EUROPEAN ECONOMIC COMMUNITY

Development of Vermiculture in Thailand

Submission Prepared by

THAILAND INSTITUTE OF SCIENTIFIC AND
TECHNOLOGICAL RESEARCH (TISTR)
(formerly ASRCT)

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CONTENTS

1.0 INTRODUCTION

Vermiculture is a new branch of agricultural activities. It is the culture of earthworms and to make use of this super creature for the benefit of mankind. Throughout history, agriculture has progressively harnessed and domesticated a long list of animals for very beneficial purposes. Dairymen have domesticated the cow and improved dairy technology, giving to mankind numerous food products such as milk and cheese. Sheep have been developed to a high degree of utility, providing an abundance of wool for textile industry. The apiary industry has made great strides in harnessing bees for producing honey and pollinating orchards and other crops. Poultrymen have domesticated the chicken and improved breeds of fowls specifically for egg or meat. From the results of 20 years of research and development, which were conducted mainly in the U.S., we are now domesticating, harnessing, and utilizing perhaps the most versatile creature of all -- the earthworm.

Thailand Institute of Scientific and Technological Research (TISTR, formerly known as the Applied Scientific Research Corporation of Thailand, ASRCT) has been actively involved for sometime in research and development of vermiculture in Thailand - and much of this has been done in association with World Worm Inc. (WWI) of Denver, Colorado and Ecology International Corporation (EIC) of El Cajon, California. At present, TISTR is culturing some 800,000 worms donated by both companies and is ready for preliminary experiment on recycling of organic wastes. TISTR wishes to acknowledge the help received from WWI and EIC for providing the earthworms as well as numerous invaluable technical assistance. With the experience obtained from raising earthworms in Thailand during the past two years, together with the observation tours to the said firms in the U.S. as well as an extensive survey of the reports on this matter, TISTR considers that vermiculture has great potential in Thailand, particularly the Northeast, in order to improve soil chemical and physical properties, to provide animal feed locally, and to make use of organic wastes which begin to create environmental problem within the region.

The development of vermiculture in Thailand will take several years. This document is concerned with action which can be taken immediately and which will produce substantial benefits. The document details an eight month programme covering the period from June 1979-January 1980, which is phases I and II of the overall development programme. Phase I,which should start in June-December 1979, is preliminary studies to be undertaken at TISTR laboratory in Bangkok to obtain necessary information on the performance of introduced earthworms in waste recycling, costing $ 155,000. Phase II, which should start in November 1979 - January 1980, is a survey of the situations in the Northeast in relations to vermiculture, costing $ 50,000. The total cost of the two phases is $ 205,000. If successful, the later phases (Phases III and IV) of the development programme will begin at the end of Phase II in January 1979.

The significance of this development programme is emphasized by the proposed involvement of a team of experts from the Ecology International Corporation, particularly Mr. Sherrel I. Hall, its President who has extensive knowledge in the field of vermiculture, and Dr. Roy Hartenstein of College of Environmental Science and Forestry State University of New York who is propably the world most knowledgable person in vermiculture.

2.0 THE EARTHWORM AND ITS POTENTIAL FOR THE NORTHEAST

The history of vermiculture dates back to the early 1950's when demand for fish bait in the U.S. was so great that people started to raise earthworms for sale as fish bait. In fact, the business was booming during the past 10-15 years. In an attempt to find the cheaper sources of feed and to make more use out of the worm, we are now realising that earthworms are potentially the answer to numerous, different problems. In many ways, our world is a failure because of overwhelming prolems. The three major problems in today's world are: (1) energy, (2) food, and (3) pollution. We must find answers to these problems if we are to live in a successful world. These are indeed complicated problems, but oftentimes complicated problems need simplistic answers. Earthworms can be part of agriculture's key to world success. To be sure, they do offer significant answers to these three major problems: energy, food, and pollution.

Presently, 800,000 barrels of petroleum per day is required in the production of commercial fertilizer. This non-renewable energy resource is rapidy being depleted. Considering the astronomical tonnage of organic waste materials (animal manure, city refuse, sewage sludge, agricultural crop residues, cannery waste, etc.), and the earthworm's uncanny ability to convert this "waste" into a stabilized, usable, crop-growing material, it appears that we have at least one positive alternative to our energy problem. We can conserve our petroleum for higher priority uses by developing this new source of organic fertiliser.

Our food-producing land requires three major elements: nutrient, humus, and water. These should be administered in proper amounts. We are losing much of our prime agricultural land to dust bowls and erosion. We cannot continue the policy of stripping the land of its humus. Instead of humus being returned to the land through recycling procedures, it ends up in land fills and sewage sludge drying lagoons, creating pollution problems. Chemical fertiliser will not add humus to the land. Land without humus is not porous, and becomes dry and compacted. This kind of land is unsuitable for cultivation. Earthworms are capable of converting organic waste (much

of it high in humus matter) into a usable agricultural material.

The USDA Research Service, doing comparative growth studies, is finding that some converted waste materials are producing better crop yields than commercial fertilizers. Earthworms are also high in proteins (60-65 % when dehydrated) and, according to University of Georgia studies, have potential as a supplemental animal food. Earthworm can improve our food-producing systems.

The greatest benefit of all is in relation to pollution. Practically every major city in the world, and most smaller cities, have severe problems in city refuse and sewage sludge management. This "waste" material does not have to be a waste disposal problem creating pollution--it could become a valuable resource. Earthworms are capable of converting organic waste into a stable, usable material, thereby eliminating city refuse and sewage sludge disposal problems. Dr. Roy Hartenstein of College of Environmental Science & Forestry, State University of New York, has shown that earthworms can consume and convert up to 80% its own weight of anaerobic-treated sludge in 24 hours. In his research he has also shown that earthworms remove a large amount of pathogens, especially Salmonella, and early results show some effect on toxic metals. Earthworms can provide significant answers for many of our greatest pollution problems.

With the development of new technology, and the discovery of improved growing techniques, along with rapidly expanding research, earthworms could eventually become agriculture's most useful and beneficial commodity.

Field crop production in the Northeast of Thailand has been rapidly increasing in the past two decades. Since the early 1960's, a huge acreage of forest land has been brought into cultivation of corn, cassava, sugarcane and other field crops, which has been supported by a national compaign of crop diversification, a favorable demand for these crops in international market, and an increase in the population. The marked increase in crop production has been achieved mainly

by the expansion of the planted area and by extensive cultivation. However, this type of activity has recently come to confront the limitation of feasible virgin lands and denudation of catchment area. Meanwhile, there have been apprehensions of deterioration of soil in cultivated lands due to poor or ill managements and of degradation of soil and water conservation. Under such situations, raising the yield per hectare through improvement or maintenance of soil fertility is the most important objective, and several intergral research work on this is necessary.

Linked with the present situation, TISTR is now taking into consideration in improving the productivity of the exhausted cassava cultivated area by the use of organic fertiliser produced by the earthworms in the form of casting, which is the excretion of the worms, as a part of integral research work on soil improving amendments for the crop diversification. This approach is possible within the region because there are tremendous amount of organic wastes available locally at practically no cost, or, in some case, there is cost of eliminating them. These wastes include domestic wastes (sewage and garbage), farm wastes (crop residue and animal mannure), industrial wastes (factory residue and sludge), and aquatic weeds (especially water hyacinth). With optimum condition (good management and proper facilities), 2,000 kg of earthworms can convert 700 kg of city refuse, 1,000 kg of cattle manure, or 1,500 kg of sewage sludge into top-grade soil amendments in just 24 hours.

The merit of this system lies in the fact that energy and nutrients are recycled effectively, economically, and ecologically through the earthworm's uncanny ability to convert these organic waste into a stabilized, usable, cropgrowing material. When applied to the eroded, denuded, nutrient depleted soils, it will greatly improve the physical property of these soils, add needed nutrients, and increase water absorption and holding capacity.

The bonus of this system is the amount of high quality protein of the earthworm itself. At present, animal industry in the Northeast cannot be developed simply because there is a shortage of protein feed. If this can be developed, it will not only improve the economy of the region, but also supply the poor people

with the protein food in their daily diet which, at present, is protein-deficient.

3.0 PLAN OF ACTION

Phase 1 Preliminary Studies (June - December 1979)

- Procurement of earthworms(varieties of species).
- Biological studies.
- Multiplication of the most promissing varieties.
- Preliminary trials at TISTR.

Phase II Survey (November 1979 - January 1980)

- Survey of organic waste avalibility in the Northeast
- Survey of organic matter requirement in the Northeast
- Survey of pollution problem created by organic wastes in the Northeast
- Survey of protein food and feed availability in the Northeast

Phase III Location trials (February - December 1980)

- Trials will be set up at 4 locations in the Northeast (making use of the survey result from Phase II)

Phase IV Extension Programme (January - December 1981)

- Transfer technology of waste recycle through the use of earthworm to local municipalities, factory owners, private firms, farmer's cooperatives, and extension officers.

3.1 PHASE I: Preliminary Studies

It is proposed that the work of phase I starts sometime in June 1979 or any time soon after that. Whilst TISTR is well equipped to undertake the basic laboratory work and, during the past two years, has paid great interest in vermiculture, its experience in waste recycle is some what limited. It is, therefore, recommended that the service of the consultant team of experts available from the Ecology International Corporation of El Cajon, California, U.S.A. be employed. During the past four years of intensive research and development, this corporation has developed vermiculture technology capable of managing organic waste materials in anenvironmentally acceptable manner that is cost-effective. Through prior personal contacts, its staff, including its President, Mr. Sherrel I. Hall, its technical advisor, Dr. Roy Hartenstein of the College of Environmental Science and Forestry, State University of New York, and other staff members are willing to cooperate as consultants in this exciting new venture in Thailand. This team of experts will not only provide their experience, but also the stock of improved breeds of worms and all other prototypes of necessary equipments which are not presently available commercially anywhere. Their biodata are presented in App. 1

The objectives of Phase I, the preliminary studies, are as follows:

(1) to introduced as many as possible varieties or species of earthworms which are known to be able to do the job of organic waste recycling.

(2) to determine the life cycle, feeding and breeding behaviour, adaptation to different climatic condition, particularly heat tolerance of each variety or species.

(3) to multiply the most promissing varieties or species for further studies or uses.

(4) to obtain the basic data on biodegradation of organic wastes (viz. amount consumed, amount of castings produced, weight gain of earthworms).

This phase will be carried out at TISTR laboratory in Bangkok, with the supply of organic wastes from Bangkok Municipality and the nearly factories which have access of organic wastes, either in the form of residue or primary sludge.

Cost Estimate	Value U.S. $
Purchase of earthworms (capsules)	$ 20,000
Earthworm shed and accessories	$ 20,000
Equipments	$ 50,000
Mateirals	$ 10,000
Assistants	$ 4,000
Labourers	$ 3,000
Consultancy (including travel and perdiem)	$ 50,000
Total	$ 155,000

3.2 PHASE II: Survey

If the results of the preliminary studies in Phase I are good, especially with respects to the adaptation of the worms and the ability to biodegradate the organic wastes, the work of Phase II will commence in November 1979 and last for three months, until January 1980. The objectives of this Phase are:

(1) to make a survey of organic waste availability in the Northeast. Particular emphasis will be made on the kinds, amount, and sources of organic wastes. These includes city refuse, sewage, and sludge in the big cities, eg. Ubon, Udorn, Khon Kaen, and Korat; the industrial wastes from

factories such as the canneries, sugar mills, peanut shelling factories, tapioca starch factories, etc.; plant residues in the farms, including, pineapple crown, leaf, and stem, stalk residue of certain economic crops (eg. kenaf, corn, sorghum), leaf of sugarcane, cassava etc.

((2) to make a survey of organic matter requirement in the Northeast to determine the amount needed to improve the soil's chemical and physical properties such as to make the soils suitable to grow some other higher earning crop.

(3) to make survey of the problem of pollution created by organic wastes from city wastes (refuse, sludge, and domestic sewage), farm residues, animal wastes, industrial wastes, etc.

(4) to make a survey of the availability of protein food for human and feed for livestock and other animals.

The estimated cost for this survey phase is $ 50,000.

3.3 Phase III: Location trials

Location trials will be set up at 4 locations in the Northeast in order to implement the findings from Phases I and II. It is anticipated that the amount of organic wastes in the four big cities, namely, Ubon, Udorn, Khon Kaen, and Korat would be large enough for commercial scale production of organic fertiliser and protein feed (from the earthworm). Detail work plan of this Phase will be available soon after the results of Phases I and II are available at the end of January 1980. Thus, the cost estimate would have to be figured out at that time.

3.4 Phase IV: Extension Programme

Extension of the knowledge gain from earlier phases will be made during the period starting January through December 1981. It is anticipated that the

transfer of technology of vermiculture would be of great benefit to local municipalities of every province in the Northeast. Factory owners, private firms, farmer's cooperatives, or even individual farmers would also get benefit of this technology. The service of agricultural extension officers would be helpful at this stage. As in Phase III, it is premature at this stage to submit detail workplan and estimated cost.

4. BENEFITS

The following benefits are expected if successful results are obtained from the works on vermiculture in the Northeast:

4.1 Organic fertiliser Since tremendous amount of organic wastes is available locally at practically no cost, the amount of cheap but top grade organic fertiliser would be enough for a large portion of the cassava growing areas which, at present, is about 5.6 million rai or 2.24 million ha. These areas will then be used to grow other higher earning crops. The merit of this system of organic fertiliser production is that it is adaptive to both the large-scale factory operation or the small-scale individual farmer operation. The former is suitable for municipalities and factories which produce large amount of organic waste and/or primary sludge, both of which create environmental problem. The latter operation, although not so effective, but so adaptive to the local conditions. Moreover, costs are negligible since the farmers can use his labour as well as his farm wastes and residues right there at the farm, thus cut down the cost of transportation of both the raw materials (organic wastes) and the products (organic fertiliser and earthworm protein).

The large amount of chemical fertilisers will be saved if organic fertilisers from vermiculture are used. This is a big saving of foreign exchange as well as a saving the world supply of energy.

4.2 Protein food and feed The recycle of organic wastes through vermiculture produces as by product large amount of earthworms, with 14% protein in the normal state, or 65% upon dehydration. This protein is of high quality and can be a good source of animal feed or even human food (see analyses in App. II). Animal production in the Northeast is limited by the scarcity of animal feed. It is anticipated that the large amount of protein from the earthworm will enhance the animal production in the Northeast and someday, the Northeasterners will have sufficient protein in their diet.

4.3 Solving environmental problem At present, our environment is in danger as the result of the accumulation of organic wastes. Although several means of treatment have been attempted, none is cost-effective. Vermiculture, on the other hand, is much more economical than conventional disposal methods. This is largely due to the fact that earthworms supply the energy while they perform their work. Most creatures, including humans, consume good products and turn them into waste; but the earthworm consumes waste and turns it into a good product.

4.4 Recycling of nutrients and energy Organic wastes contain considerable amount of plant nutrients (particularly N-P-K) and energy. At present, both are expensive and are rapidly being depleted from the world stockpile. Vermiculture is probably the only means of recycling nutrients and energy from organic waste effectively, ecologically, and economically, particularly when new technology which is a cost-effective method of managing organic waste materials is employed.

APPENDIX I

BIODATA OF CONSULTANT TEAM

SHEEREL I. HALL

President, Ecology International Corporation
755 Vernon Way, El Cajon, CA 92020, U.S.A.

Born: May 4, 1930, Seminole, Oklahoma.

Marital Status: Married.

Education: Houston High School - Graduated 1947
Activities - Senior Class President
Future Farmers of America
Sports

Tennessee Temple College - 1954-1955
California Baptis College - 1955-1959.

Employment:

1947-1950 - Vaughn Manufacturing Company, Houston, Texas
Production and shipping.

1950-1954 - United States Navy
Metalsmith.

1956 - Ordained to the Ministry. (Southern Baptist Convention).

1955-1962 - Served as a minister. Established three churches.
(Cardiff-by-the-Sea; College Grove; Mission Village).

1962-1965 - Radford Overhead Doors, San Diego, California
Sales and management.

1965-1975 - Established manufacturing-construction company.
Hall Overhead Doors, San Diego, California.

1975 - Established research program for vermiculture industry.

1976-1977 - Established Ecology International Corporation with 3 divisions: Manufacturing; Production; Marketing.

1978 - Established national network of earthworm egg-capsule producers.
Developed vermicomposting automated system.
Became publisher of THE VERMICULTURE JOURNAL, a quarterly magazine.
Founded Ecology Research Foundation (a non-profit corporation).
Served as Chairman of the California Farm Bureau Vermiculture Advisory Committee.

ROY HARTENSTEIN

Professor, College of Environmental Science and Forestry,
State University of New York, Syracuse, New York 13210

Born: January 5, 1932, Buffalo, New York.

Marital Status: Married, 2 daughters.

Education: Buffalo State Teachers College, Buffalo, NY, 1949-1953, B.Sc.

Syracuse University, Syracuse, NY, 1956-1957, M.Sc.

Syracuse University, Syracuse, NY. 1957-1959, Ph.D.

Employment: Armed Forces: U.S. Army - July 1953 to June 1955 Instructor of radio and antenna theory.

Teaching: Britten Road School, Greece, NY, 1955 to 1956. State University College of Forestry at Syracuse University:

Animal Physiology, 1959 to 1965. SU College of Environmental Science & Forestry: Histology, Animal Physiology, Invertebrate Physiology, Environmental Physiology, 1967 to 1964; Vertebrate Anatomy, Histology, Physiology, 1974 to present.

Administration: Chief, Biological Sciences Division, Science Information Exchange, Smithsonian Institute, 1966 to 1967.

Honors and Awards: Senior Postdoctoral Fellowship, National Institutes of Health, Duke University, Department of Biochemistry, 1965 to 1966; Faculty Exchange Scholar, SUNY, 1974 (lifetime).

Administrative Experiences: Chairman of Graduate Committee, Chairman of School of Biology Chemistry and Ecology; Member of Syracuse University Senate, Personnel Policies Committee: Acting Chairman of Department in absence of Chairman.

Grants: NSF, NIH. Studies of life histories of soil Oribatei and Mesostigmata; lignin and aromatic metabolism in terrestrial invertebrates; mechanism of action of adenase in microbes; nitrogen metabolism in Crustacea; properties of peroxidase and aldehyde oxidase of Crustacea; monooxygenases and dioxygenases, nitrogen fixation, nitrate reductase.

Professional Societies: American Association Advancement of Science (Fellow); American Society Zoologists; Society of General Physiologists; American Society Agronomy; Soil Science Society America; CAST*

Experiences Other than Teaching, Research and Administration: Review of grant proposals; Referee of research papers; Chairman of defenses of M.Sc. and Ph.D. theses; Advisor to Ph.D. & M.Sc. students; Presentation of research papers at professional meetings (AIBS, AAAS, Entomological Society of America, International Congress of Acarology & others); Judge at local science fairs; Curriculum advisor to undergraduate students.

* Member of the Council on Agricultural Science and Technology, Ames, Iowa.

APPENDIX II

CHEMICAL ANALYSES OF THE EARTHWORM

TABLE 1 COMPARISON OF COMPOSITION OF EARTHWORM (EISENIA FOETIDA) WITH FARM ANIMALS (PERCENT)*

Composition	Earthworm	Cow	Pig	Steer	Pullet
As Fed Basis					
Water	87.1	88.0	54.0	52.0	65.7
Dry matter	12.9	12.0	46.0	48.0	34.3
Ash	0.7	0.8	3.7	4.0	3.6
Ether extract	0.3	3.7	28.5	26.9	6.6
Protein	5.8	3.1	14.5	17.1	22.8
Moisture-Free Basis					
Ash	5.2	6.7	5.9	8.3	10.5
Ether extract	6.4	30.8	62.0	56.0	19.2
Protein	68.1	25.8	31.5	35.6	66.5

* From McInroy, D.M. 1978. Evaluation of the earthworm' Eisenia foetida' as food for man and domestic animal s. Feedstuffs.

TABLE 2 AMINO ACID ANALYSES (%) OF HIGH-PROTEIN MEALS*

Amino Acids	Earthworm	Meat	Fish
Arginine	4.1	3.5	3.9
Cystine	2.3	1.1	0.8
Glycine	2.9	7.1	4.4
Histidine	1.6	1.0	1.5
Isoleucine	2.6	1.3	3.6
Leucine	4.8	3.5	5.1
Lycine	4.3	3.1	6.4
Methionine	2.2	1.5	1.8
Phenylalanine	2.3	2.2	2.6
Serine	2.9	2.2	-
Threonine	3.0	1.8	2.8
Tyrosin	1.4	1.3	1.8
Valine	3.0	2.2	3.5
Crude Protein	61.0	51.0	60.9

* From Sabine, J.R. 1978. A new source of protein. The Vermiculture Journal 1 (1): 13-14.

APPENDIX III

INSTITUTIONAL QUALIFICATION

THAILAND INSTITUTE OF SCIENTIFIC AND TECHNOLOGICAL RESEARCH (TISTR)

The Thailand Institute of Scientific and Technological Research (TISTR), formerly known as the Applied Scientific Research Corporation of Thailand (ASRCT), was established in 1963 by Royal Act and became operational in 1964. It is a main center for applied scientific research in Thailand. With the passage of the Applied Scientific Research Corporation of Thailand Act B.E. 2506 (1963 A.D.), the legal framework was established for the creation of a semi-autonomous applied science institution operating outside the Thai civil service. Because of its semi-automomous structure, despite governmental financial subsidy, it has an almost unique capability within the country of being in a position to coordinate research programmes involving governmental departments, other governmental organizations, foreign and international agencies as well as to carry out research projects, on contract basis, for private industry.

As stated in the Act, the objectives of TISTR are to initiate, carry out, promote and support applied scientific research and investigation in connection with, or for the promotion of, any matter affecting national development, the natural resources, industries and administrative services of the kingdom, including the health and welfare of the Thai people and to promote the application of the results of applied scientific research for the benefit of the nation.

To achieve these objectives, TISTR, has established 8 departments, namely:

1) Industrial Research Department (formerly Technological Research Institute)

2) Agricultural Research Department

3) Engineering Department

4) Economic Department

5) Building Research Department

6) Testing and Standard Department

7) Environmental and Ecological Research Department

8) Thai National Documentation Center

In addition, there are a number of specialized as well as administrative offices to provide necessary supporting services to the research departments.

Research Capabilities and Expertise:-

The emphasis of TISTR activities is on applied research and its application, i.e., it is charged with the task of promoting the applications of the results of applied research for the benefit of the nation. The research activities are directed to research programe which have been assembled in the light of the requirements of Thailand's development plans. Research programs have originated in many ways, most often from geovenmental and industrial requests (contract research), but also through surveys and contact with industry (in-house research) and approaches from foreign and international agencies (grants research)., The research programmes may be divided into five main categories:

(1) Research to promote agro-industry

(2) Research to solve problems of existing industries (trouble-shooting), including pollution problems

(3) Research to adapt known technology to local conditions

(4) Research associated with techno-economic (industrial) feasibility studies

(5) Research on utilization and upgrading of local raw materials, including agricultural wastes and crop residues.

As seen from the research programmes above, TISTR is well equipped to undertake research and development in vermiculture through its multidiciplinary approach consisting of scientists, engineers, economists and other service staff.

In addition to prelinimary trials on the earthworm culture, both of the local origin and the introduced ones, three manuscripts have been published, namely:

CHOMCHALOW, N. 1978. The miracle of earthworms. Agricultural Science Society of Thailand's Newletter 11: 275-288 (in Thai).

CHOMCHALOW, N. 1979. The use of earthworms for garbage eradication. Technological Promotion Assoc. Journal 7 (31):61-68 (in Thai).

CHOMCHALOW, N. 1979. Earthworms and gardening. Society for Ornamental Plants of Thailand's Journal for 1979 (p.) (in Thai).

ECOLOGY INTERNATIONAL CORPORATION (EIC)

EIC is a technology research oriented company engaged in the development of viable, cost-effective alternatives for major world problems. Energy production and conservation, resource recovery in the field of waste management, and the development of new and improved systems of agriculture are presently receiving top priority. Expenditures in excess of $ 250,000 during the last three years have been channeled into research and development for perfecting biological control systems in waste management and solar equipment capable of producing electricity.

EIC has developed a unique earthworm breeding technique heretofore unknown to commercial earthworm producers. Automation has been brought to the earthworm industry through the development of automatic equipment (feeders, harvesters, extractors, dehydrators, etc.). Last year EIC established a national network consisting of 12 Regional Distributors, 125 Co-Distributors, and 800 earthworm egg-capsule Producers. EIC now has the capability of producing 1.5 million tons of earthworms during the next four years. This amount of earthworms will be sufficient to convert the total amount of municipal waste produced in the U.S. into top-grade soil amendments, readily useable in agriculture as fertilizer. The 1.5 million tons of earthworms can be solar-dehydrated into 150,000 tons of 10% nitrogen.

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DEVELOPMENT OF VERMICULTURE IN THAILAND.