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Integrated Nematode Management in Chickpea against Meloidogyne Incognita - A View Point

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A B S T R A C T

Early researchers identified key concepts and developed tactics for multiple option management of nematodes. Traditional management tactics include host resistance (where available), cultural tactics such as rotation with nonhosts, sanitation and avoidance, and destruction of residual crop roots and judicious use of nematicides. There have been advances in biological control of nematodes, but field-scale exploitation of this tactic remains to be realized. New technologies and resources are currently becoming central to the development of sustainable systems for nematode-pest-crop management, molecular diagnostics for nematode identification, genetic engineering for host resistance, and the elucidation and application of soil biology for general integrated cropping systems. The latter strategy includes use of nematode-pest antagonistic cover crops, animal wastes, and limited tillage practices that favor growth-promoting rhizobacteria, earthworms, predatory mites, and other beneficial organisms while suppressing parasitic nematodes and other plant pathogens. Certain rhizobacteria may induce systemic host resistance to nematodes and, in some instances, to foliage pathogens. The systems focusing on soil biology hold great promise for sustainable crop-nematode management, but only a few research programs are currently involved in this labor-intensive endeavor.

Keywords *Host Resistance, Genetic Engineering, Nematicides, Sanitation, Tillage, Antagonistic Cover Crops*

1. Introduction

During early nineteen century people discussed a wide range of tactics for nematode management that are surprisingly similar to those available today: sterilization of soil by starvation, including the use of nonhosts plants, the potential of trap crops, compost, nematicides, and soil amendments such as hardwood ashes and potash. The early work on sampling nematode communities provided a basis for the development of improved tactics and strategies essential for integrated nematode-pest management. In late nineteen century, it was offered to recommend for monitoring root-knot nematodes as well as for their management. A well-planned combination of practices will go much further for controlling nematodes than any of the recommended treatments alone [1]. It was further indicated that the presence of nematodes (root knot) in any soil can be determined by examining the roots of susceptible plants that have been growing for at least 3 weeks in warm, moist conditions. For

attempted eradication of root-knot nematodes, it was suggested some innovative ideas like burning crop residues two or three times if possible, each preceded by a spading or plowing; dry fallowing, frequent ploughing, one or more well-irrigated trap crops completely destroyed 2 or 3 weeks after sprouting; moist fallow during warm weather, without weeds; resistant crops in rotation, kept free of weeds [2]. It was also emphasized that root-knot nematodes enhanced the susceptibility of crops to such other diseases as cotton wilt, black shank of tobacco, and rhizoctonia disease of peanuts. These strategies/tactics were based on much earlier. Three key facets on which integrated pest management is based include: determining how the biology of a pest must be modified to reduce its density; combining current technology with biological knowledge to effect modifications, developing new or improved technologies for control that are compatible with economic circumstances and environmental requirements [3].

Nematode management requires flexibility and must take into account species or races of nematodes, the availability of resistant or non-host plants, the cropping system and the cropping history, economics, and the climate. Although few nematode management practice are available, due to lack of hard data and variables such as nematicide dosage, costs of chemicals, efficacy of management tactics, and crop susceptibility, the outlook for integrated nematode management is positive [4].

INM in chickpea crops against M. incognita Many species of plant-parasitic nematodes have been reported in the roots and rhizosphere of chickpea in the major growing regions in the world. However, only certain nematode species are considered constraints to chickpea production, causing an estimated 14% in annual yield losses. The symptoms and signs of nematode parasitism on chickpea differ depending upon the nematode's feeding habit. Moreover, nematode attacks can make plants more sensitive to other biotic and abiotic stresses, and overall result in stunting and poor yield. Symptoms caused by nematode attack are nonspecific and nondescript, and they are largely a consequence of disruption of normal processes of plant growth, and absorption and translocation of water and nutrients. Consequently, damage by nematodes to chickpea often goes unnoticed and is attributed to other causes, such as lack of fertility or deficient soil moisture. For example, even 50% reductions in chickpea yield caused by the chickpea cyst nematode, Heterodera ciceri, cannot be predicted by inspection of the upper part of the plant. For these reasons, plant parasitic nematodes are often referred to as the "unseen enemies" of crops [4]. The most important nematode pathogens of chickpea include root-knot nematodes (Meloidogyne spp.), root-lesion nematodes (Pratylenchus spp.), cyst-forming nematodes (Heterodera spp.), and the reniform nematode (Rotylenchulus reniformis).

2. Root-knot Nematodes in Chickpea

Sedentary endoparasitic root-knot nematodes of the genus Meloidogyne are among nature's most

successful plant parasites. Meloidogyne spp. infects thousands of different hosts, including herbaceous and woody monocotyledonous and dicotyledonous plants, and cause serious losses to numerous agricultural crops worldwide. The root-knot nematode species known to damage chickpea are M. arenaria, M. incognita, and M. javanica, a warm climate species that attack chickpea in the Indian subcontinent, and M. artiellia, a species well adapted to cool and wet conditions, which is widely distributed in the Mediterranean Basin. Root galling is the typical symptom of parasitism by Meloidogyne spp. in susceptible crops. However, compared with large galls induced by M. arenaria, M. incognita, and M. javanica on chickpea, M. artiellia produces small galls or no galls. The most evident sign in roots infected by this latter species are the egg masses produced by the nematode, which may contain 200 to 600 eggs. The limited hyperplasia in the vascular cylinder and the cortical cells that surround the feeding site of M. artiellia seems to determine the small gall size in this species [5]. Also, the frequently observed protrusion of bodies of adult M. artiellia females from infected roots, resembling the parasitic habit of adult cyst-nematode females, seems to be congruent with the lack of root galling Parasitism by root-knot nematodes in chickpea involves the establishment of permanent feeding sites called giant cells in the root cortex, endodermis, pericycle, and vascular parenchyma. Feeding sites are sinks for plant photosynthate. In addition, deformation and blockage of vascular tissues at feeding sites limit translocation of water and nutrients, and further suppress plant growth and reduce seed yield. In chickpea, the number of giant cells in the feeding site (averaging four to six) and the area of individual giant cells are not influenced by root-knot nematode species or isolates within species. However, the number of nuclei per giant cell is significantly lower for M. artiellia than for M. arenaria, M. incognita, or M. javanica. Similarly, maximum diameters of nuclei and nucleoli are significantly greater in giant cells induced by M. artiellia isolates compared with those induced by M. arenaria, M. incognita, or M. javanica[6].

Uneven patches of chickpea plant growth are commonly associated with soils infested with root-knot nematodes. Heavily infected plants show stunted growth, less branching, and leaves with pale green to yellow color. The extent of yield loss caused by root-knot nematodes is determined by a number of factors, including the nematode species, the population density, pattern of nematode distribution in soil, the soil cropping history, chickpea cultivar, climate, and soil type. Although a variety of mathematical functions have been proposed to describe the relationships between the initial nematode population density in soil and crop damage, the most widely accepted one is the Seinhorst model [$y= m + (1 – m)zP-T$ when $P \geq T$, and $y = 1$ when $P < T$]. In this model, y = relative value of the plant growth parameter being measured; m = the minimum value of y (y at a very large initial nematode population density); P = the initial nematode population density; T = the tolerance limit (initial population at which plant growth is not impaired; and z = a constant < 1 reflecting nematode damage, with $z–T = 1.05$. Threshold levels for M. incognita and M. javanica on chickpea grown under greenhouse conditions

were established at 0.2 to 2.0 second stage juveniles (J2) per gram of soil; however, tolerance to M. javanica was identified in some chickpea cultivars. Comparatively, the tolerance limits of chickpeas to infection by M. artiellia under field conditions in micro plot experiments were much lower, i.e., 0.14 and <0.02 eggs and J2 per cm3 of soil for winter- and spring-sown crops, respectively [7]. Chickpea yield losses of up to 60% were caused by severe M. incognita infections in India; whereas in southern Italy, initial M. artiellia populations of 2 eggs and J2 per cm3 of soil caused a yield reduction of 50% in winter sowings, and about 80% in spring sowings. Meloidogyne spp. attacking chickpea have a wide host range including many weeds, which constitute natural, alternative hosts for the nematodes and enable their survival and population increase. Moisture, texture, and temperature are major soil physical factors affecting distribution and reproduction of those nematodes. M. artiellia completes one generation per growing season, mostly because of a combination of low, insufficient rainfall and high temperature that prevail in spring in the Mediterranean Basin [8].

3. INM Packages

A field trial was laid out in RBD with three replications comprising of 12 treatments including control using susceptible green gram CV. dhauli. A sub plot size of 4m x 3.1m was maintained for each treatment. Observations were recorded on nematode population in soil and roots infested by root-knot nematode, Meloidogyne incognita. The initial nematode population in soil was 2.3 / g soil. The treatments were imposed 10 days after sowing (DAS) and observations on nematode population in the soil and roots of the infected plants were recorded at 45 DAS. Yield data were recorded at harvest. The results revealed that among the treatments, the combination of neem-cake + carbofuran + Pseudomonas fluorescens resulted maximum reduction of soil populations (74.83 %) and root population (87.39%) over control followed by combination of neem cake + phorate + Pseudomonas fluorescens which recorded reduction in soil population 71.51 %and root population 86.08 % over control. Application of neem cake + phorate and combination of neem cake + carbofuran were significantly different from each other with respect to soil and root population. Application of carbofuran @ 2 kg a.iIha recorded 54.08 % reduction in nematode population in soil and 76.95 % in roots followed by single application of phorate @ 2 kg a.i./ha. i.e. 48.92 and 70.43 %in soil and root, neem cake @ 1.5 q/ha i.e. 47.84 % and 67.39 % in soil and root, Pseudomonas fluorescens @2.5 kg/ha i.e. 43.98 % and 63.9l % in soil and root and VAM@100 kg/ha i.e.39.03 % and 51.53% in soil and root population, respectively over control.

The maximum yield was recorded by the combination of neem cake + carbofuran + pseudomonas fluorescens @2.5 kg/ha and the percentage increase was 81.82 % over control .The combination of neem cake + phorate, neem cake + carbofuran and neem cake + pseudomonas fluorescens were

significantly different from each other. The present results suggested that combined application of neem cake + carbofuran + Pseudomonas fluorescens was most effective in reducing nematode population and subsequent increase in yield than individual applications. This might be due to the nematicidal and nutritional components of neem cake released during decomposition and growth promoting activity and carbohydrate-lectin metabolism of Pseudomonas fluorescens[9,24]. The plant growth promoting rhizobacteria produce iron-chelating siderphos antibiotics or hydrogen cyanide and these compounds have been implicated in reduction of pathogenic rhizospheric micro-organisms creating an environment favourable for root growth. These rhizobacteria reduce the hatching and invasion due to the production of toxic metabolites inside the plant. The effectiveness of neem cake in the control of Meloidogyne incognita and Rotylenchulus reniformis was reported by many workers [10].

4. New Technologies for Pulses

Nematode Management As sustainable nematode management becomes increasingly based on soil biology and soil health, new complementary technologies are developing. These new tools undoubtedly will improve the accuracy of nematode diagnoses and assessments of potential problems, and will result in more effective management, reduced pesticides, pesticide usage, and less contamination of groundwater with agricultural chemicals such as nematicides, nitrogen, and fertilizers [11].

5. Precision Agriculture

Modern computerized harvest-management and data systems offer new opportunities for more precise management of nematodes and general crop production. This technology has the potential to improve water use and limit fertilizer and pesticide application on a spatial and temporal basis as dictated by soil fertility and, more important, differential spatial crop yields. Based on early results, this management tool should allow specially prescribed nematode control in high-intensive crop production such as Radopholus similis on banana (DH Marin-Vargas, personal communication) and root-knot nematodes on potato in the northwestern United States. Approaches that focus on a harvest index to locate environmental stress should be able to relate nematode kinds and numbers to poor yield and other stress factors. This approach is now being used in some banana operations in which fruit is harvested in small subunits and yield data are recorded and analyzed by computer (DH Marin-Vargas, personal communication). Poor-yielding sections can be examined for nematode densities and other potential problems [12].

6. Nematode Identifications and Population Assessments

The tools of rDNA technology, especially when allied with traditional taxonomic characters and host differentials, have greatly facilitated identification of nematode species and often host race. Isolated specimens of a range of nematode species have been identified by differential isozyme pattern and/or specific DNA probes, and there has been some progress in identifying and quantifying nematodes from processed soil samples. Continuing restrictions in the size of samples and numbers of nematodes that can be examined make it very difficult to fully diagnose the nematode species present in large fields. However, this new technology should facilitate a more complete characterization of the diverse nematode trophic groups and species that are affected by disturbance and management practices in various ecosystems [13]. The availability of mobile soil-samplers, especially when used in precision production systems, could facilitate more directed, selective sampling for general nematode assays and identifications. Geostatistical analyses could be interfaced with these improved sampling apparatus for more precise measurement of data on nematode population. Image analysis has been adapted to count specific nematodes, but differentiating species with computers currently available would be too time-consuming [14].

Genetically engineered and traditional host resistance The increasing complexity and costs of genetic engineering of plants for pest resistance or altering biocontrol agents make it unlikely that significant economic repercussions of molecular biology will be felt on agricultural production in the near future. There has been considerable progress made in engineering host resistance to nematodes, genetic mapping, and diagnostics. However, genetically engineered resistance to nematodes is still at the developmental stage in contrast to the recently deployed herbicide- and insect-resistant cultivars of cotton, soybean, and other crops [15]. One strategy involves transformation of plants with a transgene(s) encoding a product detrimental to the target nematode or that suppresses the expression of key plant genes involved in the nematode-host interaction. Candidate genes for this strategy include collagenase, genes expressed in the development of specialized feeding cells induced by species of Globodera or Heterodera (syncytia) and Meloidogyne (giant cells). Constructs of the root-specific TobRB7 gene in tobacco have been used to develop promising root-knot nematode–resistant genotype. Linking this gene with a BARNASE gene resulted in root knot–resistant plants, but difficulties were encountered in recovering resistant lines from progeny of the transformants. Transformed plants with an antisense TobRB7 construct also exhibited root-knot resistance; root-gall development was about 70% less in than susceptible plants [16,23].

7. Advisory Programs

Despite the development of nematode advisory programs in some states in the United States in the

United States in the 1960s and earlier elsewhere, low-cost, highly effective nematicides remained in use as a form of insurance until recently [17]. The unreliability of nematode assays, due to difficulties in sampling the contagious infestations, identification of related species, and lack of information on economic thresholds helped to prolong nematicides use [18]. Nevertheless, advisory programs have successfully contributed to lower pesticide usage and greater farm profits. Management of nematodes, including advisory programs, poses greater challenges for perennial crops than for annual crops. Control options are limited, and very low population densities often build up to cause severe damage over time. Integrated management, including assays to determine numbers and kinds of nematodes present, and appropriate control tactics such as preplant fumigation where necessary, use of nematode-free stock, tolerant cultivars where available, and organic mulches are useful for woody ornamentals [19, 20,21,22].

8. Conclusions

New approaches to nematode control hold great promise for sustainable, integrated crop-pest-management systems. Rapidly evolving knowledge and understanding of soil biology and crop molecular biology can be exploited in highly productive, intensive cropping systems. The challenge is to develop primary cover-crop, animal-waste, tillage systems that result in the build-up of favorable rhizobacteria, fungi, nematodes, protozoa, earthworms, and other fauna while also suppressing plant-parasitic nematodes and other crop pathogens. Combining this new, integrated soil biology–based nematode-pest-crop management with traditional and/or genetically engineered host resistance and cultural practices such as rotation should reduce the need for pesticides. However, worldwide the area dedicated to crop production is unlikely to expand during the next two decades; on the contrary, there is a continuous and substantial decline in grain-producing area per person. Thus, food production per hectare must be increased. In conclusion, the development of sustainable nematode-management systems is not an option. It is imperative that scientists devise the requisite sustainable tactics as one component of the world's complex food-fiber production system to meet the pressure of the rapid population increase. Management of plant-parasitic nematodes is essential to sustainability, since impaired efficiency of plants' water and nutrient utilization caused by these pathogens limits production and degrades the environment. The proposed strategy of increased use of pesticides and plastics to meet this challenge would likely provide only short-term benefits. For example, the repeated heavy use of chemicals such as methyl bromide essentially sterilizes the soil and eliminates beneficial soil micro-flora and fauna as well. Many other current crop- and pest-management practices also contribute to the instability of our food production. Fortunately, the new technologies forthcoming from molecular and soil biology and truly integrated cropping-nematode-pest management systems

are providing new strategies and tactics that can be linked to traditional nematode management for more general integrated and sustainable food and fiber production. In fact, the wide gaps between and within developing and developed countries indicate that global food production still can be increased.

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Assessment of Transverse Runoff in the Terraced Area for Adaptation and Mitigation of Climate Change

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ABSTRACT

The inland water regime is a major problem in crop production due to the irregular formation of the soil surface which includes water as the main factor for crop production. The objectives of the study were to measure and evaluate the performance of intercepted in terms of trapped soil sediments, water storage capacity, and crops produced through economic analysis. The research was carried out at BPSU, Bangkal, Abucay, Bataan, Philippines (North 14°46' East 120°30'). During the study period, the average yearly rainfall depth at BPSU-AWS Station was 2,899.4 mm, whereas the average rainfall depth from January 2019 to May 2020 was 4,059.6 mm. Four benches or terraces were built, along with four runoff interceptors. The runoff interceptor, which retained water during a rainy runoff event, is 131.6 meters long and 0.5 meters wide by 0.4 meters deep. A total of 26.32 m3 of water was stored. Vertisols were the type of soil (Antipolo Clay). At the peak of the first-year season, 4.11 m3 of soil was eroded within the runoff interceptor (4,808.7 kg of dry soil). In 284.5 m2, three rice varieties were sown. Rice was harvested with a total weight of 248.5 kg. Three vegetable crops were planted during the second crop, while Wax Pepper had the highest gross income. The ROI and payback period for the two seasons studied were 0.09 percent and 11.05 years, respectively. Water stored in runoff interceptors can be used to supplement irrigation water for the production of rice, high-value crops, and crops with low water requirements.

Keywords *Irrigation, Runoff Interceptor, Soil Sediments, Terraced, High-Value Crops, Bataan*

1. Introduction

Climate change can be defined as a major shift in climate within a region as a result of reckless human actions as measured by common indicators such as rainfall, temperature, and air quality.

The Philippines had excessive rainfall but was not uniformly distributed within the country. The unexpected distribution consequences to runoff, flooding, erosion, and water deficit during the dry season. Therefore, part of heavy rainfall water is for supplemental purposes during water scarcity [1].

The water system within the upland is one major problem in crop production due to irregular soil surface configuration. Soil surface layout is one component to consider while deciding on a production area that includes water, which is the most important factor in crop productivity. Due to this soil aspect, few areas are non-productive.

Although the rainfed upland crops, permanent and seasonal, are established in sloping agricultural land

technology (SALT) when long season drought comes, without a source of irrigation water, still sustainability in yield won't meet [2][3]. To mitigate and adapt to global climate change within the hilly areas, rainwater harvesting will solve the problem of the water system within the highlands [4][5]. In rainfed areas, water storage is used to provide supplemental irrigation water during the dry season and for the production of seasonal crops. Aside from irrigation, the water in the interceptor could be utilized for small-scale livestock watering and basic soil sediment study [6].

During the season, water in the mountains usually goes to rivers right down to lakes and oceans, which is the chance for farmers to store free water from rainfall in anyways, to use when the dry season's crops produce.

The stored water from the established runoff interceptor within the upland area was utilized in rice production (July to November) and thus the area was planted with vegetables (November to June) just after rice production. The main objective of the study was to assess and evaluate the performance of the runoff interceptor influenced by hydrological and economic factors, and to assess and evaluate the established permanent and seasonal crop yield: assess the performances of runoff interceptor in the terraced area and trapping sediment; evaluate water management and irrigation strategies using the stored water, particularly high-value crop production; to assess and evaluate the economic advantage of the system in crop production.

The study for crop production, water management strategies using runoff interceptors as a water container, and utilization of stored water for crop production.

1.1. Importance

The establishment of water storage within the upper reaches of the watershed might be a defense against floods at the same time for irrigation and erosion control [7]. The establishment of water storage uses the surface runoff water to conserve soil, and water for productive use. Apart from uses, stored water in the container eradicates evaporation, seepage, and percolation losses during storage compared to an open-pit small farm reservoir. The study specializes in the physical performance of the water storage within the upland and its economic impact [8]. Sediment trapped within the runoff interceptor will return to the production area by desilting. Trapped can store more water for incoming rainfall as a source of water. Sediment that flows along with surface runoff freely may cause nutrient losses from original soil and pollution to bodies of water downstream resulting in the reduction of aqua-marine life if the soil sediments are not trapped. Change in the environment makes people search for adaptation and mitigation strategies to survive the changing world condition. Mountains and soil fertility will degrade for a certain area. The production of crops, fish, and livestock will decrease because the volume of water we extracted will decrease. Groundwater conditions will also change, the aquifer will pollute, and salt intrusion will experience.

The technology that stores water within the upland area will ensure the availability of irrigation water even if there's global climate change, specifically the unpredictable occurrence of rain during crop growth development, still we've enough water for irrigation.

2. Methodology

Includes and present the materials used, the crop used in the study, the site identified, the preparation of the experimental area, data gathered and monitored during the experimental design, and data analysis.

2.1. Conceptual Framework

The framework and its discussion illustrated the input, process, and output of the study. The area identified was cleared, terraces or benches, and a runoff interceptor was installed while farm inputs were procured (INPUTS). Rice will be raised on terraces formed during the rainy season while collecting rainfall depth, growth parameters, and crop yield. The use of the accumulated water in the runoff interceptor was followed by vegetable development. Growth and yield (PROCESS) are also obtained. At the end of two seasons, the volume of soil sediments, evaluated irrigation method, yield, and cost-benefit, were recorded and analyzed (OUTPUT) (Figure 1).

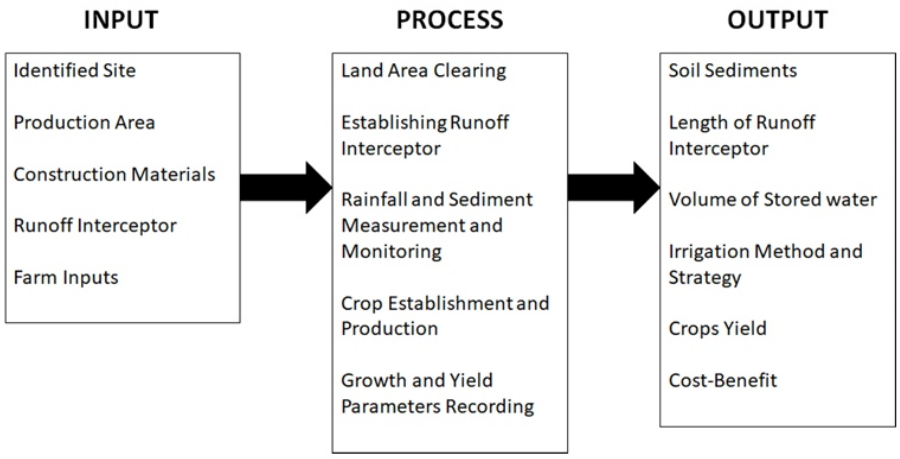

Figure 1. Conceptual Framework

2.2. Materials

Seasonal crops are to be raised and produced within the benches established.

(a) Rainy season crop. Rice will be raised in the rainy season as the main crop

(b) Second crop. High-value crops will be raised, such as eggplant, tomato, and wax pepper.

© PE pipes. Used as drainpipes and for manual irrigation.

2.3. Identified Site

The study area was located in the BPSU Abucay Campus, Bangkal, Abucay, Bataan. The area has grasses of different species at 2 – 2.5 meters in height. The identified site was sloping (17% - 30%) with an area of 1,000 square meters (25 x 40 m) including the catchment area, however, the production area was 284.5 square meters. The soil was vertisols (Antipolo Clay). The length was from east to west and the width was from south to the north. The sloping area was formed into benches through manual digging and earth movement using hoes and spades**.**

2.4. Runoff Interceptor

For each of the four benches [9] created by manual digging and constructed lined canal interceptors, Runoff interceptors were built (Figure 2). The runoff interceptor will be evaluated by calculating the catchment area, rainfall depth over the volume of water held in the interceptor (capacity), and the volume of water used for agricultural production.

2.5. Crop Production Establishment

The area defined (Figure 2) will be used for tillage and crop management using the machinery available. Seasonal crops of high value will be included in the analysis. Three rice varieties were initially soaked for pre-emergence during the rainy season and developed by manual seeding at the benches. It was cleared after rice, while seedlings of high-value crops were prepared. Twenty-four (24) eggplants, 20 tomato plants, and 32 wax peppers were planted in terraced shaped manually at the recommended distance.

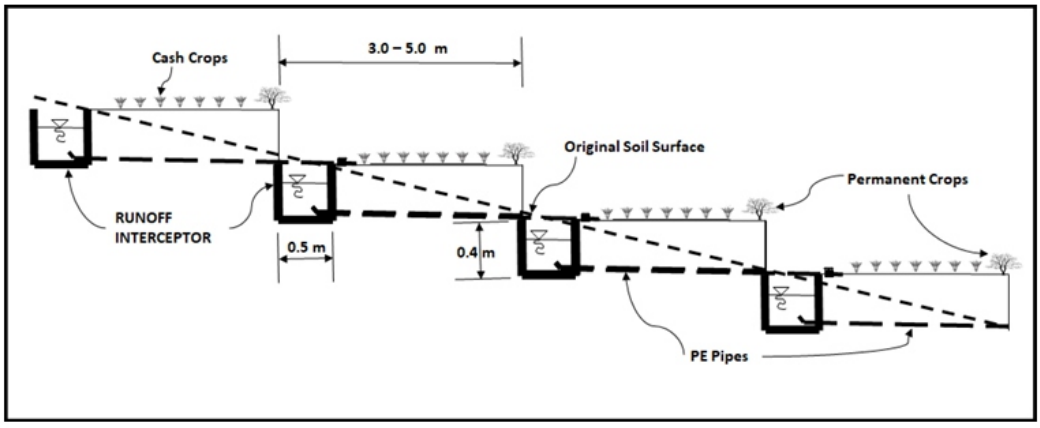

Figure 2. Experimental setup

2.6. Crop Management and Conservation

Weeding. Regular monitoring of the weed emergence and removal eradication. Fertilization. Fertilizer will be split application for rice, also with the vegetable production using both organic and inorganic fertilizers.

Irrigation. Stored water in the runoff interceptor will be used as irrigation water in crop production considering the water requirement of crops established. A manual overhead irrigation method was used.

2.7. Data Gathering and Collection

Rainfall depth, amount of stored water, volume and weight of soil silted in the runoff interceptor, growth and yield parameters in crop production, irrigation strategies, and water use efficiency were the data collected and gathered. The result was analyzed after the analysis, considering products and total revenue.

2.8. Experimental Design and Data Analysis

Using regression analysis, experimental design, and using F-Test for the significance of the data obtained, the compiled data from the study were analyzed.

3. Result and Discussion

3.1. Rainfall

The area has two distinct seasons, the dry season from November to May, and the rainy season from June to October of the year. The depth of rainfall in the BPSU-AWS Station from January 2019 to May 2020 was 4,059.6 mm (Table 1).

Table 1. Rainfall depth (mm) during the study period

Month (January 2019 – May 2020)	Rainfall Depth (mm)
January	33.4
February	10.6
March	15.0
April	70.8
May	82.6
June	789.0
July	569.8
August	965.2
September	877.2
October	57.4
November	150.2
December	98.6
January	15.2
February	19.6
March	44.6
April	46.2
May	214.2
TOTAL	4,059.6

3.2. Volume of Stored Water

Four (4) benches or terraces with four (4) runoff interceptors (Figure 3) were constructed and created. The water storage interceptor during the rainfall-runoff event [9] has a total length of 131.6 meters with a dimension of 0.5 m in width and 0.4 m in depth, respectively (Table 2).

Table 2. Dimension of runoff interceptor

	Length (m)	Depth (m)	Width (m)	The volume of Runoff (m^3)
Upper Up	35.5	0.4	0.5	7.10
Upper Middle	36.8	0.4	0.5	7.36
Lower Middle	45.7	0.4	0.5	9.14
Lower Low	13.6	0.4	0.5	2.72
TOTAL	**131.6**			**26.32**

Figure 3. Runoff interceptor with rice production

3.3. Soil Erosion

The bulk density of the soil was 1.17 g/cc, considering the properties of the soil at the study site. At the end of the rainy season, the observed soil eroded in the lined canal at 6.25 centimeters deep, and the width of 0.5m was 4.11 m3 (4,808.7 kg of dry soil at 131.6 m) [10]. On the other hand, the soil erosion was severe when the field was not terraced and planted with pineapple across the contour line. As recommended [11][12][13], reducing the hillslope gradient and length of the terrace and increasing the width of the terraced bench are beneficial to an increase in infiltration rates, reduction of runoff production, and surface flow velocity at the local scale.

3.4. Irrigation Water

Production (1st crop e.i. rice) during the rainy season (July-October), does not require more irrigation due to rainfall. But during this development period, precipitation was adequate to conserve irrigation water. Diversified crop production began immediately after the main crop when the dry season began. For each kind of diversified crop, the amount of irrigation water used was 25.5 liters (24 20 tomatoes, and 36 wax peppers) (Figure 4). Based on soil characteristics, irrigation was performed six times. Manual overhead irrigation was the irrigation method used.

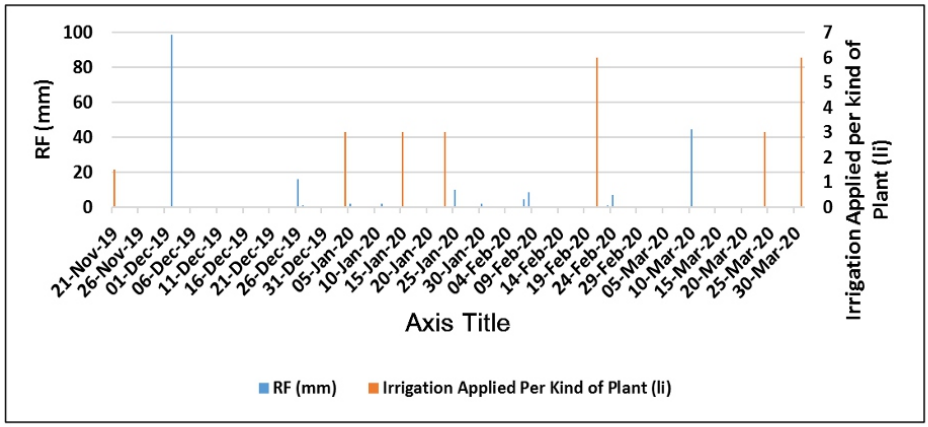

Figure 4. Rainfall and irrigation applied during crop production

Table 3. Growth and yield of three rice varieties

Parameters	APO	LG 27	NSIC 27
Height, cm	112.2	100.6	108.2
Length of Panicle, cm	18.5	17.9	15.7
Seeds per panicle	90.2	77.2	88.0
No. of Tillers	8.3	3.1	4.9
No. of Productive Tillers	7.7	2.8	4.5
No. of Unproductive Tillers	0.7	0	0.4
Seeds per hill	697.0	239.3	431.2
No. of hill (10 X 10 cm)	28,450.0	28,450.0	28,451.0
TOTAL Seeds	13,076,650.5	6,808,654.0	12,268,071.2

Table 4. Crop production after the main crop

Crop	Eggplant	Tomato	Wax Pepper
No. of Plants	24	20	36
Planting distance, m	0.75 x 0.75	0.75 x 0.75	0.75 x 0.75
Average height, cm	52	84.1	31.7
No. of Harvest, pcs	451	523	2487
Weight, kg	20.5	11.97	10.2
Average weight per piece	45.46 g/pc	22.9 g/pc	4.1 g/pc
Price as of March 1, 2020	P 40 / kg	P 30 / kg	P 150 / kg
Gross (Php)	820.10	359.30	1529.51

3.5. Growth and Yield of Crops

The area (248.5 m2) is planted with rice in different varieties. After crop care and management, including that it was supplemented with irrigation water through manual overhead irrigation from the Runoff Interceptor, the APO upland rice variety was assessed (Table 3). It has 7.7 productive tillers, the length of the panicle was 18.5 cm, seeds per panicle was 90.2, and was 112.2 cm in height. The yield was 8.73 tons/ha (248.5 kg for 284.5 m2 at 10 cm x 10 cm planting distance). The diversified crop (Table 4) used eggplant, tomato, and wax pepper (siling panigang). They were planted at a 0.75 x 0.75 m distance. Fertilization was done in four split applications for each kind of plant based on soil chemical analysis by the Bureau of Soil (Department of Agriculture Regional Field Office III). The average height of Wax Pepper was 31.7 cm. The yield was 5.04 tons/ha (143.4 kg for 284.5 m2). Fertilization was done in four split applications with a total of 15 kg for each kind of plant. Wax Pepper has the highest gross production (Php 1529.51).

3.6. Cost and Benefit

Initial expenses include runoff establishment supplies and labor. Fixed costs include depreciation, interest on investment, repair, and maintenance, while the variable costs were farm inputs and labor costs for crop production. Table 5 is derived from the first crop (rice) and the second crop (wax pepper, eggplant, and tomato). For the benefit and cost analysis, wax pepper was used because it had the highest gross production.

Table 5. Cost and Benefit Analysis

BASIC COMPUTATION	Amount (Php)
I. Initial	121,778.25
II. Fixed cost	
a. Depreciation cost (5 % of the initial cost)	6,088.91
b. Interest on Investment (5 % of the initial cost)	6,088.91
c. Repair and Maintenance (2 % of the initial cost)	2,435.57
Useful Life, years	20
Total Annual fixed cost	14,613.39
III. Variable Cost	
a. Mulching Film, seeds, fertilizers, insecticide, etc.	2,210.00
b. Labor Cost	5,250.00
Total Variable Cost	7,460.00
Total Annual Cost	22,073.39
IV. Gross Income	33,098.60
a) First Crop (Rice), Diversification (wax pepper)	
V. Net Income	11,025.21
VI. ROI (%)	0.09
VII. Payback Period (years)	11.05

4. Conclusions

The runoff interceptor is formed along contour lines. A terrace was constructed between runoff interceptors. For the first harvest, 248.5 kg of rice was produced with an area of 284.5 m2. Soil extirpation was also observed. For supplementary irrigation, the amount of water intercepted was 26.32 m3.

In the production area formed in the form of terraces with runoff interceptors along contour lines that stored water for irrigation purposes during the rainy season, three different high-value crops (eggplant, tomato, and wax pepper) were grown. There were twenty-four (24) eggplants, 20 tomatoes, and 36 wax peppers raised. Four split fertilizations were done. During this management period, rainfall occurred, but in plant water requirements manual overhead irrigation was performed. There were 588.6 mm of rainfall (November 2019 – May 2020) and 25.5 liters of irrigation water applied for every kind of plant.

The average height was 52 cm, 84.1 cm, and 31.7cm for eggplant, tomato, and wax pepper, respectively. The harvested crop was 25.5 kg for eggplant, almost 12.0 kg for tomato, and 10.2 kg for wax pepper, but the highest gross value was for wax pepper. The cost-benefit analysis illustrated that return of investment (ROI) was 0.09% and the payback period was more than 11 years for recovery of investment. In farm development in upland or rolling areas, especially during the first year, there will be almost no or zero net income, but if the area were used and maximized it would increase hypotenuse in subsequent years. Left topsoil undisturbed perimeters and catchment area should be planted with high-value crops that have been tolerant to drought and do not require adequate irrigation water. The use of low-cost substitute materials to minimize initial costs may be used to create runoff interceptors. Runoff interceptor maintenance should be followed periodically. Select high-value, off-season, and minimum water requirement crops to grow in crop production in terraced areas.

Conflict of Interest

All authors declare no conflicts of interest in this paper.

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Survival Strategies of Female Workers: A Study in a Tea Garden of Bangladesh

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ABSTRACT

The main objective of the study was to determine the survival strategies adopted by the women tea workers in maintaining livelihood. The study was conducted at tea garden of National Tea Industries, at east Shahi Eidgah of Sylhet Headquarters in Bangladesh. Data were collected from 120 women tea workers by simple random sampling throughout January to February, 2014 using interview schedule as principle tool. Most of the women tea workers (70%) had medium adoption of survival strategies. The mean adopted survival strategies were higher for food, health & hygiene and financial aspect than housing and immediate incidence aspect. Taking less preferred cheap food and avoiding protein enriched costly food item in daily diet was the top ranked survival strategy followed by male cut trees from nearby forest & sells fire wood and drinking salted tea to withstand against scorching sunlight while plucking leaves. Formal education, access to credit and communication media exposure had significant positive relationships with the survival strategies adopted by women tea workers.

Keywords *Survival Strategies, Female Workers, Tea Garden*

1. Introduction

The tea industry of Bangladesh dates back to 1857 [1]. At present there are 163 tea estates in Bangladesh. The tea estate covers 1,14,014.39 ha of the grant area of which 49.82% i.e. 56,801.99 ha is under tea plantation [2]. It plays an important role in the national economy through trade balancing and employment generation. It employs 117728 people of ethnic minority directly along with 3,50,000 dependents which constitutes 3.3% of national employment [3, 4]. According to Khan et. al. [1] on an average, Bangladesh produces 63 million kilograms tea annually which is 0.81 % to GDP and about 1.0% to export earnings [3].

Among tea workers more than seventy five percent are women and plucking leaves is their principle duty [4]. Employers prefer to engage women for plucking tea leaves since they do a better job and are paid less than the men. It is very real scenario that women workers of tea garden do not get actual evaluation in terms of financial and social aspects giving hard working whole day long as well as

[5]. The tea garden workers are considered to be among the poorest and most deprived section of organized labor [6].There is a lot of evidence that the tea workers in Bangladesh especially women live an inferior standard of life compared to that of the major tea producing countries in the world [7]. They lead a very miserable condition of life compare to other sectors such as garments factory, ship breaking industry, and even of brick field workers. It is often claimed that the minimum wage levels are highly insufficient to cover basic needs, because wages in the tea plantation sector are relatively low, even by the plantation sector's standards [8]. The tea worker communities are one of the most vulnerable people of Bangladesh [4].

It is also true that all of the main functions of Bangladesh Tea Board (BTB) are related to the raising of tea cultivation, sustaining quality assurance, and giving license to manufacturers, but only one function is related to the welfare measures for laborers and employees. It is also the same about the Bangladesh Tea Research Institute (BTRI) where there is no research department centering the social and human policy or implementing demands of laborers [7]. Therefore, it is very significant to extend substantial knowledge about the survival strategies adopted by the female workers here. For proper policy planning, the findings would provide a bench mark. Based on this circumstance, the study was conducted with following objectives:

1. To ascertain the survival strategies adopted by the women tea workers; and
2. To identify the socio-economic characteristics of women tea workers relevant to their adopted survival strategies.

2. Methodology

Study area, population and sampling: The study was carried out purposively at Doldoli tea garden, one of the three gardens of National Tea Industries of Bangladesh located at east Shahi Eidgah. The garden is situated on the northern side, at a distance of about 3 kilometers from Sylhet Headquarters in Bangladesh. As sample of the study, 120 female workers out of 186 were selected by simple random sampling.

Variables of the study and their measurement: Various socio-economic characteristics of the women tea workers like age, formal education, experience, household size, number of dependent members, income, access to credit, communication media exposure were considered as the independent variables of the study. The dependent variable was the survival strategies adopted by the female tea workers. Key aspects of livelihood such as food for dietary consumption and pure water for drinking, financial capability to maintain family, health care, housing facilities, actions in immediate incidence/ crisis were taken as the basis of measuring adopted survival strategies of women workers. Thus adopted survival strategies were categorized into five aspects as food, housing, health & hygiene, financial and

three for immediate incidence were prepared. Survival strategies were measured using a four point rating scale for each statement on those five aspects. The method of assigning scores to the four alternatives in each statement was as follows:

Extent of practice	Scores assigned
Frequently	3
Occasionally	2
Rarely	1
Not at all	0

Thus total score of adopted survival strategies for 16 statements may range from 0 to 48. On the other hand, Survival Strategy Index for each statement was calculated by following formula:

Survival Strategy Index (SSI) = $3\times F + 2\times O + 1\times R + 0\times NA$

Here, F, O, R and NA means total number of women tea workers mentioning frequently, occasionally, rarely and not at all practiced of a particular survival strategy respectively. Data Collection and analysis: Based on the objectives of the study, a structured interview schedule was prepared. The schedule contains both open and closed forms of questions. Data were collected throughout January to February, 2014 by personal interview. At the end of data collection, the collected data were coded, compiled, tabulated and analyzed. The qualitative data were transferred into quantitative data by appropriate scoring technique. Various descriptive statistical measures such as range, percentage, mean, standard deviation, rank order, correlation, F test were used for categorization and describing the variables.

3. Results and Discussions

Survival strategies adopted by women tea workers: Survival strategies adopted score for women tea garden workers varied from 20 to 43 against the possible range of 0- 48. The mean and standard deviation were 30.29 and 4.41, respectively. They were classified into three categories based on their score of survival strategies adopted and presented in Table-1.

It is revealed from Table-1 that majority (70%) of the respondents fell in medium category whereas rest of them fell in low and high category in almost equal proportion as 15.8 and 14.2 percent respectively. It indicates that most of the women tea workers adopted different survival strategies to maintain livelihood in a considerable extent. Previous studies conducted in tea garden also confirm various survival strategies adopted by women tea workers [9, 10, 11].

Aspect wise survival strategies adopted: From Table-2, the average score was 2.10, 1.56, 1.98, 2.04 and 1.56 for the aspects of food, housing, health & hygiene, financial and immediate incidence

respectively. Since the average value for each aspect could vary from 0- 3, all the mean score exceeds its half value (i.e. >1.50). It indicates the significant adoption level of survival strategy by women tea workers in each aspect of the study.

Table 1. Respondents category based on survival strategies adopted

SI. No	Category of respondents	Frequency	Percentage	Mean	Standard deviation
1.	Low (score up to 25.88)	19	15.8		
2.	Medium (score 25.89- 34.70)	84	70.0	30.29	4.41
3.	High (above 34.70)	17	14.2		

Based on mean score, the aspects were categorized into homogenous sub group as presented in table-2. Aspects within sub group do not significantly different from each other but between sub group differs significantly. It is revealed that women tea workers mostly adopted food, financial and health & hygiene related survival strategies. Comparatively strategies related to immediate incidence and housing were less frequently adopted and fall in same sub group. Previous studies in different tea gardens revealed that women tea workers mostly face crisis in food, health and economic sectors and struggle for their maintenance [12, 13, 14].

Table 2. Homogenous subsets for survival strategies of different aspects

Aspects	Sample size	Subset for alpha= 0.05	
		1	2
Immediate incidence	120	1.56	
Housing		1.56	
Health & hygiene			1.98
Financial			2.04
Food			2.10

Ranking of survival strategies adopted to maintain livelihood:

Adopted survival strategy score for each statement was calculated by using survival strategy index (SSI) and based on SSI, rank order for these statements were made as presented in Table 3. It is evident from the Table-3 that taking less preferred cheap food and avoiding protein enriched costly food items in daily diet was ranked top. 59% respondents practice this strategy frequently and 33% occasionally. Since their income is poor, they usually take rice with cheap food items like vegetables, pulses as daily diet. They rarely consume fish, meat as its market price is higher and beyond their afford. According to Mojumder and Roy [4] although the workers get rations at a concession, a family can hardly have decent food items on their plate. They indeed have very poor quality and protein-deficient meals.

Table 3. Ranking of survival strategies adopted to maintain livelihood

Survival Strategies	Respondents' percentage under each extent of practice				SSI	Rank order
	F	O	R	NA		
Food						
1. Extent of taking less food/skipping meal	36	42	18	4	252	6
2. Taking less preferred cheap food and avoiding protein enriched costly food item in daily diet	59	33	8	0	302	1
3. Using natural channels inside tea garden for drinking & other purposes when supply water scarce	29	36	21	14	216	11
4. Planting fruits trees and vegetables around homestead to meet family demand	38	32	19	11	237	8
Housing						
5. Use of straw, mud and other materials to repair broken residents before rainy season	25	47	22	6	230	10
6. To avail residence facilities, engaging wife as tea garden worker	10	17	56	17	145	15
Health & hygiene						
7. Planting & using local medicinal plants to cure from diseases	27	47	21	5	234	9
8. Drinking salted tea to withstand against scorching sunlight while plucking leaves	44	50	6	0	285	3
9. Providing package money to NGO (Water Aid, IDEA) to establish hygienic toilet	36	14	27	23	195	12
Financial						
10. Male cut trees from nearby forest and sell fire wood	49	44	6	1	290	2
11. Females engaging in tea garden to have some financial support in family	16	22	55	7	176	13
12. Rearing poultry and livestock to fetch additional income	30	47	21	2	246	7
13. Saving weekly money to any reliable person like shopkeeper, mohajon etc.	52	29	7	12	265	4
Immediate incidence						
14. Taking loan from neighbors with interest	37	45	17	1	261	5
15. Selling homestead chores	2	42	30	26	142	16
16. Selling livestock	2	35	57	6	159	14

F=Frequently, O=Occasionally, R=Rarely, NA=Not at all, SSI=Survival Strategy Index

Table 4. Correlation between socio-economic characteristics of the women tea workers and their survival strategies adopted (N=120)

Socio-economic characteristics	survival strategy (r value)	Tabulated value significant at		Remarks
		0.05 level	0.01 level	
Age	0.136			Not significant
Formal education	0.222			Positively significant at 0.05 level
Working experience	0.117			Not significant
Household size	0.123	0.177	0.231	Not significant
Number of dependent member	0.108			Not significant
Monthly Income	0.155			Not significant
Access to credit	0.309			Positively significant at 0.01 level
Communication media exposure	0.214			Positively significant at 0.05 level

Next top ranked survival strategy was drinking salted tea to withstand against scorching sunlight while plucking leaves. It is found that 44% of the respondents drunk frequently and 50% respondents occasionally. Plucking leaves under scorching sun light hours after hours is very laborious job. It is their indigenous techniques to collect some young leaves, drying in sunlight, boiling and mixing salt with it to make it edible. In tea garden, most of the women workers have a plastic bottle containing that salted tea and consume whole day long.

Relationship between socio-economic characteristics of the women tea workers and their survival strategies adopted to maintain livelihood Pearson's product moment correlation co-efficient ® was computed in order to explore the relationship between the socio-economic characteristics of the women tea workers and their strategies adopted to maintain livelihood. The findings are presented in Table 4.

The findings indicate that formal education, access to credit and communication media exposure of the respondents had significant positive relationship with their survival strategies adopted. Education increases the knowledge and understanding of the respondents. It enables them to determine better strategies and more adoption of those strategies. According to Ruma and Dipak [18], poor educational status of the tea garden workers is one of the major reasons for insecure livelihood and miserable living condition of the community and Mojumder and Roy [4], stressed both formal and informal education among tea garden community for better livelihood.

Again, more access to credit makes people able to create more income sources. Thus enables them to adopt strategies for better livelihood. Rajasenan [19] recommended easy access to credit for better livelihood of tea garden workers. Exposure to communication media increase their knowhow and make them aware about better livelihood. Thus direct them to adopt more strategies for better living. Das and Islam [20] suggested frequent communication between the people of tea gardens and mainstream society to uplift their livelihood. Thus there are certain socio-economic characteristics of women tea workers that influence their adopted survival strategies. Proper nourishment and maintenance of those characteristics can enable them to adopt more strategies for better livelihood.

4. Conclusions

The women tea workers adopted survival strategies centered on food, health & hygiene and financial solvency. They struggle a lot to manage food items for their family members. Women tea workers try to involve in different extra income source since salary from garden is not enough to maintain livelihood but isolation form mainstream society is a great hindrance here. For health purpose they mostly depend on indigenous and traditional survival strategies. To increase their adoption of strategies for survival and better livelihood, educational status (adult education, educational campaign etc.) and easy access to different credit opportunity (micro-credit, bank loan etc.) should be improved. Different communication media (radio, television, development workers etc.) should be available to them. Adopted survival strategies should be scientifically proven and ultimately beneficial for them. In this concern, tea garden authority, government and non-government organization should initiate collaborative action.

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of Citrus aurantium rootstock the most commonly used citrus rootstock in Morocco [31].

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The Increasing of Peasants' Income Farmers in Amoron'i Mania Region by Ameliorating the Production System of Rabbit

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ABSTRACT

Madagascar is a developing country on agricultural issue. The population growth brings about poverty problems due to the inadequate master of the production technics. The recrudescence of cattle-rustling leads the Malagasy population to adopt a short cycle animal husbandry. Rabbit-breeding is a real source of income and it makes up for the lack of animal protein in the daily nutrition. The increased prolificacy of doe-rabbits for this kind of breeding is not high. The purpose is to assess the production system of rabbit in the study field. The method is about inquiries and field observations close to 100 peasants in this region. The social, economic and technic data of rabbit-breeding are gathered in the bosom of the farmers. The family agricultural exploitation system characterizes the rabbit production hesitating between politic of supply and that of self-sustenance. Such hesitation in the level of microeconomic is aggravated by the low study level of the farmers and a critical attitude of practices towards the modern norms of cuniculture. The majority of the farmers do not dun rabbit-burrdo and the local of animal husbandry is combined with human's habitation. The rabbits cohabit without any distinction by statute. Generally, green leaves are food distributed to them without taking into consideration by statute. A minority of the farmers give treatment to the sick animals. The performances of this breeding is still so weak because the technical management result is by 50% inferior to that of the production of a female rabbit in French and the production remains of a dominance of autosustenance yet. Despite the largely traditional practice and a production system on family bases, this activity is profitable in Amoron'i Mania, but with a scanty source of income. The supervision and training of the farmers on the cuniculture technic are primordial, the popularization of the isolated practices of amelioration and the initiatives of solidarity of the "Fihavanana" (kinship) about the common use of buck rabbit producer and green plants.

Keywords *Cuniculture, Prolificity, Production System, Alimentation, Amoron'i Mania, Solidarity*

1. Introduction

The lack of animal protein is difficult to control so far subject. Given the increase in theft of oxen, the Malagasy population has adopted other breeding cycle solution courses like rabbit breeding. Rabbit breeding is easy to accomplish and with an interesting productivity [6]. Thanks to the high prolificity and the very short run cycle of production, the does have the potentials of raised production, besides the

necessary investment for that kind of animal husbandry is low [6]. For the rabbit farmers, the production acceleration leads to the swiftness of the treasury motion. For the customers, the rabbit's mead has a better nutritional value than ox' and pork's meat [2], [7], [12] usually consummated by the Malagasy population and can make up for the insufficiency of animal protein within the daily nutrition. In Amoron'i Mania, rabbit-breeding is less developed [16]. That current condition ascertained puts pressure upon the supply of rabbit product. The meat of rabbit and the alive rabbit sale is even rare. That problem of weak rabbit production ascertained brings about the genesis of this study so as to analyze the cause. Many parameters can be considered as factor of underdevelopment of the cuniculture in Amoron'i Mania such as the production system which leads to the product insufficiency in the region studied. The objective of this study is to get technical and economic data about the current rabbit production and the major problems to the development of this field. That knowledge is useful to apprehend the means which permit the elimination of restraints and to work out appropriate strategies for the development of the sector, to bring about to a sustainable production. So as to reach these goals, an assessment of the socio-economic and technical characteristics of rabbit-breeding is necessary in this studied region. The methodological approach adopted consists of the inquiries and observations in the fields by 100 visited animal husbandry. Two hypotheses have been considered in this study: The hesitation at the level of the Agricultural and Family Exploitation (AFE) between the organized system toward the commercial supply and autosubsitence, brings about by a neglect of the farmers in the application of modern technics. As such hesitation in politic micro-economic provokes the weakness of the peasants' income.

2. Material and Methodology

The approach methodology adopted consists in investigations and field observations from 100 farmers in four districts of the study area.

2.1. Material

100 sheets of investigations have been previously established and used during the collection of field data. The CSPRO version 4.0 software allows you to create an input mask to introduce this information. The XL 2008.6.03 STAT software is used for descriptive statistics.

2.2. Site Selection

Near surveys of traders Petite Antananarivo speed markets rabbit sled to the region Amoron'i Mania.

Much rabbits for sale in Low speed market are original rabbits Amoron'i Mania, where almost every house hold farmers raising rabbits as a source of fertilizer used for cultivation because of the poor soil in this region. Both arguments have led to choose the region Amoron'i Mania as the research site.

2.3. Sampling

Because time constraints, insecurity, materials, information, 100 elevators are surveyed in this region which twenty-five (25) Livestock localities by district. The choice of these family farms of farms visited was done on the basis of their nearest accessible road. National irrespective of the size of the farm breed of rabbit. This choice also takes into account the safety vis-à-vis investigators zebu thieves "dahalo".The researcher does not consider isolated localities in the red areas.

2.4. Database Creation

During the discussion, the researcher realized the data collection by completing the survey form and the pre-established questionnaire in the form of semi-directive questions about the social, technical, economic and breeding issues encountered. During the conversation, the interviewer visits the livestock houses, fulfills the survey sheet.

2.5. Statistical Data Processing

The survey forms are stripped and copied to the computer using the CS Pro software version 4.1. The data developed by CS Pro is converted to Excel. This result allows Excel to leave staffing table, as well as percentage curve and graph. This result also obtained by Excel allows for calculations of average, standard deviation, minimum and coefficient of variation using the XL 2008.6.03 STAT software.

2.6. Data Calculated

2.6.1. Calculation of the Expenses of Rabbit Productions Total expense = Expense of construction + food Expense + Expense on the care and treatment + cost of manpower.

2.6.2. Calculation of the Returns of Rabbit Production

Number of rabbit produces per year = sold rabbit Number + Number of rabbit consummated

Cost of rabbit produces per year = Number of rabbit produces x middle Price of rabbit

Total recipe = Cost of rabbit produces + cost of manure. 2.6.3. Calculation of the Beneficiary Margin

2.6.3. Calculation of the Beneficiary Margin

The yearly margin = Total recipe - Total expense

3. Result

3.1. Social Features of the Breeder

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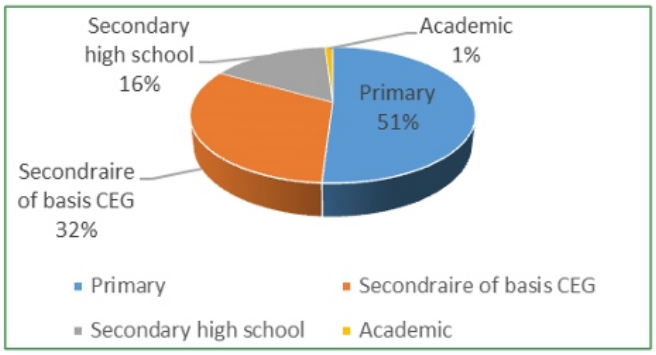

Figure 1. Distribution of the EAF according to the level of survey

According to this figure, the major part of the breeders reinvestigated is level primary (51%), then of secondary level of basis (CEG) (32%). The secondary level of the high school (16%) is minority. The academy clever is very rare (1%). This result shows that the level of most breeder survey is very low. As for the level of survey increases, the number of the breeders decreases. Concerning the rabbit formation as a preliminary, the whole farmers (100%) don't have formed about the technic of rabbit production yet.

3.2. Technical Features of Raising

3.2.1. The races of Elevated Rabbit to Amoron'i Mania

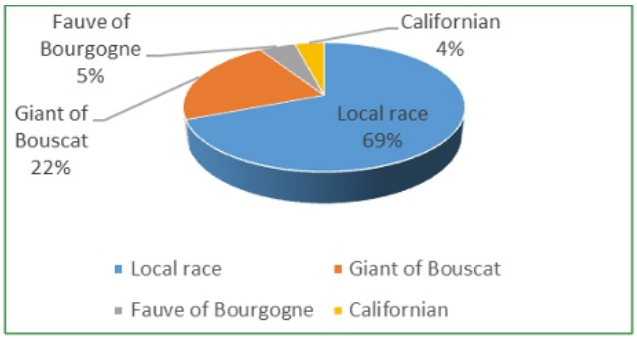

Figure 2. Distribution of EAF according to the elevated race

According to the figure 2, amidst the 4 races existing, the local race dominates in the region with an elevated percentage (69%). Then, the race Giant of Bouscat occupies a fairly elevated percentage of (22%). The races Fawn of Burgundy and Californian are very rare in this region. Their percentage is respectively 5% of the Fauve de Bourgogne and 4% of the Californian race. The inquiries show that 100% of the visited exploitations did not possess a genealogical registration.

3.2.2. The house of Rabbit Breeding

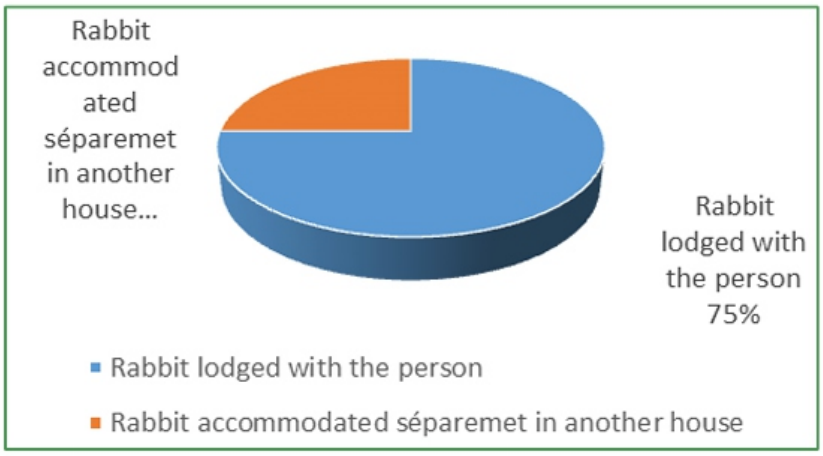

Figure 3. Distribution of the EAF according to the presence of raising house separated of dwelling house

According to the figure 3 and the investigations on land 75% of rabbit raisings are combined totally with the building of breeder dwelling. In this case some raisings are in the same room with the man or in the same buildings with the man but of different room. Among these breeders only the 25% possess one of breeding separated of their dwelling house.

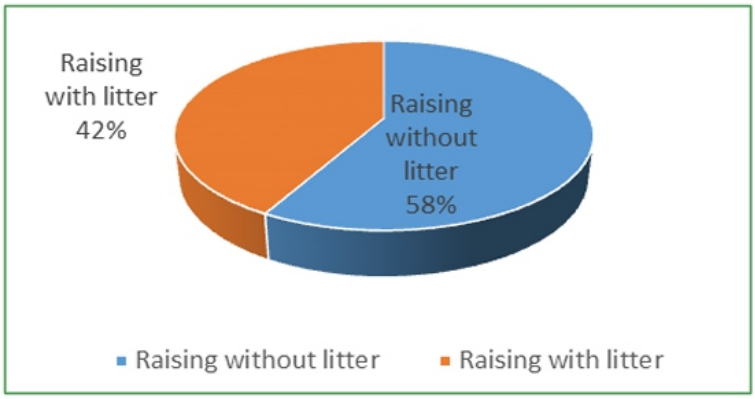

Figure 4. Distribution of raisings according to the use of litter

According to the figure 4, the majority of raisings doesn't use the litter (58%). Only a minority uses some litters (42%) but the renewal makes itself two or three times per year.

According to the figure 7 the majority of breeding is without ordering of rabbit by statute (79%). That is to say that the elevated rabbits are all compounds in only one room without partitioning and without distinction of sex and category. Only, a minority of breeder follows the norm for the ordering of the rabbits by statute (21%). In that case, the house of dwelling is partitioned to have several small cages in order to classify the rabbits.

3.2.3. Food

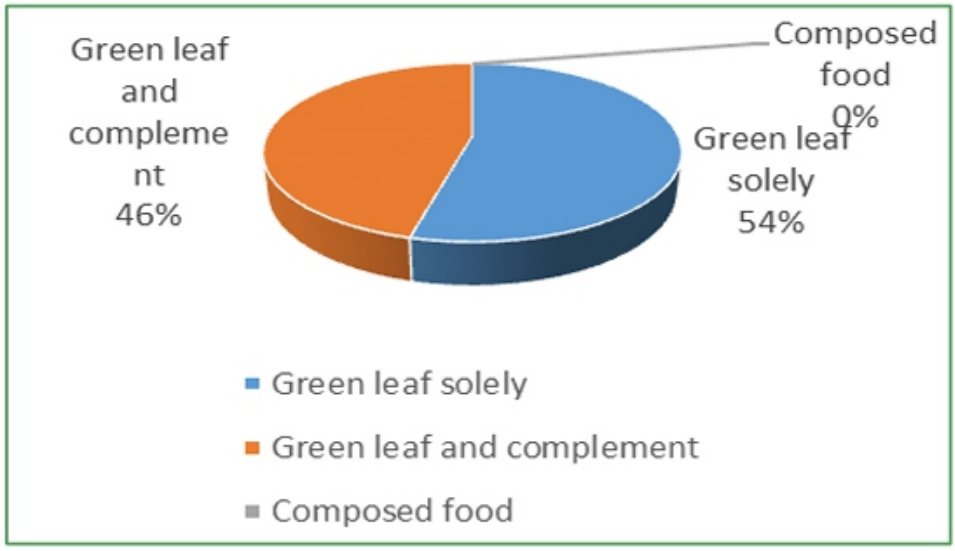

Figure 8. Distribution of the EAF according to the food regime of the rabbits

According to the figure 8 and the investigations on land, the majority of the AFE distributed solely to the green leaf rabbit (54%). Certain farmers who distribute green leaves and the complement (rice, cassava, sweet potatoes) occupy a second place (46%). These breeders valorize all human food garbage for feeding the rabbits. The use of provender (composed food) doesn't exist for the population investigated in the region Amoron'i Mania (0%). The breeder achieves this activity by groping and without objective. Most breeders think that the use of provender is difficult and expensive.

3.2.4. Health

According to the figure 9, the majority of the Agricultural Family Exploitation (AFE) underestimates the disease of rabbit (55%). These breeders note the very frequent death of several rabbits without obvious symptom. 35% of the breeders affirm that scabies is the more frequent disease at them. 10% of the breeders noted the coexistence of scabies with the diarrhea that provokes the successive death of rabbits. No breeder signaled the existence of diarrhea only (0%).

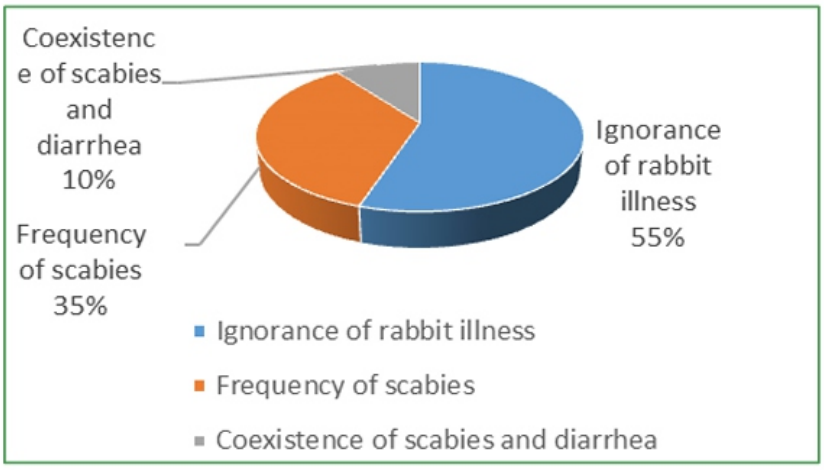

Figure 9. Distribution of the AFE according to the frequency of disease

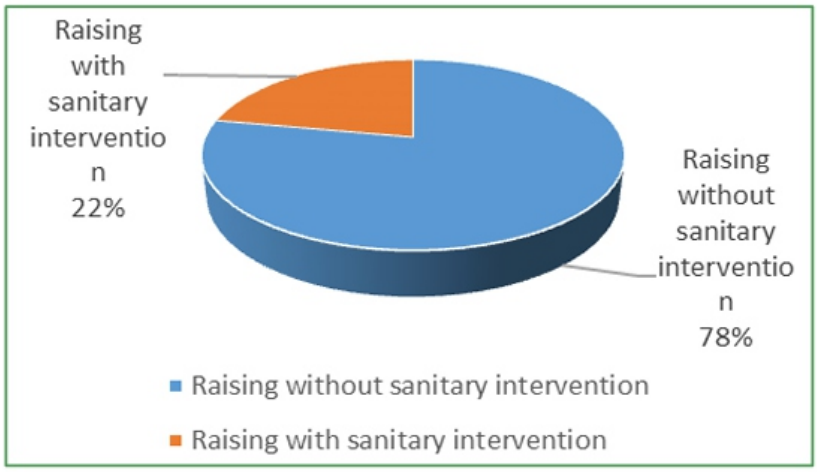

Figure 10. Distribution of the breeder according to the sanitary intervention

According to the figure 10, most exploitation is without sanitary intervention even in case of disease (78%). A minority of exploitations is with sanitary intervention, killing the parasitical and decontamination of the raising locality (20%).

3.2.5 The result of the reproduction and the rabbit production

Table 1. Result of the reproduction and the rabbit production

Parameters	Modality	Average
Reproduction parameter	Number of low placing per female per year	4,5±0,6
	Number of total born per low placing	5,6±0,2
	Number of alive born per low placing	5,1±0,3
	Rate of mortality of young rabbit	13,6±1,5
Parameter of production	Age to the sale (month)	4±0,5
	Medium weight to the sale (kg)	1,8±0,8
	Density of rabbit (m^2)	3,2±3,2

The table 1 represents the result of the reproduction and the rabbit production. From this chart, the medium age to the sale of rabbits was supplied by 76% of the farmers. It was of 4 months (extreme: 3 to 8 months). For the alive weight to the sale, the inquiry pointed out a medium weight of 1,8 kg (extreme: 1,4 to 3,2 kg) for the farmers who supplied an answer. Concerning the number of low placing per female per year, the inquiry pointed out an average of 4,5 low placing per female and per year. The inquiry has brought back a number of total average bore of 5,6 young rabbits by low placing. That study has shown an average of alive born per low placing of 5,1 young rabbit per year. The result about the number of died per bear allow to calculate the number of died per bear allow to calculate the mortality of rabbit. The rate of mortality between 0 to 20% had a value very high of the percentage (68% of the exploitations). The mortality between 20 to 40% occupied the 18% of the exploitations. When the mortality of the young rabbit increases, the effective of the animal husbandry is became more and more weak. A minority of animal husbandry (5% of the exploitations) found a mortality so high of the young rabbit (80 to 100%). Generally, the average rate of mortality of the young rabbit before weaning was of 13,62%.

Table 2. Expenses, recipes, and annual beneficiary border of the rabbit production (1 year)

Parameter	Average	Standard deviation	Min	Max	CV (%)
Number of sold rabbit	9	8	0	50	92,51
Number of the consummated/year	15	9	0	50	57,37
Price of rabbit	5196	937	3333	8000	18,03
Cost of the production/year	92 333	39 330	68 438	240 313	42,52
Annual recipes of production/year	186 474	86 242	79 692	475 500	46,24
Beneficiary border/year	94 141	63 420	11 255	252 546	67,36

3.3. Feature Economic of Raising

The elements of response of the inquiries enable to put out some parameter of farming economy. The table 2 below shows the number of sold rabbit's prince, expenses, recipes and annual beneficiary border of the rabbit production in the Amoron'i Mania Region.

From this chart, the coefficient of variation was superior to 15% which signifies that the values were changeable with any exorbitant discards. That means that the studied population has been very heterogeneous. The number of sold rabbit was very variable following the objectives of the farmers and the availability of the alimentary resource. The value is varied from 0 to 50 rabbits sold with an average of 9±8 rabbits a year and per animal husbandry. The consummated rabbit was higher than that destined for the sale. The consummation per year varies from 0 to 50 with an average of 15±9 rabbits. The rabbit's prince has been very changeable too, following the size of the animal. The price is between 3333 to 8000 Ariary with an average of 5196±937 Ariary per rabbit.

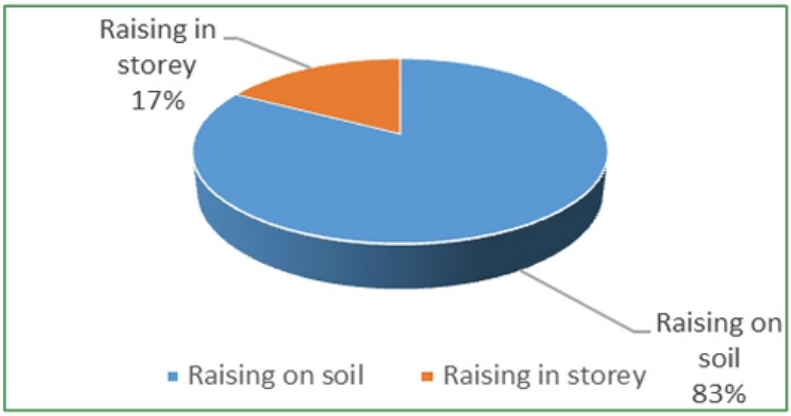

Figure 5. Distribution of the EAF according to the fashion of raising

According to this figure 5, 83% are raisings on soil without use of litter. 17% are only breeding in floor.

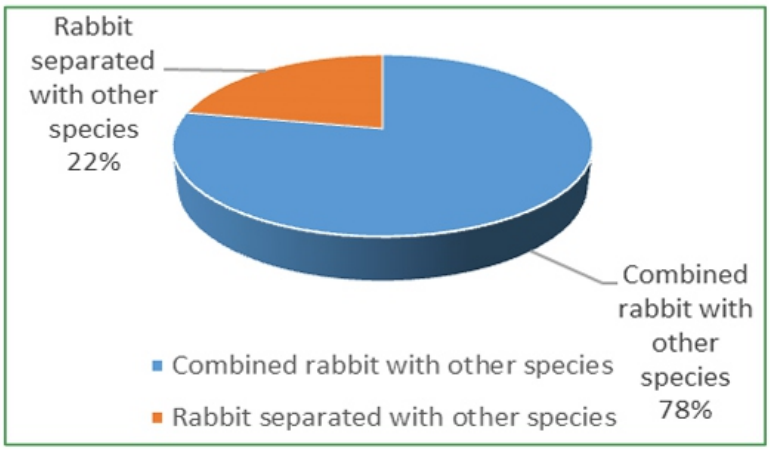

Figure 6. Repartition of the agricultural and family exploitation according to the combination with others species

According to the figure 6, most breeder (78%) separate the rabbits with other animals who risk killing them. Whereas 22% some breeder combine their rabbits with other animals (a fowl)

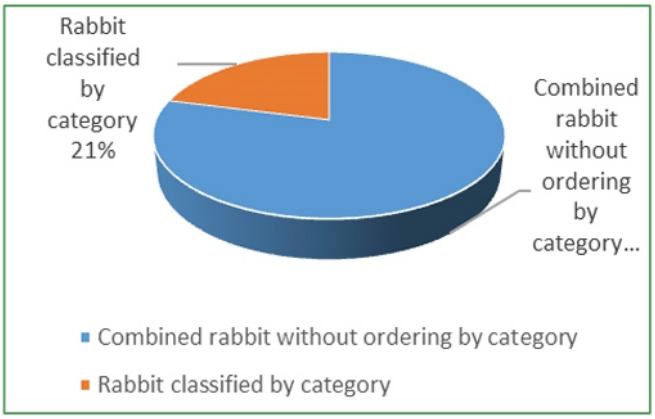

Figure 7. Distribution of the EAF according to the ordering of rabbit by category

The total expenses for the production of rabbit is changed from 68 438 to 240 313 Ariary per year with an average of 92 333±39 330 Ariary. The whole recipes along the year is varied from 79 692 to 475 500 Ariary with an average of 186 474±86 242 Ariary per exploitation.

The beneficiary border changed according to the exploitation's size. In general, the values of that beneficiary border found for all the exploitations were positive. The annual border is varied from 11 255 to 252 546 Ariary according to the productivity of the workroom with an average of 94 141±62 420 Ariary per exploitation along the year.

3.4. Constraint of Production

The problems conjured up by the producers along the investigation are presented in the chart below.

Table 3. Distribution of the animal husbandry according to the constraints of production

Constraints	Percentage (%)
Genetics resource	30
Lack of technical knowledge and supervision	40
Sanitary pressure	18
Alimentation	6
Theft	6

From this table, it's pointed out that 40% of the problems mentioned in the rabbit-breeding turn around the lack of formation and supervision for the technical management of the cuniculture. The genetics resource problem with the dominance of the local breed occupied a second position among the quoted constraints (30%). For certain farmers (18%), any diseases none mastered were frequent and the treatments are still represented blurred for them. The alimentary problem is the less evoked by the breeders reason why the percentage is work (6%). These last farmers demanded the need of complete nutriment (provender) for rabbit so as to resolve the feed shortage problem during the dry period. The problem of theft and security of animals are evoked by a minority of breeders (6%).

4. Discussion and Recommendation

4.1. Discussion

According to BURGAUD [1], rabbit-breeding figures a strong representation of women in 2005. This feminine majority is married in this study according to the result of investigation done to Amoron'i Mania where the 58% of the breeder investigations are some women. The raising of rabbit doesn't have need of the man power that exercises other a lot stronger activities, what justifies their relatively weak number in relation to the women. That result is contrary those reported in the past by JAZOUI T. et al.

. [9] in Marocco. That author found that the masculine breeders are more numerous (70,4% the case).

The totality of the farmers (100%) non-formed in the rabbit production technic in that study is still superior to which the result found by JAZOUI T. et al. [9] in Marocco. That author reported 95,84% of the case non-formed. But, the success of an animal husbandry lays principally on the competency of the farmers [15]. That indicates that in that study, the farmers practice this activity by proceeding tentatively without any technical knowledge. That lack of formation constitutes a handicap in the master of the production technics which are necessary to the success of the rabbit exploitation. Accordingly, this animal husbandry is practiced in a traditional way, and remains of a family type and a secondary activity for of the commercial and modern production.

The level of survey of the breeder has a major influence on the evolution the development and the production. According to DJAGO and al. [5], a good breeder must be above all an intelligent and untiring worker. He/it must have the scent and a good mind of observation while avoiding the bad habit. He/it can follow the new techniques of intervention and improvement of breeding. In revenge, in Amoron'i Mania the majority of the breeder has a low survey level. This insufficiency of survey level is one of the blockage factors that prevent the curiosity, the research of the improvement techniques and even the discussion with the facilitator and farming technicians. This situation accentuates the bad situation of the rabbit breeding in the Region of Amoron'i Mania handled achieved again in a usually traditional system. Consequently, this is very low survey level pulls up the development of this path in this region and aggravates the hesitation to the level of the agricultural and domestic exploitation agricultural and familial between the politics of market and the one of the auto substance the absence of the breeder in full time influence also on the production of rabbit in this region because this activity becomes secondary. But according to DJAGO and al. [6], the rabbit cultural is a very productive and profitable activity for a good breeder because the fecundity of the female rabbit permits to get an important the youngster bunny number quickly. For example, in good conditions of raising, in climate tropical, a good female rabbit.

According to DJAGO and al. [6], the different race of rabbit distinguishes his herself/itself according to the nature and the color of hair and the format of the animal. But according to the done investigation and the observation on land to Amoron'i Mania, five races are found in the Agricultural Family Exploitation (AFE) visited. Among his/her/it's remarkable races, the race the more exploited is the race locale (40%). This local race dominance in the exploitations for has explain itself/themselves by the fact that this survey achieved itself in farming environment where raising is practiced more in a goal of source of engrains and less commercial, what drives the breeder to exploit it the local races. In that case, the manures production is of a primary importance and the meat remain secondary. Besides, the dominance of the autosubsistence devaluates the commercial quality of the product. That mentality can be the

origin of the insufficiency of rabbit supply in the market and the weakness of the peasants' income.
75% of the breeder investigated not possessed of the houses of raising separated of the dwelling house. For decrease risks it of the animals towards the thieves and the carnivorous predators (dogs, mice, and other animals), they combine the rabbits with the house of dwelling of the breeder. Some breeders exercise this method because of the insufficiency of bottom, material of construction and the exploitable surface for a new construction. This situation explains poverty in the farming world. This choice valorizes the spatial resource already existed instead of spending outraged, this method of combination of the house of raising and human dwelling confirms the situation of the rabbit raising achieved of traditional way and domestic type production in the region of Amoron'i Mania handled.

According to SERRES O. [17], LEBAS F. and al. [13], the slots are necessary in order to isolate the female rabbit reproductive to assure the viability of the youngster rabbit it's time for stake low. In the case of raising to Amoron'i Mania this method is not consider by the majority of the breeder to Amoron'I Mania (79%). The majority of raisings combined the rabbits in the same a room without baffle or separation of the animals by category (79%). That value is inferior to the result of JAZOUI T. et al. [9] in Marocco which was till 87% of the case. That mode of lodging brings about a strong mortality of the young rabbits between weaning and also a weak number of the produced rabbit each year. The reproduction of the young is difficult to manage and increase the risk of early reproduction. This is entails a strong mortality of the small rabbit before severance and driven a weak number of rabbit produces per year. The reproduction of the young is unverifiable, the baggers to the level of the livestock his/her/its none mastered him there a lack of surveillance of the small, an absence of growth follow-up in size and in number of the elevated individuals. This situation is one of the factors of decrease of the effective that the time of the yield. Nevertheless, that practice justifies the existence of consanguineous farm in that studied region. The consanguinity is a cause of the reduction of stock size from generation to generation but also the strong mortality of rabbits. That mode of housing enlarges the surface allocated for the rabbits which diminish the performance of production. According to COMBES S. et al. [3], the augmentation of the available surface provokes numerous displacements of the rabbit that is one cause of the deterioration of the growing performance and of a stringer mortality, morbidity observed. That idea justifies the slowdown of rabbit growing and augment the age to the sale in that study. In more 22% of the rabbit raising are combined with other animals (poultry). There are possibility of germ transfer and pathogenic agent then between them. That practice favors equally the mortality of rabbit and brings about the effective's reduction.
According to DJAGO and al. [6], the hutches whose soils provided of a clean wire fencing, constitute a remedy already, because the droppings content the coccids falls on the floor and is not able to therefore more re-contaminate the animals. This model of construction or even the equivalent is not visible in the

region of Amoron'I Mania. The majority of the breeder uses soil for the inferior of the press immediately like matter available premiere, easy to construct molder expense. This choice is also motivated by a very low standard of living that doesn't permit to spend a lot of money. Some breeder thinks that soil is most convenient because it facilitates the organic matter obtainment and makes a hole of the female before the stake bottom. The practice of the breeding in soil doesn't consider the hygiene of the rabbit and favor the appearance of coccidiose. That practice mainly in the presence of litter augments the rabbit's mortality until being multiple of 5[4]. The non-adaptation of cage detected in that study can also be one of the factors determining the produced rabbit's effective at the origin of bad result of technical management in that region.

According to DJAGO and al. [6], the clean litter is added all 2 on 3 days and that the totality of the litter must be renewed all 7 on 10 days (of 1 times per week at 2 times all 3 sowed born at least). This is not the case in the region of Amoron'I Mania. The totality of raising makes itself on soil, the renewal of litter is disregarded. For the case of rearing to soil cleaning makes itself only during the organic matter evacuation about two or three times per year. What implies the lack of control of tidiness and hygienic during of the realization of the breeding rabbit in this region. According to LEBAS F. [10], it is necessary to determine the type of raising in order to exercise the food recommendation. It must follow very near the food of rabbits by the choice of the food type intended to the animals according to their age and their type of production; The follow-up of this technology is missing for the raising of rabbit to Amoron'i Mania. The majority of the breeder only distributes the unique green leaf (54%), and a few minorities reinforcing with of the complements. The distribution of food in disturbed doesn't exist in addition; they distribute foods without consideration of the necessity in quantity and quality according to category of the animals. That practice of green food distribution sole without any respect of the nutritional needs consistent provokes also a bad performance zootechnic. For LEBAS F. [10], the use of all balanced food doesn't allow the breeders to profit of the genetics potential of their animals. The use of balanced food is a mean, key for a better production because it can have multiple influences on the rabbit performance: performance of reproduction, of growth and the reduction of the mortality [10]. That practice of alimentation restarted can so be the origin of the bad technic result in Amoron'I Mania.

One can say that the breeder of rabbit to Amoron'i Mania is again far from being professional. The amelioration of the production is this path. The politics of public establishment centralization (CEG and High school) will be continued to increase the level of farming instruction. The solutions and measures long-term would be studied to solve the problems of insecurity in Madagascar.

According to DJAGO and al. [6], one of the geneses of the mites of agent origins responsible of the itch is the soiled object. According to investigate in Amoron'i Mania, un-respect of the cleanliness and hygiene in the house of breeding is remarkable. This bad habit encourages the evolution of this illness.

The bad conception of building and the non-utilization of cage soil either fenced equivalent drives to the humidity of the raising house. In addition, the majority of breeding is again on soil that provokes the retention of the humidity encouraging the spot of the litters, food loss and matter organic. Following the result of investigation to Amoron'i Mania, 97% of Agricultural Family Exploitation (AFE) are without treatment of animals and without preventive action. That result is contrary to that of BURGAUD A. [1], in France where the rabbit farming uses quantities of very important antibiotic. This situation explains itself by technician's insufficiency in animal health or breeding to discuss, to note and to solve the facts in the farming world. The breeders are in state of same ignorance of the simple diagnostic of symptom, reason and treatment of illness. This pain treatment and absence of prevention in the majority of breeding are a main reason of bad result of rabbit product in this region investigates.

The technic result reported above is very weak compared with the French production. The average of produced rabbits

per year is obtained by the sum of sold rabbits and consummated, give 24 rabbits per year pear exploitation. That number of produced rabbits doesn't reach but the half of a female production per year in France. As for LEBAS F. and al. [11], a female hybrid produces 48 to 50 rabbits of butcher per year. We can say that the average numerical productivity of rabbits of this current study is near to 50% inferior to that of doses of the French breeding lead by artificial insemination. That result from Amoron'i Mania has a very high discard as that which was reported by XICCATO G. et al. [18], in Vénétie, that reported an average of sold rabbits of 42,8 by female each year. The bad result in this study can be due to the practice of the traditional breeding: non-practice of weaning, non-intervention of the breeder to make the rabbits gush out, consanguineous breeding and the increase of stock mortality too, caused by the lack of technical and sanitary supervision.

The average age to the sale around 120 days (4 months) in Amoron'I mania so as to get a medium weight of 1,8 kg isn't alike those reported in the past by GUERDER F. [8], in France (72 days), by XICCATO G. and al [18], in Vénétie (83 days). But, it is essential to not that the age and weight alive to the sale of this study is alike those reported by JAZOUI T. and al. [9], in Marocco. The long last of breeding in that study results from a diminution of the growing speed due to the physical activity of the animal after the non-respect of the suitable density during the cage construction, but also caused by the use of the local breed of slow growth. So, the consequence of the traditional practices, the unbalanced alimentation, the cages non-adapted for rabbits can be bound to that bad result of the technical management.

According to MOENS M. [14], in spite of the numeric productivities and a modest relative weight, the raising of rabbit remains profitable: yearly clean margin by reproductive female of 32,000 F b u (France Burundian) superior to the one of the raising agro pastoral the system extensive carping to Bandai. For the domestic raising to Amoron'i Mania this activity is profitable and non-negligible income source.

The cost of rabbit production doesn't pass the selling price produces. In this case the difference gives a positive value. The yearly margin is 94 141±63 420 Ariary by exploitation. That shows the results of two or several reproductive females in a farm. This value is minimal in relation to result it of Burundi with well-organized exploitation and professional. This difference resides in the lack of capacity of the rabbit breeder but also in the difference of the again domestic and traditional operating system in the studied region. This weakness of the yearly margin is bound to the investment done by the breeder. In this region the investment achieved by the breeder is very weak and same hopeless for some parameters. Of this fact the size of exploitation is small the investments also weak on the construction, the medical and sanitary expenses, zero on the food, hygiene and prophylaxis that the materials of breeding Besides, there is not budget planned for the raising of rabbit. This insufficiency of bottom and investment justifies the quantity reduced the yearly margin by exploitation.

The major constraint of this breeding the most serious is the lack of formation of the breeders on the cuniculture. Every one accepts and recognizes the importance of preliminary formation in animal husbandry. A long the surveys, the majority of producers affirmed that the master of technical knowledge in term of conduct and flock management remain the key of the success of that exploitation. That lack of technical knowledge is also at the origin of genetics resource problem. In that case, the production is not preliminary planned to exploit the characteristics of a breed, even though the conformation of animal diminishes from a generation to another is caused by the consanguineous breeding. Moreover, the absence of breeders association, lack of formation structure and the supervision in almost the whole studied field are prejudicial to the development of the rabbit production. That failure of organization justifies the default of consideration of that field in Madagascar. Accordingly, this activity remains secondary and practiced in a traditional way. The sanitary pressure also occupies a big place in the blocking-up factor. That point is related to the lack of hygiene in the firm. Besides, the failure of sanitary supervision, distribution of medicines, popularization of the technologies are the aggrieving factor of the sanitary pressure. Certain producers affirmed the ignorance of the disease symptoms, the treatments and the necessary prophylaxis. By the absence of technician of supervision and/or veterinary, much exploitation didn’t have the sanitary intervention even in case of disease.

The problem evoked by the breeders is all constraints to the development of cunicole production. These constraints allow to search the essential conditions to the success of such exploitation. Those difficulties are generally bound to the behavior or mode of life of the producers, at the supervision of technicians, at the politic of development agreed by the state, the availability of resource in the physical space and the insufficiency of the financial resource.

This study leads not only to search the strategy in order to maximize the production but also to minimize the risks of the job and guarantee the augmentation of incomes. The success of this breeding

depends on the willing of the actors, the available means to exclude or a least diminish the constraints to its development. From that idea, some points will be ameliorable for the best future of this field in the studied region.

4.2. Recommendations

In order to assure a good management technical result to the best profitability of an exploitation of the breeding rabbit, he/it comes back to the actors intervening notably in the exploitation to clarify if the objective of raising is of the blows rabbit or the production of manure and to provide the corresponding efforts to this choice. The recommendation concerns three levels of intervening party as the practicing breeder, the technicians of raising, and the administrative authorities.

For the Breeder

The first activity of food concerns the conception of building and accessory of raising and also the environment. This better mentis about the norm while valorizing the raw materials existing to limit the expenses. These improvements of construction permit to respect the hygienic norms, prophylaxes regular and the care and treatment. The minority breeder will abandon the traditional and domestic production system to the profit of the industrial production system while adopting the technique of race improvement and the introduction of new more effective race. This change of behavior makes itself while increasing the size of exploitation to be more professional and commercial in order to have margin considerable recipient. The breeder winning to respect the food need of the animals by statute and to attend the activity of reproduction and will avoid to the so much that possible the inbreeding.

For the Technicians of Raising and Researcher

Framing technical - economic of the rabbit breeder is necessary, so possible while organizing the program the raising of rabbit on the parameters zoo techniques and sanitary for an improvement of the incentive and the profitability of raising and the prevention of the illnesses. For the Administrative Authorities They need to come with the creation of the associations of the rabbit breeder (financial support, concession of credit, etc).The formation will be reinforced by specialists in number being sufficient in zoo technician and or veterinary. The programs of genetic improvement are to also promote that the application of the modern technology. The incentive of the researchers will be studied to find new technologies for donated about 40 youngster rabbit per year, either 50 to 60 kg of meat per year to merchandise. The mentality of the breeder influences on the goal of his/her/its raising and duct to the consideration of the breeding rabbit like a simple pleasure but not a productive activity and a serious income source. The notion of system as collection of element operated unit, interactive manner permanently can contribute to the classification of the peasant breeder choice. In the region studied, the operating system Agricultural and domestic represent a third type in relation to the theoretical

distinction between the fashion of subsistence on the one hand and the commercial profit research on the other hand.

5. Conclusions

The survey made in the zone of rabbit production in the Amoron'I Mania Region, Madagascar has enable, from the evaluation of the socio-economic and technical characteristics of breeding, to identify the leading characteristics of breeding, to identify the leading mishaps to the cuniculture's development. From that study, it's pointed out that the cuniculture is generally a secondary activity for women aged of 30 to 50 years at a level of primary study. The modality of practiced animal husbandry confirms the family and traditional characters of this field. In that case, the performances of this breeding is still so weak because the technical management result is by 50% inferior to that of the production of one female rabbit in French and the production remains of a dominance of autosustenance yet. The non-development of this field in that region is due to the very low level of study of the farmers, aggravated by the lack of formation as a preliminary and the supervision on cuniculture.

Those failures favor the non-master of the suitable technics. The weak level of study induced a mentality far from the commercial production well organized, that confirm the hypothesis stipulating that « the hesitation at the level of Agricultural and Family Exploitation between the organized system towards the commercial supply and the autosustenance, brings about a carelessness of the breeders about the application of modern technics ». Besides, the investment is small or missing to the construction, the alimentation, the care and treatment of the rabbit. In that fact, the expenses of production are weak, that give back an annual beneficiary border positive.

That activity is profitable for the peasants but induce a money resource weak correlatively to small investment effected. That weak resource justifies the second hypothesis formulating that « the hesitation an politic micro-economic provokes the weakness of the peasants' income».

Those performances can still be ameliorated by the use of the means allowing to eliminate at least to alleviate the major constraints that are technical knowledge, the genetics resource, the alimentary resource and the sanitary pressure. It is obvious that if the conditions indispensables for the success of an exploitation are gathered, this rabbit-breeding supply for a short run the possibilities of animal protein growth and augmentation of the producer's incomes. Par consequent, the research of solutions to the evoked problems above enables to reach that objective. From that restitution, the respect of norms, the adoption of new technics and abandon of the traditional method will prioritized by the farmers so as to increase the productivity of this field. Meanwhile that production growth, the technicians will assess the programming of formation session and the popularization of modern technics of the cuniculture, less administrative authorities will study a politic to augment the level of study of the peasants and the master of the security in the rural world. Internal studies should be

be conducted in order to master the health and the amelioration of rabbits' breed in that region.

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Hot-water-soluble Carbon and Surface Properties of Water Repellent Soils

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ABSTRACT

Hot-water-extraction of water repellent soils from Australia, Portugal and UK eliminated soil water repellency (SWR) in the soils studied. Gas chromatography/mass spectrometry (GC/MS) analysis showed that the dominant compounds were aromatic acids, short chain dicarboxylic acids (C4-C9), sugars and esters of stearic and palmitic acids. Aromatics and dicarboxylic acid contents increased upon saponification due to cleavage of ester bonds of high molecular weight and polar compounds. Specific surface area and pore distribution showed that the sandy loam and loamy sand soils from Australia had micropores and adsorbed water more efficiently than the sands, while the sandy loam soil from Portugal having a higher content of aromatics in the hot-water-soluble extracts, was strongly water repellent. SWR may intensify upon drought. It has an effect upon soil organic matter

1. Introduction

Soil water repellency (SWR) is a phenomenon which prevents water from penetrating into the soil and is recorded in soils of different types, texture, climates and land uses [6]. It is considered to be a soil organic matter (SOM) stabilization mechanism, enhancing carbon sequestration and reducing CO2 emissions. These benefits are due to the presence of specific organic compounds coating soil particles and presenting a hydrophobic surface towards the soil pores, thus preventing rapid microbial decomposition of SOM [11]. However, in longer term soil water repellency leads to reduced plant especially if especially if climate change leads to an increased soil drought and water scarcity. Hot water soluble carbon (HWSC) has been suggested as a sensitive indicator of the effects of climate change and management practices on carbon sequestration potential and soil sustainability. It is positively correlated with soil aggregation, soil microbial biomass, microbial nitrogen, total carbohydrates and total C [10]. Water soluble organic matter (WSOM) was found to be dominated by sugars, aromatics and N-containing compounds indicating origin from soil microbial biomass, root exudates and lysates [12,14,15]. It has been shown that not only lipophilic and amphiphilic [9], but also polar compounds such as phenolics, short-chain diacids, and saccharides play an important role in SWR development and the stabilization of hydrophobic interactions [2]. To our knowledge few studies to date [1,3] have been concerned with the molecular composition of solvent soluble fractions of hot

water soluble extracts of water repellent soils obtained under conditions of accelerated solvent extraction (ASE) and using gas chromatography- mass spectrometry (GC/MS).

In this study we give emphasis to: (i) the effects of HWSC on soil hydrophobicity; (ii) the molecular composition of HWSC and (iii) the link between surface characteristics and molecular structure of HWSC in water repellent soils of different texture.

2. Materials and Methods

Soils with different levels of soil water repellency under Eucalyptus vegetation in South-East Australia (GP, NT, ML, AUS), North-central Portugal (PO), and under dune herbs and grass vegetation in the SW-United Kingdom (UK) were sampled from 0-5 cm depth (Table 1). Bulk soil samples in South-East Australia were pooled from at least five areas more than 2 meters apart [8]. In the case of the Portuguese soil (PO) and the UK soils, samples from a depth (0-10 cm) from similar parent material and land use were collected [9]. Particle size analysis was performed on Beckman Coulter Particle size analyzer. The Australian soils GP, NT and UK are classified as sands of medium sand texture (mean particle diameter 268 μm; 295 μm and 339 μm, respectively). The AUS soil is classified as loamy sand, while the PO and ML soils are sandy loams. The content of clay was < 1 % for all the soils studied. Silt contents were 0%; 7%; 7,5 % in the case of UK, GP and NT soils, and 30%, 12% and 54 % for the ML, AuS and PO soils. The soil texture classification is given in Table 1. Sample preparation involved air-drying and passing through a 2-mm sieve before further analysis. Total organic carbon of sieved (< 250 μm) soil material was measured with a Skalar Primacs SC TOC Analyzer (combustion T 1050°C), specific surface area (SSA) was determined by N2 adsorption performed on mm fraction with a Micromeritics ASAP 2020 surface area analyzer at -196°C. Samples were degassed at 110°C for 12 h prior to analysis. Specific surface areas were calculated using the BET equation in the 0.05–0.3 range of relative pressure. The equation used was:

$$V/V\infty = C.Z/((1-Z).\{1-(1-c).Z\}),$$

where

Z = p/p0; p/p0 = relative pressure

c = constant;

V∞ = monolayer capacity (volume corresponding to

monolayer coverage).

Soil water repellency was measured before and after extraction with hot water using the water drop penetration time (WDPT) method after equilibration at an atmosphere of 20°C and 45–55% relative humidity for 24 h [7]. Free Fe and Al oxides and hydroxides and organically complexed forms were

were determined by the dithionite-citrate method and the pyrophosphate method and subsequently analyzed by atomic absorption spectroscopy (Varian Spectra 22FS). Soil samples were subjected to accelerated solvent extraction (ASE) with water (10.3×106 Pa, 100°C, lyophilized at (-50°C) and fractionized in dichloromethane (DCM), DCM/iso-propanol and methanol (MeOH). Each extract was split into half and one of the aliquots was saponified (reflux for 6 h under N2 with 0.5 M NaOH, methanol (MeOH)/H2O 9/1 v/v and stirring overnight at room temperature). The saponified lipids were extracted with DCM after acidification with HCl (pH 1.5), before being silylated and analyzed by GC/MS. An Agilent 6890 gas chromatograph, splitless mode and equipped with a 5975 B mass-selective detector, was used. Separation was done using HP-5ms capillary columns (30 m×0.25 mm I.D., film thickness 0.25 μm) and He as a carrier gas. The gas chromatograph was programmed in the following temperature mode: initial temperature 60°C, hold 1 min, linear ramp 10°C /min to 180°C, then ramped at 4°C /min to 300°C and held for 15 min. The MS detection was full scan, (m/z) 50-650 with a cycle time 2.28 scans/s and EI ionization of 70 eV. Identification was based on comparing the mass spectra of the chromatographic peaks to those in the NIST-MS library, comparisons with authentic standards, GC retention times, literature mass spectra and interpretation of mass spectrometric fragmentation patterns [2].

For the chemical and physical soil analysis, as well as for the gas chromatography/mass spectrometry analysis triplicate soil samples were used. Compounds differences between soils were analyzed by the t-test at $p = 0.05$ (SPSS 19 for Windows).

3. Results and Discussion

The sandy loam soils Po and ML, and the loamy sand AuS contain more free and organically complexed iron (Fecd and Fepyr) than the sandy NT, GP and UK soil. These data correspond to the larger specific surface area (SSA) and the higher content of total organic carbon (TOC) determined for the ML, AuS and PO soils (Table 1 and Table 2). Contrary to the ML sandy loam soil from Australia, the PO soil from Portugal with similar texture and free sesquioxide contents, was strongly water repellent.

Table 1. Total organic carbon (TOC) and WDPT of the soil samples before and after hot water extraction (HW). [a]data from Atanassova & Doerr (2010); [b]Atanassova et al., (2014); [c]AuS, PO, and UK this study.

Soil code & texture (USDA)	TOC before HWE wt %	TOC after HWE wt %	WDPT before HWE (s)	WDPT after HWE (s)	Fe_{cd} %	Al_{cd} %	Fe_{pyr} %	Al_{pyr} %
GP[a] sand	3.9	3.5	993	< 5	0.07	0.03	0.03	0.08
NT[a] sand	3.4	3.1	287	< 5	0.16	0.03	0.03	0.04
ML[a] sandy loam	9.0	7.9	10	< 5	0.58	0.23	0.25	0.69
AuS[c] loamy sand	9.3	7.8	<5	< 5	0.27	0.14	0.2	0.4
UK[b,c] sand	1.3[b]	1.2[b]	205[b]	< 5[b]	0.2[c]	0.005[c]	0.0007[c]	0.007[c]
PO[c] sandy loam	9.5	8.1	757	< 5	0.76	0.37	0.6	0.56

The extracts from the sandy loams from Australia and Portugal were dark brown colored due to water soluble humic substances of polyphenolic nature. Aromatics and their derivatives were detected with high intensity, the most abundant being benzaldehyde, benzoic, hydroxy-, dihydroxybenzoic and methoxyhydroxybenzoic acids (example of PO soil, MeOH extract), (Figure 1a, b) and Figure 3 (two sands and two sandy loam soils are presented). Hydroxybenzoic acids are components of hydrolysable tannins. In the non-saponified extracts predominantly sugars in the GP, NT and ML soils, and aromatics (PO soil from Portugal) were detected in the MeOH fraction. Hot water extraction detaches polar components from particles surfaces, as well as micelle like colloidal material.

Short chain C7, C8 and C9 dicarboxylic acids dominated the total ion current (TIC) trace in the sandy loam soils. These acids are suspected to originate from microbial metabolism [13]. Adsorption of the short chain ω-hydroxy dicarboxylic fatty acids takes place through coordination to the polymeric organic matrix or ligand exchange on sesquioxides. The sandy loam soils of heavier texture, i.e. the ML, PO and AuS contribute to a larger extent to the sorption of these acids, than the GP, NT and UK sands. Sugars were detected at high abundance in the more polar dichloromethane/iso-propanol fraction in the soils studied (>65% of TIC traces). Of highest intensity were hexoses (mannose), (Figure 2) and disaccharides (turanose). The neutral sugars represent the labile pool of soil organic carbon and provide energy for soil microorganisms. Pentoses, e.g. xylose and arabinose are important constituents of plants, while hexoses, e.g. mannose, ramnose and galactose are considered to be products of microbial synthesis [4].

Upon saponification the amount of aromatics and polar dicarboxylic acids increased in the methanolic extracts (Figures 2, 4). Organic carbon saturation with aromatics and dicarboxylic acids was higher in the sandy loam ML soil than in the sandy GP and NT soils. Upon alkaline hydrolysis aromatics can be liberated from carbohydrate moieties covalently bound to phenolic structures in lignocellulose-degradation products through cleavage of ester and glycosidic bonds thus differentiating between "free" and "bound" aromatics and diacids. The occurrence of salicylic, vanillic, protocatechuic and

and syringic acids therefore probably reflects the contribution of lignin-derived components of HWSC ester-linked between the core lignin and polysaccharides.

Surface properties and pore distribution are presented in Table 2. It's obvious that the sandy loams and the loamy sand possess micro- and mesopores, contrary to the sandy UK, NT and GP soils. The soils with higher specific surface area (SSA) possess higher contents of TOC and HWSC. We speculate that the presence of the hydrophobic compounds (e.g. oleic, palmitic and stearic acid esters) in the water extracts is due to solubilization from micelle-like colloidal particles in HWSC. Both "free" and esterified aromatics contribute to water repellency elimination.

Water repellency generally appears in dry soils and disappears when the soil reaches a certain critical moisture threshold [5,6]. It has been shown by Doerr et al [6] that a complex relationship exists between water repellency and soil water content, while Dekker et al [5] define a transition zone, rather than a sharp threshold. The variability of the critical water content (CWC) is caused by the heterogeneous distribution of water in and around the micro- and mesopores of the aggregates of soil, and is controlled by the concentration and distribution of hydrophobic compounds at surfaces of all soil aggregate-size fractions [5,16].

In the case of PO soil, the higher water repellency, despite the finer texture and the higher micropore and specific surface areas might be due to: (i) the higher and type of water repellency causing compounds incorporated into larger molecules of humic substances, and forming water impermeable aggregates. In this soil > than 60% of HWSC was unextractable by organic solvent due to the presence of tannins, similarly to ML and AuS soils; (ii) the Portuguese soil contained more aromatics originating from the polyphenolic framework of tannins; (iii) the higher critical water content at which the repellency causing compounds coat the surface particles in organic soils and soils of finer texture.

Except on texture, the differences in the degree of water repellency between the soils studied depend on multiple factors including specific surface area, free sesquioxide content and the content and composition of amphiphilic, lipophilic and polar compounds. We can speculate that the Eucalyptus vegetation and the content and quality of soil organic matter (SOM) in combination with the factors mentioned above, dictate the development and persistence of surface water repellency in the studied soils.

The hot-water-soluble carbon composition, as part of TOC results from microbially mediated soil reactions and is potentially the most susceptible to oxidation to CO2. Thus, has a greatest impact on global climate change. The signature of amphiphilic, hydrophobic and polar organic compounds identified in the extracts and the expected changes in their molecular composition due to climate change, makes them valuable indicators in water repellent soils and ecosystem functioning, in general.

4. Conclusions

Based on the composition of organic solvent extracts of HWSC, we can speculate that compounds responsible for soil water repellency are present in this fraction, because of the complete elimination of SWR following extraction with hot water. Specific reasons for elimination are due to: (I) extraction of critical quantity of HWSC and removal of amphiphilic aromatics and polar sugars; (ii) removal of hydrophobic compounds (C16 and C18 fatty acid esters) and high molecular weight humic material (tannins) in the case of the sandy loam and loamy sand soils; (iii) enhancement of desorbed colloidal organic carbon of complex nature including ester bound aromatics and diacids; (iv) autohydrolysis of ligno-cellulosic structures of particulate and humified organic matter under the conditions of accelerated solvent extraction; (v) desorption of polar compounds is critical for water repellency elimination; (vi) the higher TOC and the specific surface area of the soils of finer texture, contribute to more efficient desorption of polar and amphiphilic compounds, including aromatics and sugars.

Table 2. Surface properties of the experimental soils.

Soil Code	BET surface area m^2/g	Micro-pore volume cm^3/g	Micro-pore area m^2/g	External area m^2/g
PO	4.18	0.000252	0.6018	3.577
NT	0.43	-	-	-
GP	0.32	-	-	-
ML	4.41	0.000166	0.3488	4.065
AuS	2.44	0.000215	0.4179	2.023
UK	0.42	-	-	-

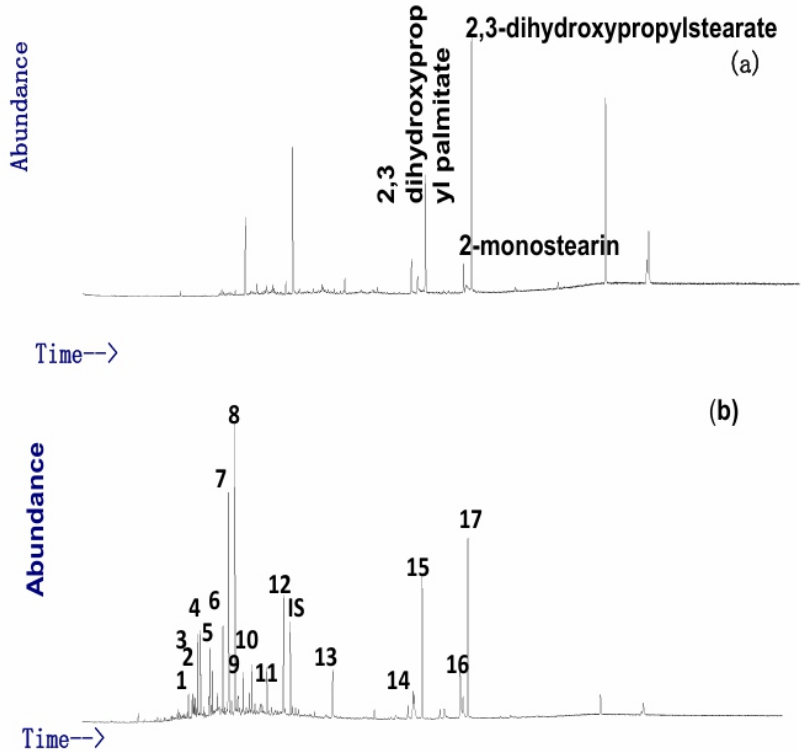

Figure 1. TIC chromatogram of the DCM/iso-propanol and MeOH fractions of the HWSC extracts of the soil from Portugal (PO). 1. 4-hydroxyphenylethanol; 2. C_7 dioic acid, 3. 4-hydroxybenzoic acid; 4. Sugar acid; 5. C_8 dioic acid; 6. 3-methoxy-4-hydroxybenzoic acid; 7. azelaic acid (C_9 dioic); 8. 3,4-dihydroxybenzoic acid; 9. C_{14} acid; 10. 3,5-dimethoxy-4-hydroxybenzoate; 11. 3,4,5-trihydroxybenzoic acid; 12. C_{16} acid; IS= 10-nonadecanone; 13. C_{18} acid; 14. 2-monopalmitin; 15. 2,3-dihydroxypropyl palmitate; 16. 2-monostearin; 17. 2,3-dihydroxypropylstearate.

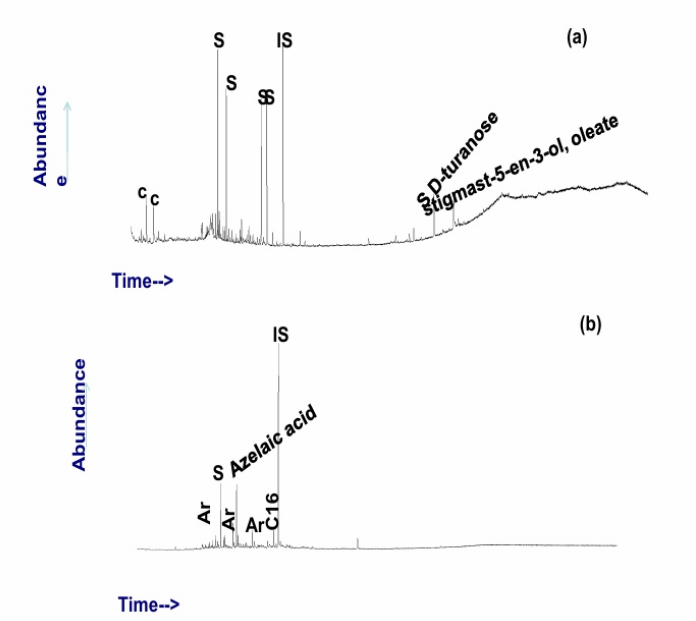

Figure 2. TIC chromatogram of the MeOH extract of a sandy water repellent soil (GP) (a) non-saponified and (b) saponified extract. S = sugar; Ar = aromatic compound; c = contaminant; Aze = azelaic acid; C_{16} palmitic acid.

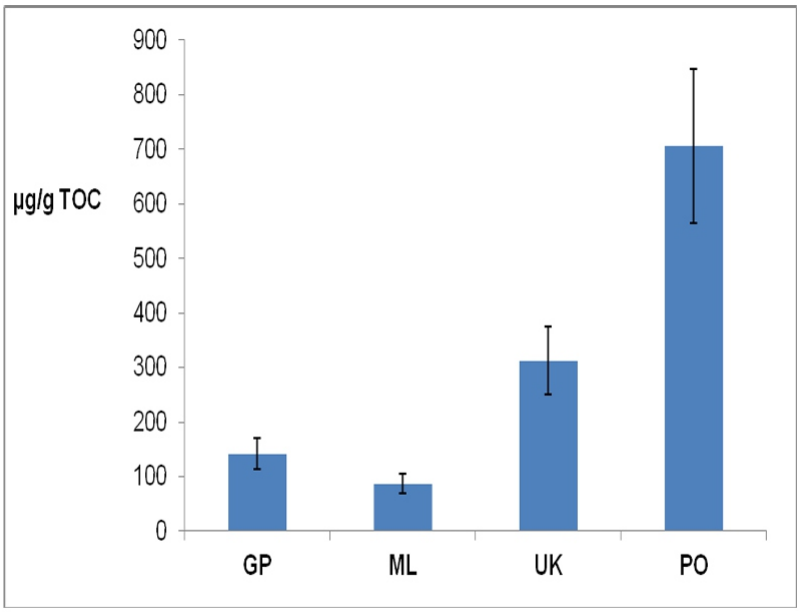

Figure 3. Contents of aromatics in hot water soluble extracts (HWSE) from four WR soils in the DCM, DCM/IPA and MeOH fractions based on the GC-MS data (only identified compounds of relative abundance > 0.1% of total peak area were computed and included).

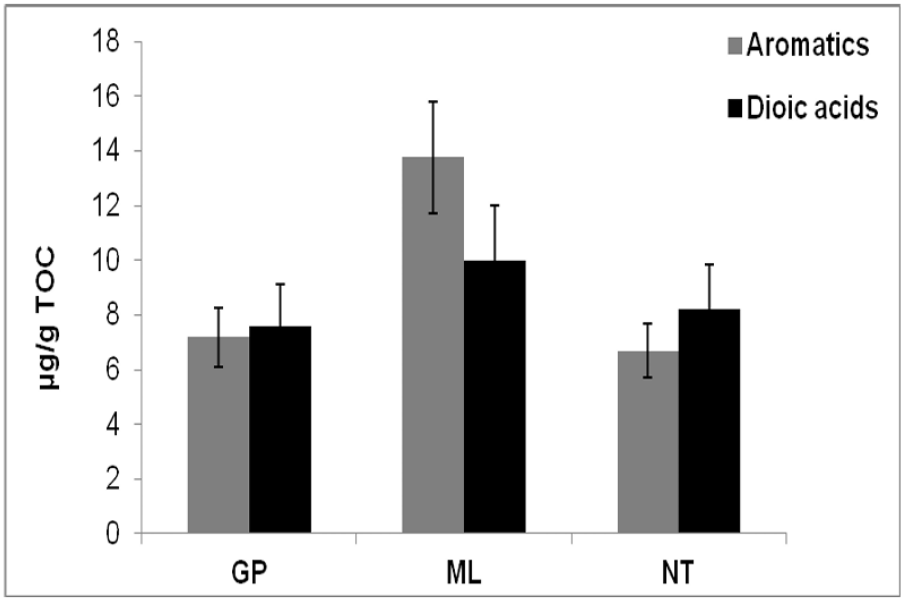

Figure 4. Aromatics and dicarboxylic (C_7-C_9) acids in the saponified MeOH fractions of HWSE from the sandy GP, NT and ML sandy loam soils.

Conflict of Interests

The authors declare that there are no conflicts of interests.

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