differed. Comparative criteria were based on fertilizer prices in ariary/kg, comparing costs of fertilizers and the yields acquired, costs of agricultural inputs, and the impact of the fertilization methods with total income of the operator.

2.2.3. Multiple Correspondence Analysis

A Multiple Correspondence Analysis (MCA) in XLSTAT was used to study the variables according to membership in a defined type. The variables that had strong correlations with major constraints farmers faced with the use or development of vermicompost were analyzed based on the responses of each household in the investigative survey and following the typology.

3. Results and Discussion

3.1. Differentiation of Farms

The factor analyses method classified the operators into three types (Table 1). Households using vermicompost as fertilizer were categorized as Type 2, and were considered the minority (25% of the total). Households using other types of fertilization were classified as either Type 1, judged as the majority class (38%) using more fertilizer, or as Type 3 (37%) using less fertilizer. The number of households using vermicompost was low compared to all households, while 75% of surveyed operators used other types of fertilization, such as chemical fertilizer and/or cattle manure.

Table 1. Summary of household typology.

Types of Households	Type 1	Type 2	Type 3
Denomination	Type using more fertilizer	Type using vermiculture	Type using less fertilizer
Fertilization	mixed fertilizers	vermiculture	mixed fertilizers
Percentage	38.3%	25.0%	36.7%
People employed	>4	1 to 2	3 to 4
Total harvest area	>0.3 ha	0.15–0.3 ha	≤0.15 ha
Area reserved for rice	>0.15 ha	0.05–0.15 ha	≤0.05 ha
Area for vegetables crops	>0.2 ha	0.1–0.2 ha	<0.1 ha
Area for cassava	>0.1 ha	0.02–0.1 ha	<0.02 ha
Area reserved for making vermicompost	0	≥2 m^2	0
NPK	>15 kg	0	≤15 kg
Urea	>8 kg	0	≤8 kg
Cattle manure quantity purchased	>500 kg	<200 kg	200 to 500 kg
Insecticides used	>2 L	0	≤2 L
Cattle	≥2	0	0
Pigs	1 to 2	0	0
Poultry	≤4	0	>4
Practice other activities	No	Yes	Yes

3.2. Socio-Economic Analysis of Vermicompost Production

Based on the practical experiences of households using vermicompost, and comparing three methods for installing a worm bin (in basement, ground framed by brick lined, floor framed by boards), the time involved was not a constraint, as the amount of labor required in persons/day was low and did not exceed 1 person/day. In addition, with a cost of about 60 ariary/kg, vermicompost

was produced at a low cost (Figure 1). By investing more to get more fertilizer, the IRR was high, assuring the profitability of the investment. The low cost incurred for the production of one kg of vermicompost was explained, first, by the tools of construction of the worm bin, which were not expensive, reducing the costs incurred [3]. In addition, the raw materials needed were readily available in the area at a very low price or were even free. Furthermore, vermicompost provided a waste recycling opportunity for households. Thus, the overall advantage was that this system facilitated the farmers' respect of the environment.

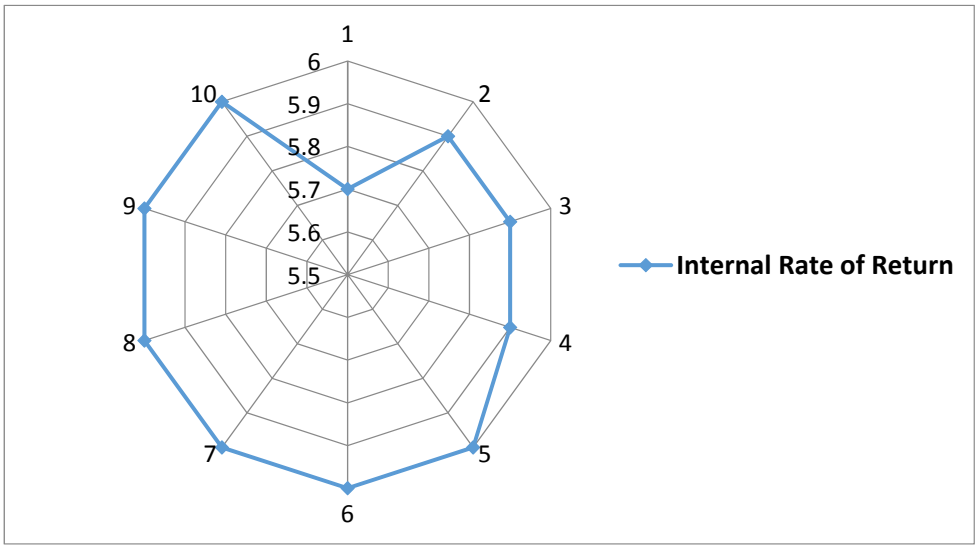

Figure 1. Internal Rate of Return of the manufacture of vermicompost (in increments of 100).

Figure 1 shows that the IRR increased every year during 10 years, and had a high value, which assured a good return on investment when making vermicompost.

3.3. Fertilizers Costs Impact on Crop Yields

There were some significant differences between household Types 1 and 3 using mixed fertilizers with respect to their fertilizer costs, and between these two types compared to Type 2 that used vermicompost (Figure 2A). High fertilizer costs were not associated with greater yields (Figure 2B). The low costs of fertilizers for Type 2 households were due to making their own manure, and suggested that high yields were a result of good quality vermicompost. The use of vermicompost reduces production costs by reducing expenses in chemical inputs, particularly fertilizers and pesticides [4].

Type 1 households had the highest expenses for fertilizers for all crops except zucchini and cassava, while their yields were in the middle among the three types, and they did not differ from Type 3 households. Type 2 had lower fertilizer costs and also generally higher returns. In the case of cassava cultivation, Type 1 and 3 households did not use fertilizer while a Type 2 household paid 600 ariary/are. Type 2 obtained a yield of 47 kg/are, but Type 1 had 22 kg/are and Type 3 had 20 kg/are. Logically, when fertilizer expenses decrease, and yield increases, the value of production also increases, from 10% to 50% in the present study.

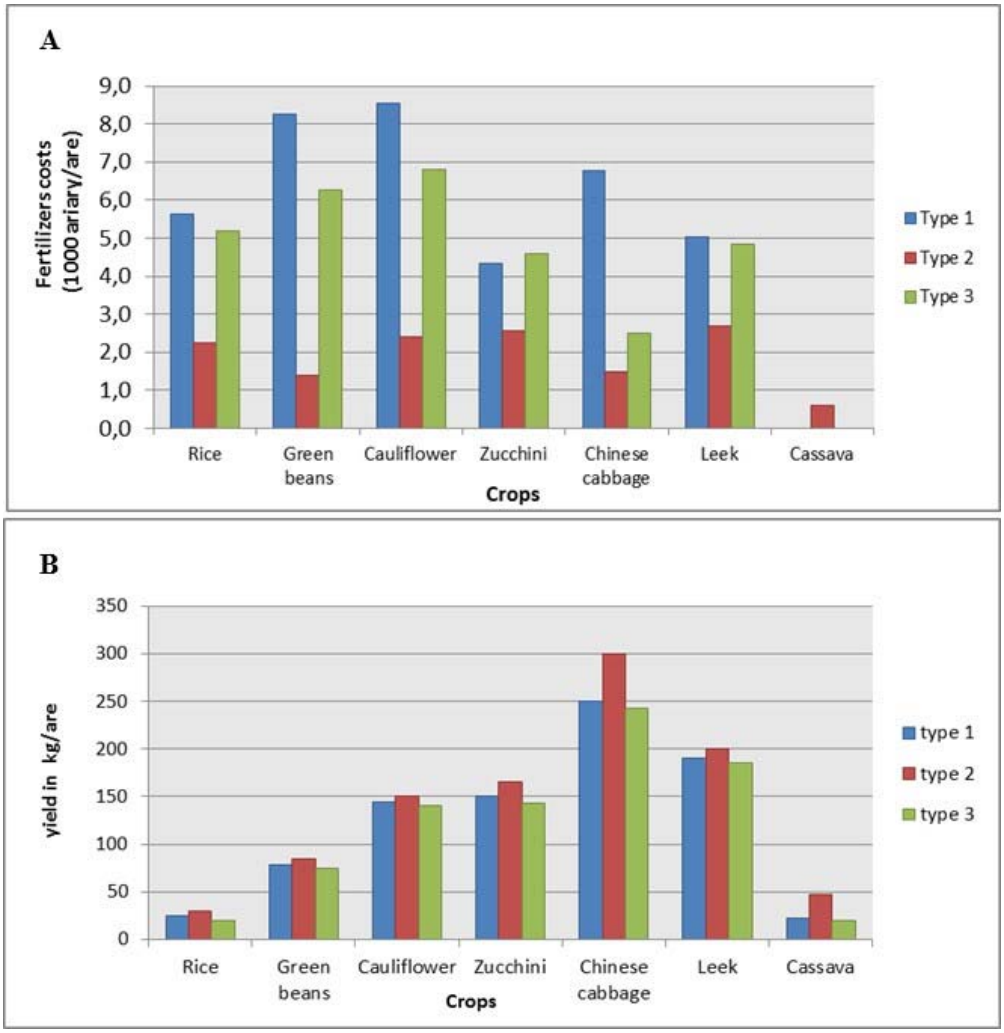

Figure 2. Comparison of (**A**) fertilizer costs and (**B**) yields for several crops by household type using Wilks' Lambda test. Area units are "are", or 100 m^2 or 0.01 ha.

3.4. Impact of the Use of Vermicompost on Total Household Income

In addition to the benefits obtained from the use of vermicompost on the farm, the manufacturing process creates a new source of income. The TATA Association offers its members an opportunity in terms of a market, but considers requests from entities or individuals with combined vermicompost production of 500 kg to 1 ton per month, depending on the growing season. In addition to the advantages of selling and using vermicompost, households would reduce their spending on agricultural inputs and improve soil fertility while increasing long-term yields [4].

3.5. Factors Affecting Development of Vermicomposting

3.5.1. Analysis of Households' Opinions by MCA

Survey results refer to different perspectives and expertise of households on the use and the manufacture of vermicompost. Type 1 households did not know vermicompost manufacturing techniques, or had not fully mastered the methods. Some did not understand the value of vermicomposting, while others consider it a more or less good fertilizer according to information circulating in their locality. Type 2 households knew that the manufacture of fertilizer from worms was feasible, and had mastered the manufacturing techniques in general, so for them the value of vermicomposting was appreciable. Type 3 households only knew that it was possible to produce

vermicompost with earthworms, although some were unable to control its manufacture, and others had very few production skills. They knew that vermicompost had good qualities and allowed good yields, but some hesitation was noticed among them.

3.5.2. Constraints for Those Producing Vermicomposting

Failures due to behavioral factors have been observed by the founder and president of the TATA trainers association, given the amount that a household could produce. The number of active people was not a constraint, but insufficient observation, anticipation, and the lack of development of planning the manufacturing of vermicompost could be constraints [5].

3.5.3. Constraints for Those Not Producing Vermicompost

In analyzing the situation of Type 1 and Type 3 households, one of the major problems facing the use of vermicompost was insufficient information. Indeed, in the Rural Municipality of Ambohimanambola, vermicomposting training has been done only by the TATA association, but there has been no specific budget for public awareness campaigns and/or information sessions. In short, the lack of information has led to a lack of awareness of the benefits of using vermicompost. Moreover, farmers have not mastered the steps to make it. Many operations have succeeded over time in promoting the use of agricultural inputs in Madagascar such as chemical fertilizers, but efforts promoting vermicomposting have been unsuccessful. Currently, in most of the rural world, the only information on fertilizers has been for the use of chemical fertilizers. Farmers believe that the best solutions for improving their operations are by the use of chemical fertilizers. Thus, insufficient information has been an important factor blocking the development of the use of vermicompost.

3.6. Valuation and Maximizing the Benefits of Vermicomposting on the Farm

3.6.1. Optimization of the Benefits of Vermicompost

To make the most of the advantages of using vermicompost, more needs to be used. Farmers should be encouraged to consider making vermicomposting a substantial part of their operation. With an increase in production of vermicompost, the farmer/producer could receive more income by selling unused quantities. To better maximize the benefits of vermicompost, it would also be important to restore and maintain soil fertility and ecological balance by crop rotation, vegetation cover, natural fertilization and minimum tillage [6].

3.6.2. Valuation of Organic Products and Local Market Development

Currently, the possibility of disposal of agricultural products for all growers is through local distributors who offer the same price irrespective of the type of fertilization. It would be important to organize marketing by selling organic products at a separate price. It would be useful to establish some regulations concerning product quantity and quality. The creation of a common marketing center would be necessary, which would mean uniting producers in cooperative-type associations authorized to act as strong traders in managing the flow of quality product. Finally, it would be recommended to induce consumers to buy organic products, eating food that balances human health.

3.6.3. Strategies for Developing the Use of Vermicompost

State Intervention

The development of organic farming, in direct relation to the use of organic fertilizers like vermicompost, is not included fully in national politics in Madagascar [7]. It would be important to clearly define a national policy on organic agriculture by supporting the private sector, NGOs and associations working in this field such as the TATA association, and encouraging farmers to produce their own fertilizer as vermicompost.

Creating Network or Movement that Brings Together All Stakeholders

Currently, the only group in Madagascar which brings companies operating in the field of organic farming together is PRONABIO (Produits Naturels et Biologiques), comprised of 31 companies working in the field of organic farming. Members have the support, activities, and ambitions of its members as a permanent source of advice and information, promotion of activities and products (participation in fairs, exhibitions, conferences, seminars and international exhibitions, creation of a permanent office with a technical secretariat), and the defense of the interests of its members. Most of these companies establish contracts with smallholder farmers, collect their products, and export them. By creating a network, farmers could be motivated to use vermicompost and also produce more for the international organic market. The network should include all the players in this sector at a regional level: research, production, training, supervision, technical assistance, and export financing. Members could share their experiences, lobby to defend the rights of players in the industry, represent the sector at national and international levels, and encourage professionalisation of the sector for better quality, improved competitiveness in the marketplace, and sustainability of organic farming in Malagasy [8]. To establish the development of the use of vermicompost, it would also be important to establish a website that would bring together farmers associations, private entities, and/or the public who may be applying vermicompost.

4. Conclusions

This research focused on the identification of the mode of development of vermicomposting by farmers in the Rural Municipality of Ambohimanambola to resolve fertility problems, improve organic agriculture and agricultural productivity, and increase household incomes. The analyses indicated that the agricultural practices of farmers using vermicompost were different from those of households using other types of fertilization according to predefined criteria. About 25% of the households surveyed were classified as Type 2 that practiced vermicomposting, while the other two types used mixed fertilizers and were differentiated by other factors. The results indicated that the use of vermicompost does not yet hold an important place for most farmers. The study also showed that the use of vermicompost reduced average spending on agricultural inputs from 45% to 60%, and resulted in yield increases of 10% to 50%. Sale of unused vermicompost could provide another source of income. The analysis confirmed that the lack of information and awareness inhibited growth in the use of vermicompost, but strategic points for promoting development of vermicomposting were identified. The survey revealed a good knowledge of vermicomposting techniques for improving crop yields, for avoiding unnecessary expenses by the use of chemical fertilizers, and for protecting the environment. A trend towards sustainable organic agriculture and its principles was observed during this research, but it remains to be verified if the presence of the TATA association working in the field of vermicomposting has really expanded its use. For other regions or towns, the question is: "How can vermicomposting be introduced in areas where there are no organizations or associations working in organic agriculture?"

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References

1. Rasoarimalala, S.; Andriamialijaona, H.; Rabemanantsoa, M. *Support for the Establishment of a System of Production of Inputs (Fertilizers and Pesticides) in Areas of Intervention PARECAM*; Study Report; PARECAM: Antananarivo, Madagascar, 2001; p. 122.
2. BIMTT; MAMABIO; MINAGRI; RTM; TATA. *Manual on Basic Techniques in Organic Farming: For Technicians*; RTM (Reggio Terzo Mondo): Antananarivo, Madagascar, 2011; p. 60.

3. MB Bouche, M.B. *The Earthworm for the Treatment of Waste*; Periodically Biofutur 7; Lavoisier: Paris, France, 1982; pp. 43–46.
4. Kouassi, K.J. Technical and Socioeconomic Analysis on a Farm in Attiégouakro (Ivory Coast). Available online: http://www.memoireonline.com (accessed on 23 December 2012).
5. Rajaonarison, A. Organic Farming in Madagascar. Master's Thesis, Laulanié Green University, Isoraka, Madagascar, 2009.
6. CTA; UNCTAD; WTO. *Global Markets for Organic Fruit and Vegetables*; FAO: Rome, Italy, 2001; pp. 301–309.
7. Vermicompost. Available online: http://www.erails.netconsulted (accessed on 5 November 2011).
8. Andriamady, T.V. Agricultural Experimentation Based Manufacturing Vermicompost for Soil Fertility. Master's Thesis, Superior School of Agronomy, Antananarivo, Madagascar, 2011.