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SPEAKER 4: DR TAN BOUN SUY

HOW TO ENSURE SUSTAINABLE AGRICULTURAL DEVELOPMENT IN ANGKOR WORLD HERITAGE?

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APSARA-Authority

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WORKSHOP ON

THE HERITAGE OF ANCIENT AND URBAN SITES:

GIVING VOICE TO LOCAL PRIORITIES

14-15 MARCH 2016

SINGAPORE

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ABSTRACT

The UNESCO intergovernmental meeting in Paris (Nov 2003) recommended that APSARA National Authority ensure sustainable development of Angkor Park and Siem-Reap region. Because 80% of people living in the park are farmers, promoting **organic farming** is one of the priority activities of the APSARA National Authority. This topic and approach is relatively new to Cambodia. It demonstrates that the welfare of the people who live in the Park as well as the monuments in the Park are top priorities. The Department of Agriculture and Community Development assisted efforts by implementing agronomic research.

Organic farming frequently suffers lower yields worldwide. **Our primary research objective is to improve yields,** especially through locally available and environmentally friendly methods. The economic and environmental benefits are straightforward: increased yields with decreased use of synthetic/chemical fertilizers, insecticides, and other additives. Decreased use of these additives results in less cost, less dependency and possibly increased long-term and environmentally friendly sustainability. This is the main reason why we initiated research.

The following are key outcomes:

1. **Compost processing**: Compost is a primary natural fertilizer. Our research allowed us to discern the best process for producing organic compost in the local context.
2. **Beneficial microorganisms:** We assessed natural stimulants from beneficial micro-organism activities: our Khmer Effective Microorganisms are proven very efficient in crops cultivation, chicken breeding and fish raising.
3. **Green manure**: We identified highly effective **local** green manure in rice fields and vegetable crops: ***Chromoleana odorata***, ***Sesbania grandiflora*** and ***Cassia siamensis.***
4. **Bat guano:** Bat guano is one of the best natural fertilizers we identified. Its effect has better longevity than green manure. We encouraged farmers to promote increased bat populations around sugar palm trees (***Borassus flabellifer***).
5. **System of Rice Intensification** through natural means (SRI): This new technique was imported from Madagascar and successfully promoted in the Angkor Park.
6. M**itigating climate changes in vegetable cultivation:** We have identified and implemented techniques to increase resiliency of vegetable cultivation.

BIODATA

HE Dr Tan Boun Suy has been Deputy Director in charge of the Departments of Agriculture and Community since 2008. Previously he was the Director of the Department of Agriculture and Demography. He received his Doctorate of Science in France in 1998. His research in Cambodia has focused on Cambodian agriculture and organic farming. He is also a key innovator for Effective Microorganisms. Dr Tan has worked on Cambodian agricultural soil maps of Stung Chinit and a soil survey of two districts in Siem Reap. During the 2012 NSC Archaeological Fields School, he presented a lecture on the application of a natural Cambodian plant which would slow lichen growth on rocks and temple features. His contribution to environment, archaeology, agriculture and subsistence systems, soils sciences and conservation has greatly benefitted students, professionals and the field of archaeology in Cambodia.

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CONFERENCE PAPER
HOW TO ENSURE SUSTAINABLE AGRICULTURAL DEVELOPMENT IN ANGKOR WORD HERITAGE?

*Dr Tan Boun Suy et al**
Department of Agriculture and Community

APSARA National Authority

**Ly Phally, Lach Sam Nao, Aing Sochenda, Kea Reaksa, Kor Tong Seng, Mao Mithona*

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Introduction

The intergovernmental meeting of UNESCO Paris, in 2003 recommended APSARA National Authority (ANA) to ensure sustainable development in Siem Reap/Angkor area. This naturally includes sustainable agricultural development.

The recent tourist boom in Angkor created a growing demand for food. As space for agricultural activities are limited, farmers are encouraged to improve the crop yields. To increase yields most farmers are tempted to use chemical inputs (e.g., fertilizers, pesticides, herbicides). We know that Siem Reap/Angkor region is located upstream of Tonlé Sap Great Lake. What happens with generalized utilization of Chemical inputs?

The chemical residues would flow into and accumulate in the Tonlé Sap Great Lake. *They will pollute Fish*, one of the main foods and protein/meat sources for all Cambodian people (and tourists). The cumulative results could be catastrophic.

In face of this disastrous scenario, ANA adopted Organic Farming. This practice is handicapped by low crop yields. In addition, the soils in Siem Reap are lower quality for agriculture. How to solve this issue in Siem Reap ecosystem characterized by poor sandy soil and the desire for chemical free organic farming? Since 2005, our department carried out agronomic research focusing on the following topics:

1. How to make the best organic (natural) compost in poor conditions of Cambodia?

2. How to use the Effective (beneficial) Microorganisms (EM) in agriculture?

3. How to use the local natural fertilizers: green manure, rice husk ash, bat guano?

4. How to apply new techniques of SRI (System of Rice Intensification by Natural Means)?

5. How to mitigate the effects of climate change?

6. How to transfer the new technology to farmers?

Once these issues solved, we seek feedback and assistance from local farmers. Thus, we constantly interact with farmers, inform farmers and seek their opinions. Ultimately, many of the practices we want to implement have to be understood and accepted by local communities. We also seek to teach the local farmers. This process takes time. Evaluation also takes a considerable amount of time as we have to work with farmers throughout multiple growing seasons. Annual and long- term cycles are important. In many cases, this can take decades to thoroughly examine results and impact.

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1. How to make the best compost in poor conditions of Cambodia

Compost is a basic natural fertilizer for organic farming. We improved the compost processing by compacting the compost pile and by activation using KEM.

1.1. Compacting the compost heap

In Europe, this practice is inadvisable; while in Cambodia, it is advisable (Photos 1 and 2). In Europe, they used heavy machines for compacting. In Cambodia, we compact the compost heap by foot (manual labor). In doing so the temperature in the compost pile reaches 60-70 degrees C during the first 2 weeks, killing weed seeds and various plant diseases.

Photo 1. Compost heap at Tuk Vil Research Station

Photo 2: Utilization of bad compost: *weed seeds have not been eliminated; weed grows as huge as lettuce*

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1.2. Activation by natural stimulant (KEM)

We activated the compost processing by a natural stimulant (KEM). Every week, we watered the compost pile (1m x 2,5m x 1,2m) with a solution using 2 liters of KEM 10%.

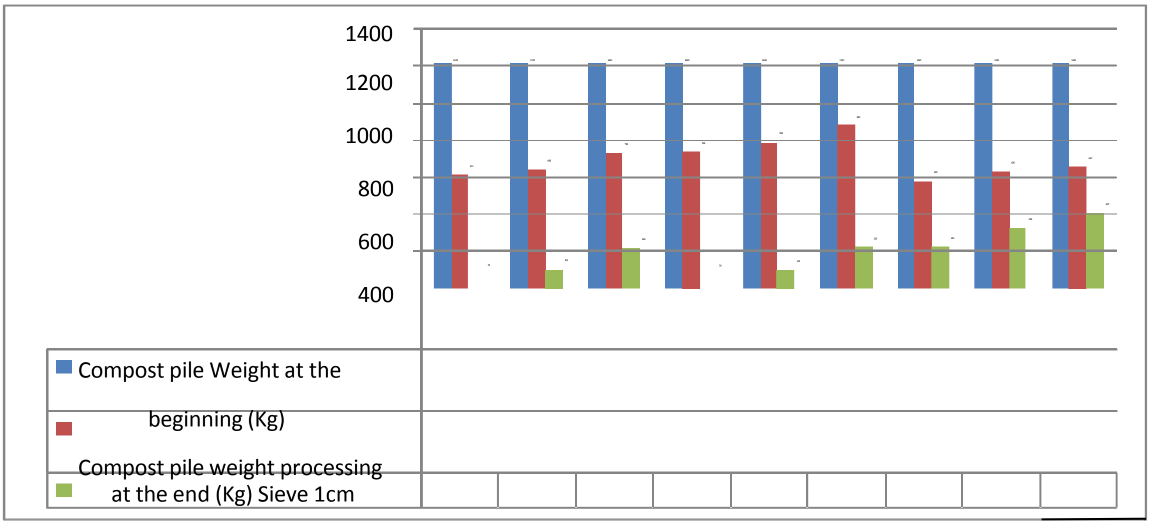
RESULTS:

1.2.1. The duration of compost processing is shortened by 1 month (i.e., 4 months instead of 5 months);

1.2.2. Starting with a 1220 Kg pile, we obtained at the end the following results in 3 experiments (trials): 640 Kg for the Control (without KEM), 687 Kg for the treatment KEM 5%, 755 Kg for the treatment KEM 10%. (Table 1).

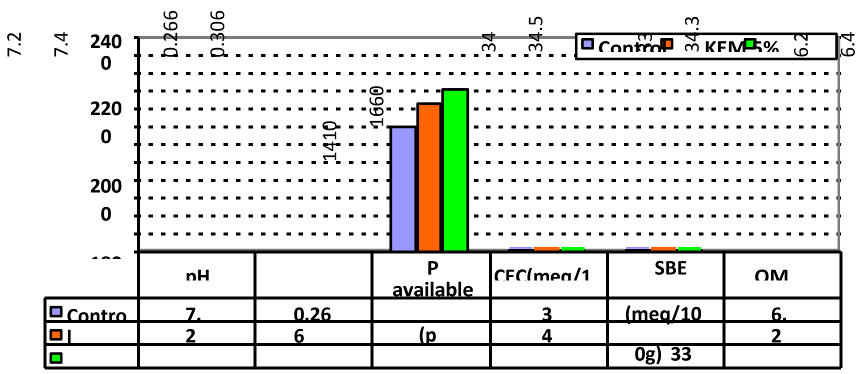
1.2.3. The compost qualities were improved. For example, the content of available Phosphorus passed from 1410ppm for the Control, to 1660ppm for the treatment KEM5%, up to 1820ppm for the treatment KEM10% (during the 1st experience, Table 2).

Table 1: Compost activation by KEM (5% and 10%); Improvement of the compost yield



Control	KEM 5%	KEM 10%	Control	KEM 5%	KEM 10%	Control	KEM 5%	KEM 10%
1220	1220	1220	1220	1220	1220	1220	1220	1220
612	642	732	738	789	880	580	630	657
73	103	220	70	101	223	224	328	407

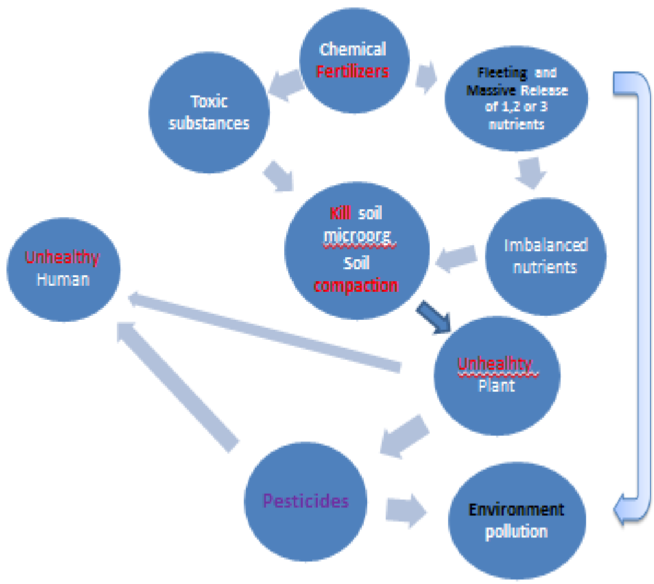
Table 2: Compost activation by KEM; Improvement of physic-chemical properties



2. Utilization of Effective (beneficial) Microorganisms (EM) in agriculture

The Green Revolution in 1940s promoted Chemical Fertilizers. Vast quantities of the latter were applied for improving the crop yield. In 1960s, the world was horrified by catastrophic impacts on the environment from chemical farming. Diagƌaŵ 1 sho‖s the ĐoŶseƌueŶĐes of Cheŵical Faƌŵiŷg killiŷg soil ŵiĐƌooƌgaŶisŵs ƌesultiŷg iŶ uŶhealthy plaŶts and then unhealthy humans.

Diagram 1: Chemical Farming



Organic Farming is based on the utilization of Organic Matter in which Compost is the main component. Bringing compost to the soil (Organic Farming) improves activities of efficient microorganisms (EM) of the soil resulting in healthy plants and again, healthy humans (diagram 2). World scholars agreed with C. Altomare 2011 (1) that soil beneficial microorganisms are a major component of the natural fertility of soils.

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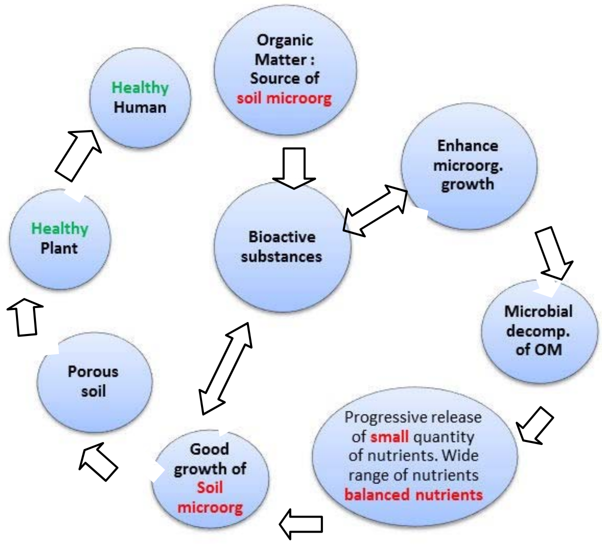


Diagram 2: Organic Farming

2.1. Our research in Effective Microorganisms.

Our research aimed to make Effective Microorganisms initiated by Teruo Higa, 1994 (2). For that purpose, we experimented with many kinds of local raw materials (vegetables leaves, fruits) and found the best result with **Noni *(Morinda citrifolia)*fruit**.

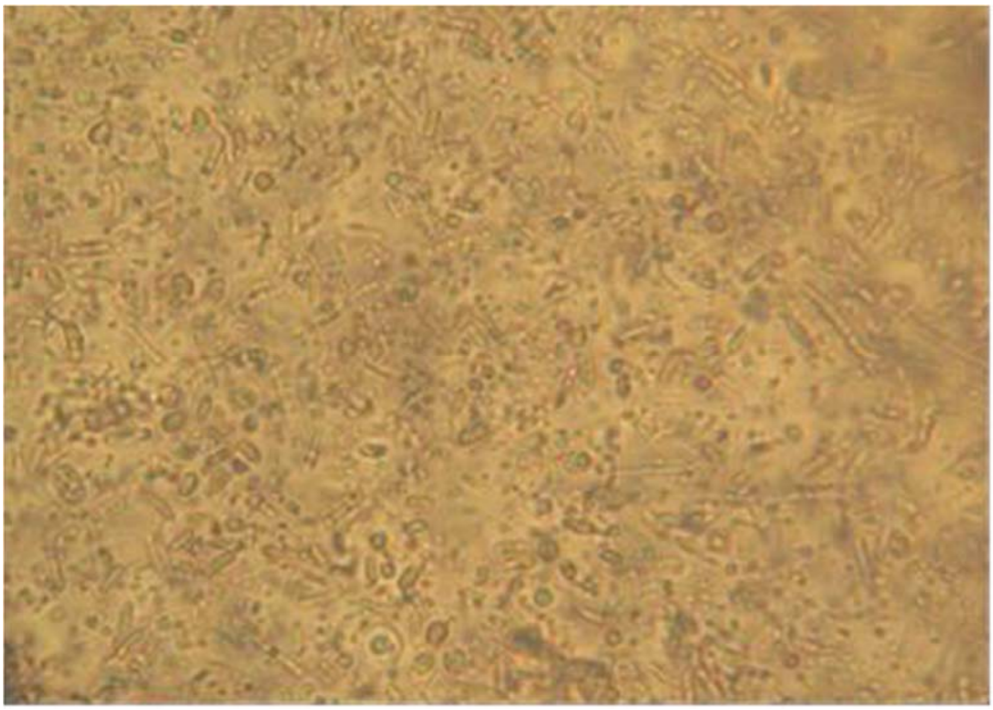
Our product is called Khmer Effective Microorganisms (KEM) because all ingredients are from Cambodia: Noni fruit, Sugar palm (*Borassus flabellifer*), Well Water, Microorganisms (in the air). The final product is a brown liquid with pH 3.

Photo 3 essentially shows the ***Yeasts***, ***Lactic Acid Bacteria*** being the small size elements. We expected the presence of ***Photosynthetic Bacteria*** at a magnification of x400 on the microscope.

KEM Microbiological counting was carried out in France by Ecole de Laiterie de Mamirolle (Franche-Comté Region): we found 50,000 *Lactobacillus* and 1,000 *Yeasts and Mold* per ml.

The medical analysis of KEM by the Pasteur Institute of Phnom Penh revealed no harmful pathogens (*Thermotolerant coliforms, Staphylococcus coagulase positive, Clostridium perfrengens, salmonella, Escherichia coli, Bacillus cereus*). Thus, KEM is safe for human and animal.

Photo 3: Picture of KEM (x 400)



2.2. Utilizations of KEM by APSARA National Authority: in Rice-field, vegetables, mushroom culture, fish and poultry raisings, activation of compost (see compost chapter).

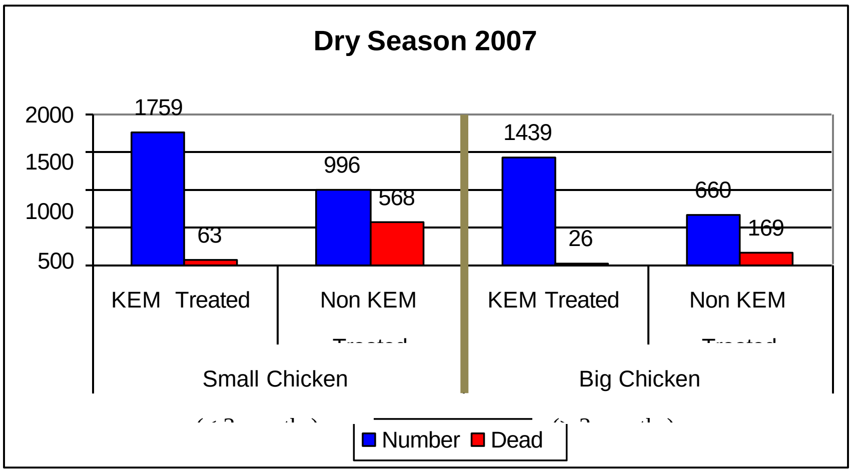
- ***Rice-field***: 150 L of KEM/ha combined with 5T Compost resulted in 10-15% improving crop yield.
- ***Vegetables*** (Lettuce, Green Mustard): by watering KEM 2% 3 times per week, the production grew by 15% (3). We recommend to associate KEM with compost as basic natural fertilizer.
- ***Mushroom*** (Oyster Mushroom): by replacing 0.5 Kg urea by 1L of KEM in the following formula, the production raised up from 74 Kg to 96 Kg (Table 3):

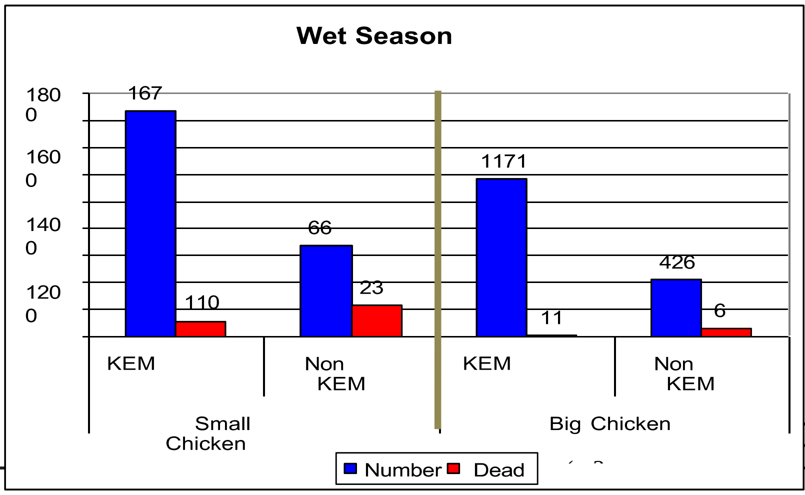
Table 3: Oyster Mushroom results

Improved composition of the Oyster Mushroom Medium	
Rubber Tree Sawdust de bois cc:	100Kg
Rice bran:	10 Kg
Lime:	0.5 Kg
Sticky Rice flour:	1 Kg
Sugar:	

- **Fish (Pangasus) Raising :** we recommended 2L of KEM in 10m3 of water, every week. With this treatment, Fish become healthier and grew faster; 1 month faster than the control.
- **Chicken Raising in the villages (traditional practice) (4)**: Our agriculture officers followed-up the situation of chickens in the countryside in 2 cases: chickens treated with KEM(2cc in 1L water) and chickens non treated. In dry season as in wet season 2007, the mortality decreased drastically thanks to KEM treatment making farmers very happy (Table 4).

Table 4: Chicken Raising results





3. How to use the local natural fertilizers: Green manure, Rice husk ash, bat guano?

3.1. Green Manure

3.1.1. CHROMOLAENA ODORATA

This plant is considered one of the worst weeds in the world (5). It was imported by French in Cambodia. It spread to all provinces. However, in the 1960s, Litzenberger and Ho Tong Lip (6) found this weed very useful in agriculture. Our research confirmed a large and supportive interest by farmers in using this invasive weed as a source of natural Nitrogen in place of Urea (Photo 4).

Photo 4: *Chromolaena odorata*

Photo 5: *Cassia siamensis*

3.1.2. CASSIA SIAMENSIS

Cassia siamensis (Photo 5) is a fast growing tree. This plant is recommended to solve firewood issues in areas threated by deforestation. Its flowers are edible. We experimented with its leaves as green manure in rice-fields.

3.2. Comparison of the effects of *Chromolaena odorata* and *Cassia siamensis* on Rice crops (*Sen Pidor* variety)

Our trials were carried out on the same plot (16m2) during 3 campaigns (8/01/14 – 11/15/14, 1/04/15 – 4/25/15, 8/05/15- 11/08/15). It consisted of 2 treatments (T1 with *Chromolaena odorata* and T2 with *Cassia siamensis*) and the Control (without green manure)(Table 5).

Conclusion: there is positive response of Rice crop to the both green manures. The best result is obtained with *Chromolaena odorata.*

Table 5: Results of *Chromolaena odorata* and *Cassia siamensis testing*

	T0	**T1**	**T2**
Compost	0.5 kg/m2	0.50 kg/m2	0.50 kg/m2
Chromolaena odorata	0	1.25 kg/m2	0
Cassia siamensis	0	0	1.9 kg/m2
Results: average of the 3 campaigns harvest (kg/16m2)	**2.2**	**3.0**	**3.1**

3.3. Comparison between Natural and Chemical Fertilizers on Green Cabbage

- **I**n spite of the change due to the seasons, we can observe the following trends in the production (Table 6; Diagram 3).
- For T2 (with only chemical fertilizer 15.15.15) the production rapidly decreases to the level of the control (without any input) T1.
- T4 (compost + KEM) > T3 (compost): Demonstrates the effect of KEM.
- T6 (compost + KEM + 1Kg *Chromolaena*) > T5 (Compost + KEM + 15.15.15 10g)**:** This shows **that we can replace** chemical fertilizer by green manure to reach equivalent and even better production.

Conclusion:

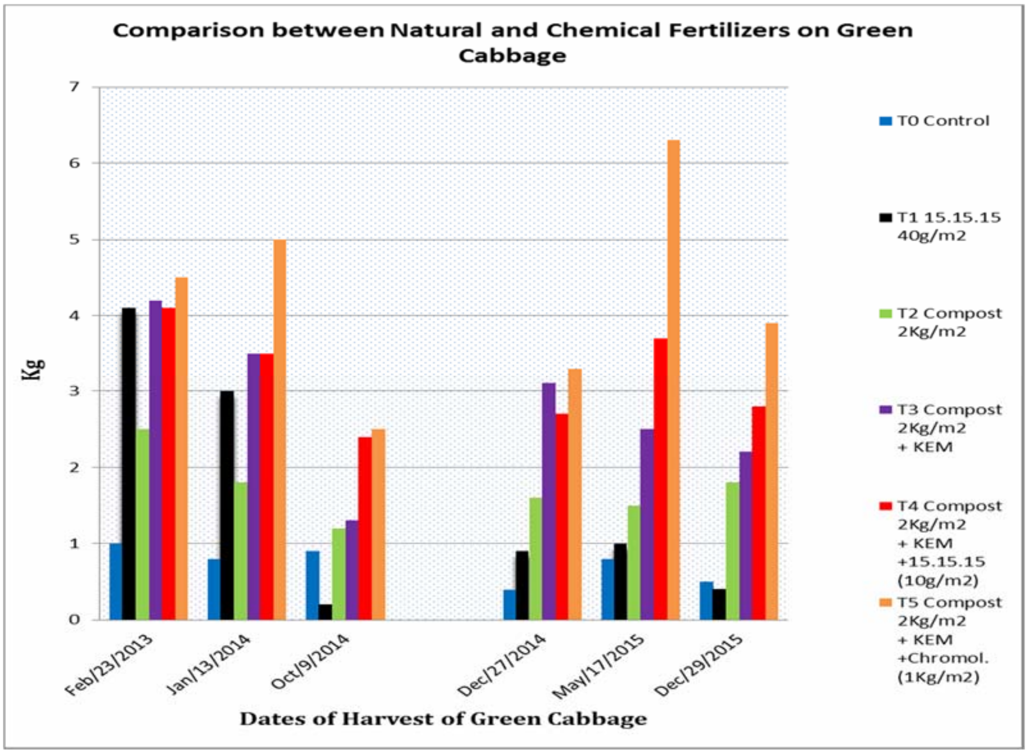
On sandy soil of Siem Reap, utilization of chemical fertilizer alone is unadvisable. The compost combined with KEM alone or with green manure is recommended.

Table 6: Timetable and results of compost experimentation

Date of harvest	**T1** **Control**	**T2** 15.15.15 40g/m2	**T3** **Compost 2Kg/m2**	**T4** **Compost 2Kg/m2** + KEM	**T5** **Compost 2Kg/m2** + KEM +15.15.15 (10g/m2)	**T6** **Compost 2Kg/m2** + KEM +***Chromol.*** **(1Kg/m2)**
02/23/ 13	1.0 kg	4.1 kg	2.5 kg	4.2 kg	4.1 kg	4.5

01/13/ 14	0.8	3.0	1.8	3.5	3.5	5.0
10/09/ 14	0.9	0.2	1.2	1.3	2.4	2.5
12/27/ 14	0.4	0.9	1.6	3.1	2.7	3.3
05/17/ 15	0.8	1.0	1.5	2.5	3.7	6.3
12/29/ 15	0.5	0.4	1.8	2.2	2.8	3.9

Diagram 3: Comparison between natural and chemical fertilizers on green cabbage



3.4. *Comparison between Tul Vil soil, Chemical Fertilizer(15.15.15.), Tuk Vil Compost, Green manure (Chromoleana odorata) and Bat Guano in regards to nutrient content.*

According to the results of analysis carried out by laboratory of Cambodian Agriculture Ministry (Table 7; Diagram 4),**Tuk Vil Soil** is a very poor soil, deficient in four main nutrients (N, P2O5, K20, CaO).

Incorporating **Compost** in Tuk Vil soil improves N content by 8 times, P2O5 by 10 times, K2O by 52 times, CaO by 12 times. If we compare with 15.15.15, Compost is far poorer but it brings **microorganisms** absent in the chemical fertilizer.

The natural stimulant (KEM) improves activities of **microorganisms** of organic matter (Compost).

Chromoleana odorata is richer than compost, so combined with the latter, it is proven efficient for crop. Other Green Manures as *Cassia siamensis, Sesbania grandiflora*… ĐaŶ ďe used

Bat guano is almost equivalent to 15.15.15 regarding Nitrogen content. It is an ideal natural fertilizer for many crops. Furthermore, besides nutrients, it brings **microorganisms**.

The problem is its high price and its scarcity. We have to encourage farmers to host the bats by creating favorable conditions around the trunk of sugar palm tree (Photos 6 and 7).

Some people capture bats to eat. So we promote their protection by local authority (decree)

Table 7: Nutrients contents in Tuk Vil Soil*, Chemical Fertilizer (15.15.15.), Natural Fertilizers proposed to replace Chemical Fertilizers. *(Analysis made by Soil Laboratory of Agriculture Ministry, Phnom Penh, Cambodia)*

	N (Nitrogen) %	P2O5 (Phosphorus) %	K2O (Potassium) %	CaO (Calcium) %
Tuk Vil Soil	**0.15**	**0.06**	**0.02**	**0.08**
15.15.15.	**15.00**	**15.00**	**15**	**0**
Tuk Vil Compost**	**1.31**	**0.62**	**1.10**	**1.08**
Chromoleana odorata	**3.06**	**1.01**	**3.07**	**1.66**
Bat Guano***	**9.99**	**3.76**	**1.40**	**2.52**

* Representative of Siem Reap Soils
** Compost made at Tuk Vil
*** Bat Guano of Siem Reap

Diagram 4 : Nutrients contents in Tuk Vil Soil*, Chemical Fertilizer (15.15.15.), Natural Fertilizers (*Chromoleana*, Bat Guano) proposed to replace Chemical Fertilizers

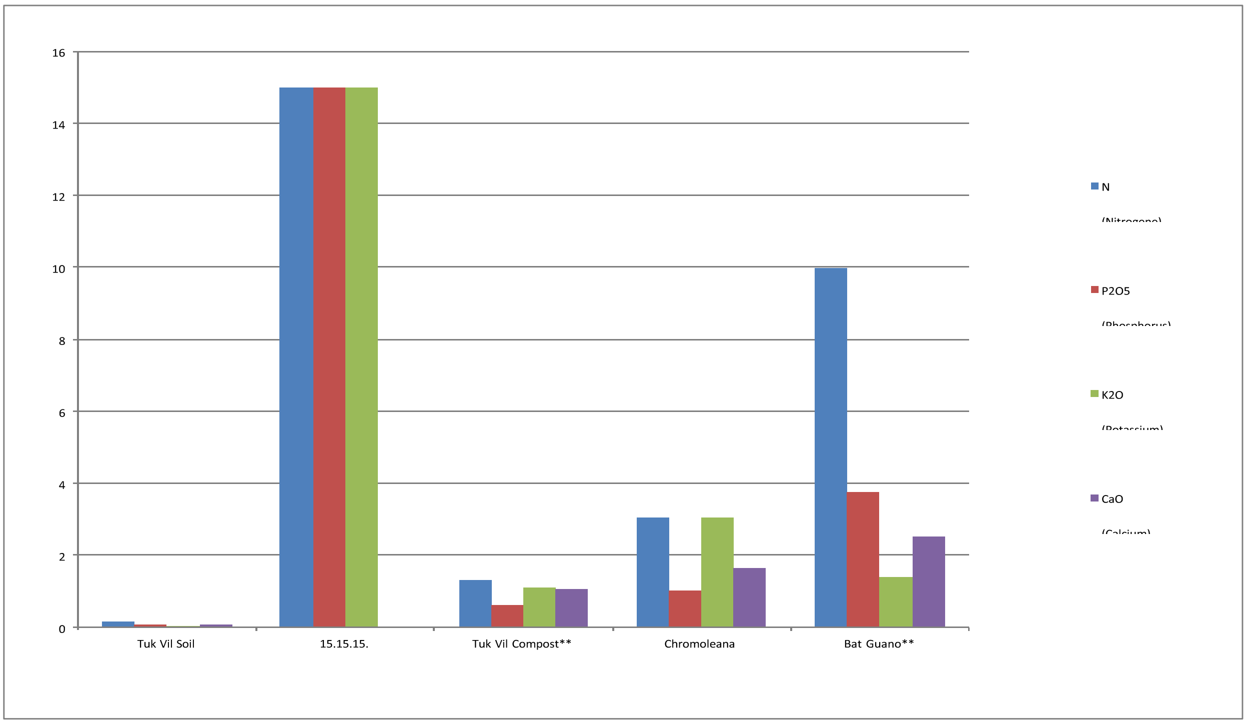


Photo 6: *The sugar palm tree leaves are pulled down around the trunk to create a shelter for bats.*

Photo 7: *Bats Guano builds up on the ground from dro*

3.5. Rice Husk Ash

In Cambodia, rice mills burn rice husk as source of energy. The large quantity of rice husk ash produced is only used by some garden nurseries. Our experiment aimed to determine the best rate of this new input. Olewale et al, 2012 (7) obtained the following chemical composition of rice husk by spectrophotometry (Table 8).

Table 8: chemical composition of rice husk

SiO2 (%)	Fe2O3(%)	Zn(%)	Mn(%)	CaO(%)	Mg(%)	Na2O(%)	K2O(%)
97.02	0.37	0.03	0.06	0.20	0.18	0.88	0.88

We expect the composition of rice husk ash is not too different. Due to its high content of K2O, its good retention capacity of water and nutrient,s and in particular its low price, rice husk ash should become rapidly one of the most interesting natural inputs for sandy soils of Siem Reap. Its high content of SiO2 should make this product very suitable for Rice field, silicon contributing for the protection of rice leaf against pests.

4. How to apply the new technique of SRI

(System of Rice Intensification by natural means)?

SRI methods essentially consists of:

4.1 Transplant rice by 1 seedling instead of 10-12 seedlings with traditional method;
4.2 Use young seedling (2-3 weeks) instead of old plants (4-5 weeks);
4.3 Transplant in rows;
4.4 Just wet the soil instead of inundating it from the stage of transplantation to the flowering;
4.5 Using natural fertilizers (compost, green manure…).

Our approach is firstly to make trial in our research station, then to install field's demonstration in the village.

5. How to mitigate the effects of climate change

Plants such as cabbage and lettuce need 50% or more of sunlight to effectively grow. With the climate change, maximum temperature rises up to 40 degrees C or more. This could damage the plants. One solution is shade plants and clearings spaced appropriately to allow enough light, but also keep the air and soil temperatures lower. Additionally, other plants (the shade plants) can produce fruits, usable products or other consumables depending on the species chosen (e.g., luffa- sponge plants that can be eaten). Lastly, the cover plants protect the vegetables and soils below from rain damage (Table 9; Photo 8; Diagrams 5 and 6).

Table 9: Weight of crops (on 12 m2) growing under shade and outside (open air

Crops	**Under shade** (Compost 2 Kg/m^2)	**Open air** (Compost 2 Kg/m^2)	***Date of planting***	***Date of harvest***
Lettuce	**28 Kg**	**21 Kg**	Jan 2^{nd} 2015	Feb 2^{nd} 2015

Green mustard	**10.5 Kg**	**7.5 Kg**	Mar 18th 2015	Apr 18 2015
Lettuce	**6 kg**	**2 Kg**	*Aug 3rd 2015*	*Sep 3 2015*
Green mustard	**8.5 kg**	**8 Kg**	Dec 1rst 2015	Dec 23 2015

Photo 8: Comparison of plots (Cabbage) under shade of Luffa sponge with open air plots

Diagram 5

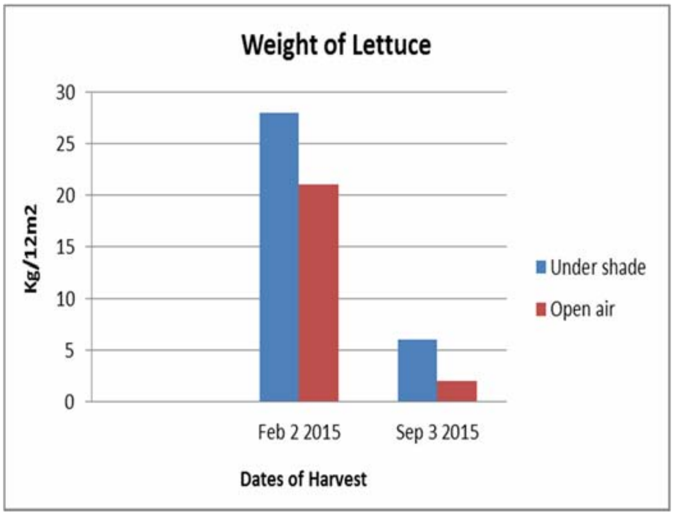


Diagram 6

6. How to transfer the new technology to the farmers

Before arriving to this stage of the project, we have obligations to validate the results of the new technology. Some agronomic experiments need to be repeated during 4-5 years. Thus, among all new techniques, only 4-5 of them that are proven reliable have been transferred to the farmers. For this purpose, our agriculture officers worked closely with the farmers. We choose seleĐt͞model͛ farmers and explained our results and the implications.

6.1. SRI

We invited the farmers to visit our research station and then we set up field demonstrations on their own land. At Tuk Vil station, the results were spectacular. SRI allowed us to double the rice yield. In the village, we also obtained great success. The farmers can see the differences compared to traditional methods. However, SRI needs more labor. From 2005 to 20012, SRI spread very fast. Unfortunately, from 2013 to present, we are facing shortages of manpower in the countryside. Many of them migrated to the town because they are attracted by tourist activities and opportunities. This explains why SRI is not heavily applied now.

6.2. KEM

Our greatest success was obtained in traditional chicken raising using KEM. It is emphasized that this activity is the most profitable compared to rice and vegetable cultivation. By drastically reducing the mortality of chickens, KEM is praised by farmers.

Someone questioned us as follows: ͞Why doŶ't we teach the farmers to make KEM by theŵselǀes? IŶ JapaŶ, ĐuƌƌeŶtly soŵe people doŶ't ďelieǀe iŶ KEM. Why? I think this is due to the bad qualities of the product: either the process making KEM is not correct, or the storage condition is not respected. *If oŶe tiŵe the produĐt doesŶ't ǁork, the farŵers doŶ't trust you aŶyŵore.* Thus, KEM would lose its notoriety and local support. We know that presently it is difficult for the farmers to respect the intricacies and requirements of proper product manufacture (the correct process), and checking the quality of the product. That is, if the farmers took shortcuts or did not have proper facilities and adequate quality control, they might make a bad batch. The bad batch would lead to a bad reputation and then discontinued use. At present, the best solution for us is to make KEM by ourselves and distribute a good product quality until we can sufficiently train local experts.

6.3. Compost making

There are two issues dealing with quantity and quality of compost.

6.3.1. Quantity

The traditional practice of the farmers is to use cow dung. We explained to them that with

100 Kg of cow dung, they can obtain at least 500kg of compost having similar qualities. They understand but they are facing shortage of raw material. For example, rice straw, the main waste from rice harvest, is insufficient for feeding the cattle. Thus, the quantity of compost produced is limited. Other agricultural rubbish is scarce.

Recently, the provincial authority signed a contract with a company for making compost from urban waste. This is a good idea for promoting organic farming in Siem Reap/Angkor region.

6.3.2. Quality

Some model farmers followed our recommendations concerning compacting, activation of the compost by KEM, and regular watering of the compost pile. They are convinced of the benefits of the new method. However, most of them are facing shortages of time because they have many other activities.

6.4. Green manure

This matter seems very simple for small scale, tiny plots. But for large scale of green manure utilization, we have to consider the planting of *Chromolaena odorata* instead of having recourse to spontaneous vegetation.

Photo 9: visit of the farmers at Tuk Vil Research Station

Conclusion

Based on our experience and discussions with the farmers, we think that the most important issue is the ***price of organic products***. It is easier for us to convince them to adopt organic farming if our technique can improve the yield and if the price of organic products on the market is interesting.

Nowadays, thanks to media, many people are aware that their health depends on safe food. Therefore, there is a potential demand for chemical free food. How to sell organic products at a higher price than chemical ones for motivating farmers?
The first thing to do is to guarantee the authenticity and quality with a **label** displayed on the packaging and recognized by law. For us, this is a long and obligatory process.

Naturally, at the same time, we continue our efforts to communicate and interact with the farmers through the activities of our agriculture officers in the villages.

The farmers believe you if they see the results: Explanation and discussions are important but more important are the concrete results in the field. They believe in SRI because they saw the positive results—much higher than expected. They believe in KEM because its efficiency to reduce chicken mortality is undeniable.

Another approach was the creation of ***saving groups*** (similar to a farmer local cooperative). Since 2008, our agriculture officers succeeded to form these farmers associations. The locals see tangible results. They earn money. The profits allow the expansion of technical activities such as chicken raising/production; more compost production; more organic vegetable; i.e more output. It also builds solidarity in the village and encourages a democratic environment. Everyone can participate. They decide what to do with the funds. Our role is to advise and assist them with the funds management, especially accounting.

This stage helped build significant trust. It allows “buy-in” (they trust us and believe we could advise on better farming solutions). Thus, local farmers were more willing to accept organic farming recommendations. Building rapport and trust, even through lateral means such as the savings group, enhances local community inclusion, participation and voice. This allows us to effectively work together for continued improvements.

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