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Article

Alley Farming in Thailand

Elizabeth Adebola Ogunlana [1,*], Athapol Noomhorm [2] and Teerapol Silakul [3]

[1] School of Management and Languages, Heriot-Watt University, Riccarton Campus, Edinburgh EH14, 4AS, UK

[2] Asian Institute of Technology, P.O. Box 4, Klong Luang, Pathumthani 1200, Thailand; E-Mail: athapol@ait.ac.th

[3] Ministry of Agriculture, Royal Thai Government, Ratchadamnoen Nok Avenue, Bangkok 10200, Thailand; E-Mail: silakul@yahoo.com

* Author to whom correspondence should be addressed; E-Mail: elizabethadebola@yahoo.com; Tel.: +44-131-623-0010.

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Abstract: Poverty alleviation and environmental preservation are very important issues to many governments. Alley farming is beneficial to the environment because it conserves soil and sustains yields over time. Specifically, alley farming reduces soil erosion, which is a major problem in Thailand. Alley farming was conducted on a farmer's field at Khaokwan Thong, a village in Uthaithani Province, Northern Thailand. We did a two-by-two factorial with and without alley farming, and with and without fertilizer. From this study, we observed that the two species used, *Leucaena leucocephala* and *Acacia auriculiformis*, grow well in Thailand, and that alley farming is suitable for Thailand. Few Thai farmers have heard about alley farming. However, it is nevertheless useful to know that there is potential for alley farming in Thailand using the two species. These plants, based upon the diameter and height measurements provided, grew well.

Keywords: alley farming; poverty alleviation; environmental preservation; permanent field cultivation; sustainable agricultural technologies

1. Introduction

In early times, the predominant feature of the Thai rural sector was small scale subsistence farming meant to provide for family consumption, in which many Thai farmers engaged in shifting cultivation.

Surplus crops were used for trade by barter, or for tribute to the local elite. However, a large farming population created a shortage of land for shifting cultivation. Consequently, Thai farmers changed to permanent field cultivation or decreased the fallow period. As a consequence, rapid deterioration of soil structure, soil erosion, flooding, and declining productivity constitute major problems for agricultural productivity and also cause rural poverty.

In order to reduce the problem of soil erosion affecting farmers in Thailand [1], and achieve sustainability in agricultural productivity, alley farming was introduced, though on a small scale, in Thailand. Few farmers in Chiang Dao in Chiang Mai and Doi Tung in Chiang Rai have engaged in alley farming [2]. The hedgerow species used were leucaena, "*Gliricidia Sepium*", "*Cajanus cajan"*, or "*Flemingia macrophylla"* [1]. In Chiang Mai, hilltribe farmers, who cultivate sloping lands, adopted alley farming.

Poverty alleviation is a focus of many governments. It is a major objective of rural development scientists. The governments of many developing countries have tried numerous rural development strategies to alleviate rural poverty. In Thailand, every government has tried to alleviate poverty. In order to increase agricultural production in Thailand, the use of chemical fertilizer was introduced into farming. The misuse of chemical fertilizer led to increased degradation of land, soil erosion, destruction of plants and animals, and destruction of farmer and consumer health. Tantemsapya [3] pointed out that the use of agro-chemicals in Thailand has resulted in soil erosion and soil exhaustion. Many researchers are of the opinion that it is the misuse of chemical fertilizers that causes soil erosion and land degradation. The result is shortage of food [4], which leads to increased poverty. Many writers have said that fertilizer residues are destructive to the environment. The residues are particularly harmful to the soil structure [5] and water resources quality [6,7]. Some rural farmers also believe that chemical fertilizer application on their farms pollute the rivers that provide their drinking water. Thus, these farmers do not use chemical fertilizers.

Thailand is one of the world's food exporting countries. The Thai economy has improved over the years. There have been rapid industrialization and urbanization in Thailand. The main cities of Thailand have experienced increased economic growth. Bangkok's ever growing economy cannot be overemphasized. Nevertheless, many of Thailand's rural areas, where over 70% of the population lives, are still affected by poverty. Development efforts have focused on main cities with the hope that increases in production will automatically trickle down to other parts of the country. This did not happen. Since the majority of the people in Thailand's rural areas are farmers, the farmer's adoption of low cost sustainable agricultural technologies, which can enhance agricultural production as well as preserve the environment, can help alleviate poverty. This project focuses on the extension of sustainable agricultural technology in rural areas of Thailand.

1.1. Towards a Sustainable Agricultural Development

Despite the urgent need for an agricultural technology that could increase farm productivity, many researchers were concerned about the impact of such technology on the environment. Development and environmental protection were seen as two sides of the same coin, and the goal was to develop an environmentally sustainable agricultural technology that could increase agricultural productivity. With respect to the environment and development, the concept of sustainable development is now of central

concern. Sustainable development's acceptance has been growing recently to the extent that it is now a major international issue. It is the most commonly cited and the best known idea that links environment and development [8]. The root of sustainable development thinking is the preservation of nature. Sustainability is about working with nature, not against it. As a result of environmental degradation, which is caused by permanent field cultivation, many theorists are advocating for the sustainability of the environment. There is therefore a need for a sustainable, viable, environmentally sound, and low-input farming system that would eliminate fallow periods. Alley farming is a sustainable farming technique that could eliminate fallow periods.

1.2. The Concept of Alley Farming

Alley farming is a farming system in which leguminous trees are planted in rows with crops cultivated between them. The leguminous trees are planted four or five meters apart. The distance between trees in one row is flexible, but is usually 25 or 40 centimeters. According to Sumberg and Okali [9], alley farming is the production of crops within alleys formed by rows of fast growing leguminous trees. The trees are pruned and used as mulch and livestock feed. Alley farming can be cultivated on plains and sloping lands.

The leguminous trees determine the success of alley farming. These trees rely on the rhizobium bacteria to fix nitrogen from the atmosphere [10]. The rhizobium bacteria inoculate the root hairs of the leguminous trees and are housed in the nodules of the trees. Thus, the trees can fix atmospheric nitrogen only through a symbiotic association with the rhizobium bacteria. The trees provide the energy to feed the bacteria, and in return, the trees receive nitrogen for growth. When the leguminous trees drop organic matter, or when they are used as mulch, other crops absorb the nitrogen from their tissues. Moreover, due to the fact that the leguminous trees are deeply rooted, they gain access to nutrients in subsoil layers. These nutrients are made available to other crops for growth. Thus, these trees naturally enhance soil fertility. Alley farming utilizes this natural and sustainable fertility process by using leguminous trees. Alley farming allows farmland to rejuvenate naturally.

The leguminous trees are occasionally pruned. When applied as mulch, prunings are distributed on the soil surface in the alleys where the crops are cultivated. The mulch is therefore a nutrient source for the companion crops. Prunings are also used as fodder for livestock, staking, and firewood. Ogunlana *et al.* [11] observed that 56.3% of those adopting alley farming in Southwestern Nigeria used alley trees as fodder for their livestock, 7.1% used the trees for maintaining soil fertility, and 36.3% used them for both forage and maintenance of soil fertility. Pruning prevents shading of the companion crops. It is done by coppicing or pollarding. In coppicing, the trees are cut at a height of 30 to 60 cm, whereas in pollarding, the trees are cut at a height of 2 m. The first pruning can be done when the trees are about 3 m tall [10]. This is around 12 months after tree establishment. In subsequent years, hedgerows can be pruned four to six times per year. The leguminous trees perform the same function as observed in the bush-fallow system. They yield large quantities of nitrogen, give large nutrient yield, and show higher nutrient recycling capabilities than other woody species.

Alley farming combines many agricultural activities, namely crop production, livestock husbandry, tree planting, and soil management. Ogunlana [12] observed that alley farming has some characteristics that can be found in the indigenous farming system of many societies. For example, in

many societies, farmers practice the bush-fallow system, in which they plant trees on the farm and utilize the leaves for mulch. The Food and Agriculture Organization (FAO) [13] documents the environmental benefits the system provides. However, in alley farming, land use efficiency is higher and sustainability is achieved even when there is a shortage of land. This is because in alley farming, cropping and fallow are carried out on the same plot of land at the same time.

1.3. History of Alley Farming

Traditionally, farmers in Africa and Southeast Asia have practiced the principles of alley farming for generations [10]. In the early 1930s, in Amarasi, a district on the island of Timor in southeastern Indonesia, traditional farmers planted *Leucaena leucocephala* in order to control erosion and to increase soil fertility [10]. Moreover, in the southern Philippines, Nalaad tribe farmers have practiced alley farming by planting *Leucaena leucocephala* hedgerows in their crop production system [10]. In eastern Nigeria and in Ethiopia, farmers have cultivated traditional alley cropping systems [14].

Other terms are used to describe alley farming. In the Philippines, it is termed contour hedgerow farming and in Sri Lanka it is called avenue cropping. Moreover, the International Centre for Research in Agroforestry (ICRAF) uses the term hedgerow intercropping.

1.4. Functions of Alley Farming

Alley farming is profitable because it leads to high crop yield at low cost under continuous cropping conditions [12]. Alley farming can recuperate degraded land and can increase rice production. It is economically viable, socially acceptable, and ecologically sound [15]. Alley farming sustains the fertility of farmlands by imitating the self-renewing natural process of the forest [16]. Pandey and Lapar [17] pointed out that alley farming is capable of reducing soil erosion and improving soil fertility. It can sustain maize production relative to indigenous methods of farming by contributing nitrogen to the cropping alleys [18]. According to the FAO [19], alley farming provides poor households with a more reliable supply of food and substitutes for products they cannot afford to buy (e.g., leguminous trees instead of chemical fertilizers). Alley farming restores degraded soils [20].

Alley farming improves livestock production. Reynolds and Jabbar [21] observed that it is beneficial to use alley leaves as fodder for livestock. Milk production of dairy cattle is high in early lactation when fed with *Leucaena*, especially in the dry season, when the nutritive value of grass is low. In East Africa, more dairy farmers are expected to adopt alley farming than farmers who keep small ruminants. This is because milk provides food for the household and a source of income. Additionally, dairy cows have a high capital value [21]. When *Leucaena* and *Gliricidia* fodder were offered to pregnant and lactating sheep and goats, at levels of inclusion ranging from 0 to 50% of daily dry matter intake, as supplements to a basal diet of Panicum *ad libitum* and cassava peels (50 g DM/day), the effect was beneficial. Growth rates to weaning and to six months of age improved as the quantity of fodder in the diet increased, and parturition intervals declined. The response of sheep to supplementary feeding was almost twice as large as that of goats [22]. The secondary benefits of alley farming are the provisioning of stakes and firewood [23]. Ogunlana [24] pointed out that there was a positive and significant relationship between the relative advantage of alley farming and farmers' level of adoption. In her study conducted in southwestern Nigeria, she found out that the correlation

coefficient for women farmers' level of adoption and the relative advantage of alley farming, in terms of its cost, was 0.8291, and in terms of its satisfaction was 0.8493.

1.5. Farmers' Participation

The research utilized a bottom-up approach. Farmers' participation is very important in rural development projects and was emphasized. Ogunlana [25] observed that many alley farming researchers already encourage farmers' involvement. In the past few decades, scholars have emphasized the relationship between grassroots participation and rural development. Many writers have suggested that in order to achieve meaningful development in the rural sector, there is need to adopt and implement a strategy which reinforces the grassroots involvement of rural people. They attributed the failure of past development projects to the lack of local participation at all stages of development. Chambers [26] pointed out that for a project to be successful, intended beneficiaries should adequately participate in all stages of the process.

1.6. Rationale

In recent years, sustainable development has become a major international issue. Governments of many countries, development planners, and researchers have realized that agricultural development which focuses on the use of chemical fertilizers and pesticides is destructive to the environment and leads to land deterioration. Furthermore, capital-intensive agricultural technologies are not affordable to poor Thai rural farmers, who are an important part of Thai farming population. Shifting cultivation, which was the crop production pattern in Thailand in the past, and which was noted for its efficiency in crop production and in restoring soil productivity, can no longer be practiced due to the shortage of land. Long fallow periods have disappeared. This has led to soil erosion, land degradation, declining crop production, and poverty. Researchers and development planners now focus on providing farmers with technologies which can increase farm productivity and which have long-term sustainability. Alley farming enhances soil fertility even when there is land shortage. This is because it eradicates the fallow phase and allows for continuous cropping [14]. Alley farming, which can increase rice and other crop production, can meet Thai farmers' needs. Thailand is unique in the sense that the king of Thailand promotes organic farming. Since alley farming is organic farming, many Thai farmers may like to adopt it if they are informed about its establishment. Thus a study of this type is highly significant because it focuses on alley farming, a low input technology, which has shown great ability in reducing soil erosion, enhancing sustainability, and increasing farm productivity.

1.7. Constraints to Alley Farming Adoption

Ogunlana [27] pointed out that the major constraint to the adoption of alley farming is the lack of information about alley farming. Some writers, such as Leach and Marslan [28], emphasized that the difficulty involved in pruning alley trees can hinder alley farming's adoption. Others pointed out that the extra labor costs involved in establishing and managing alley trees is also constraint to the adoption of alley farming. Contrary to this view, ILCA [29] pointed out that alley farming was still significantly more profitable than the no-tree farming system when the cost for clearing trees was included. The

extra costs must be balanced against its benefits and savings. It takes two to three years for farmers to derive the benefits of alley farming. This is because the leguminous trees will take some time to grow, and if the trees have not grown enough to be pruned, farmers cannot expect any benefits. This delay in the achievement of benefits may hinder alley farming adoption [30]. Contrary to this view, Shannon *et al.* [31] noted that though chemical fertilizers increases yield faster, this method can only increase yield in a short term, whereas alley farming increases production for a long term, even though alley farming requires a longer time to start yielding benefits. Alley farming is therefore still more profitable than the usage of chemical fertilizer.

Adesina *et al.* [32] observed that other major constraints include a lack of seedlings of alley trees and high labor demand. In the Philippines, 50% of the farmers said that there was no constraint to the adoption of alley farming. Indeed, many farmers in the Philippines have adopted it. Other constraints reported include high cost of labor (35%), increased labor time (3%), and shading of crops by hedgerows (2%) [17].

This project is a preliminary analysis of alley farming in Thailand. The major objectives of the project were:

1. to analyze the effects of alley farming and chemical fertilizer use on continuous long-term crop production;
2. to extend alley farming to rural farmers in Thailand with the aim to preserve their environment, increase their farm productivity, and thereby alleviate their poverty.

The specific objectives were to:

1. examine the existing alley farming practices in Thailand;
2. select, with farmers' participation, the crops to be cultivated;
3. select, with farmers' involvement, the best hedgerow species for the sites, so as to ensure good performance of the species, which will enhance increased crop production and farmers' adoption;
4. choose the hedgerow species that are deeply rooted, easy to establish, capable of rapid growth, tolerant of pruning, and capable of easy growth after pruning, and which possess high foliage production and high nitrogen content in their leaves;
5. ensure that hedgerows are palatable and can produce year round fodder for livestock;
6. note the frequency of pruning and the height at which it must be done;
7. design and implement, with farmers' participation, on-farm trials of alley farming;
8. develop strategies that can enhance the adoption of alley farming by Thai rural farmers.

2. Materials and Methods

2.1. The Study Area

The on-farm alley farming trial was carried out in northern Thailand in a village called Ban Sanambi Tumbol Khoakwan Thong Amphoe, near a city called Nong chag, in Uthaithani province. The population of Uthaithani province is 332,927. The rainfall starts in May and stops in November. The main occupation of the people is farming. Non-farm occupations are trading, sewing, crop selling, and food selling. Community members acquire land through inheritance; women have the right to

inherit land from their parents. Community members can also buy and sell land. The major crops cultivated are lowland rice and corn in the uplands. Rice is the staple food. Other crops include soybean and sorghum soybean during the rainy season, and sweet corn in the dry season. The bush fallow farming system is not practiced in this area due to land shortage. Farmers practice continuous farming and apply fertilizer on their farms. The livestock raised by people are cows, buffaloes, ducks, and hens. Some families have no land because they sold it when they needed money. Many farmers cannot buy land due to poverty. None of the farmers know how to establish alley farms: the farmers and the laborers therefore needed to be first taught how to establish alley farms.

The trial land is 4,800 square miles in area and is sloping. The land was previously planted with soybean; we thus first had to wait until the crops were harvested. The sorghum seeds and the stem cuttings of *Leucaena* we planted did not grow due to lack of rain. We were then given another trial land, which is flat, and which posseses irrigation in the same area. The land belongs to a woman farmer.

2.2. Alley Farming in Thailand

According to the farmers, the benefits they derived from alley farming include reduction in soil erosion, increased crop yield, and economic benefits derived from the sale of legume seeds. However, many farmers in Thailand do not want to adopt alley farming. It is the view of the farmers that it takes a long time before the benefits of alley farming can be seen. Thus, it takes a long time to find farmers who are willing to adopt alley farming. Additionally, in Thailand, many farmers have not heard about alley farming. It has only been introduced to a few farmers and is not widely practiced. Another drawback is that many rich farmers in Thailand may not adopt alley farming because they can afford the cost of chemical fertilizers. Since Thai women, unlike women in some societies, have the right to inherit land from their parents, the Thai women's right to land could enhance their likelihood of alley farming adoption.

2.3. Benefits to Thai Farmers

Many poor rural farmers in Thailand get their supply of drinking water from rivers in their community. As a result, they prefer to utilize organic farming so that their rivers will not be polluted. Soil erosion is a problem in Thai rural communities; farmers will benefit from adoption of alley farming since it will reduce soil erosion on their farms. Soil erosion is reduced by the physical barrier of the leguminous trees. Thai farmers also face the problem of lack of rain, which can lead to poor crop productivity and low grazing resources. Alley trees can overcome these problems due to their long tap roots, which can access water at deeper soil levels and can therefore produce leaves and branches for livestock feed and mulch for crops throughout the year.

Alley farming, being a type of organic farming that can increase farm productivity as well as preserve the environment, can play a significant role in improving soil and water conservation in rural Thailand. Moreover, being a low cost environmentally and economically sustainable farming system, alley farming can increase farm yield over time and thus enhance the economic status of rural Thai farmers. Many Thai farmers will benefit from feeding their livestock with leaves from hedgerow species, as this can increase their livestock production and hence produce a higher income derived

from the sale of livestock. Alley farming, due to its ability to limit fallow land to narrow strips, saves land and makes possible continuous cropping, which can reclaim impoverished land that is caused by permanent field cultivation. Additionally, the farming can control weeds, thus eliminating the need for pesticide application. It provides stakes and firewood for home cooking. Rice, corn, and many other crops can be planted on alley farms.

Since research in alley farming is not well developed in Thailand, researchers will benefit from studying alley farming and will be able to develop more research topics on alley farming. A participatory farmer-centered approach will be utilized in the project and this will enable farmers to gain empowerment and to develop their creativity and many useful practices through their experience. Direct participation of farmers in on-farm research will help both farmers and researchers exchange ideas, and enhance researchers' knowledge of indigenous farming techniques.

2.4. Land Preparation

An initial trial conducted with stem cuttings of *Leucaena* failed because of drought and because the cuttings did not root properly.

The second, irrigated plot of land, which belonged to a woman farmer, was used for the second, third, and fourth trials. The land was cleared, plowed, ridged, irrigated, and measured from January 23–24, 2004.

2.5. *Choice of Leguminous Trees*

It is important to choose leguminous trees that can biologically fix nitrogen. In addition, alley trees that are sufficiently available and that are appropriate to local conditions must be chosen. The trees must be fast growing and resistant to insects. Trees that do not need fertilizer or pesticides, and that have many uses, are suitable for alley farming. Initially, we planned to use *Leucaena leucocephala* and *Gliricidia Sepium*, but the seeds of *Gliricidia Sepium* were not available. Thus, we used *Acacia auriculiformis* instead.

2.6. Plot Treatments

The trial design was a two-by-two factorial with and without alley farming, and with and without chemical fertilizer. It was not replicated. Fertilizer N-P-K 15-15-15 was applied to the plots with fertilizer at 50 Kg/hectare (ha). The land was divided into four plots namely:

1. Alley Farming + Fertilizer
2. Alley Farming
3. Control + Fertilizer
4. Control

2.7. Plot Layout

The hedgerows and the crops were planted on ridged land. The ridges were made along the contours. In the on-farm trials, the hedgerows were planted in alternate rows that were four meters apart; the plants within each row were 25 cm apart.

2.8. Hedgerow Establishment

The farm was properly weeded before the alley trees were planted, because weeds retard the growth of the young seedlings in the first months of growth. The trees and the crops were cultivated on ridges in the field so that the ridges trapped runoff and fertilizer, and prevented fertilizer from being washed from one plot to another. In the second on-farm trials, the trees were planted four meters apart in alternate rows and 25 cm within the rows. Three rows of crops were cultivated between the hedgerows.

2.9. Hedgerow Management

Weeds grew very fast and the young tree seedlings could not compete with weeds. Thus, the farm had to be cleared again. The first pruning after tree establishment must be done when the trees are about 3 m tall; this occurs around 12 months after planting. The hedgerows were pruned when they were about 3 m tall to a height of roughly 2 m, and the prunings were distributed on the surface of the soil in the alleys where the crops were growing. The prunings served as mulch to the companion crops. Due to the fact that the project was for only one year and that the leguminous trees did not grow on time, the trees were pruned once.

2.10. First On-Farm Trial

The trial, established with stem cuttings of *Leucaena*, did not succeed due to drought and failure of the cuttings to root.

2.11. Second On-Farm Trial

On February 4–5, 2004, farmers planted seeds of sweet corn in all the plots on the second plot of land. Both *Leucaena leucocephala* and *Acacia auriculiformis* were planted from seeds in plots with alley farming. In the fertilized and alley farming with fertilizer plots, N-P-K 15-15-15 was applied three times at 50 kg/ha each time. The fertilizer was applied before planting, around 20–25 days after emergence and around 45 days after emergence. Sweet corn grew, however *Leucaena* and *Acacia* did not grow well. Sweet corn was harvested on April 21, 2004.

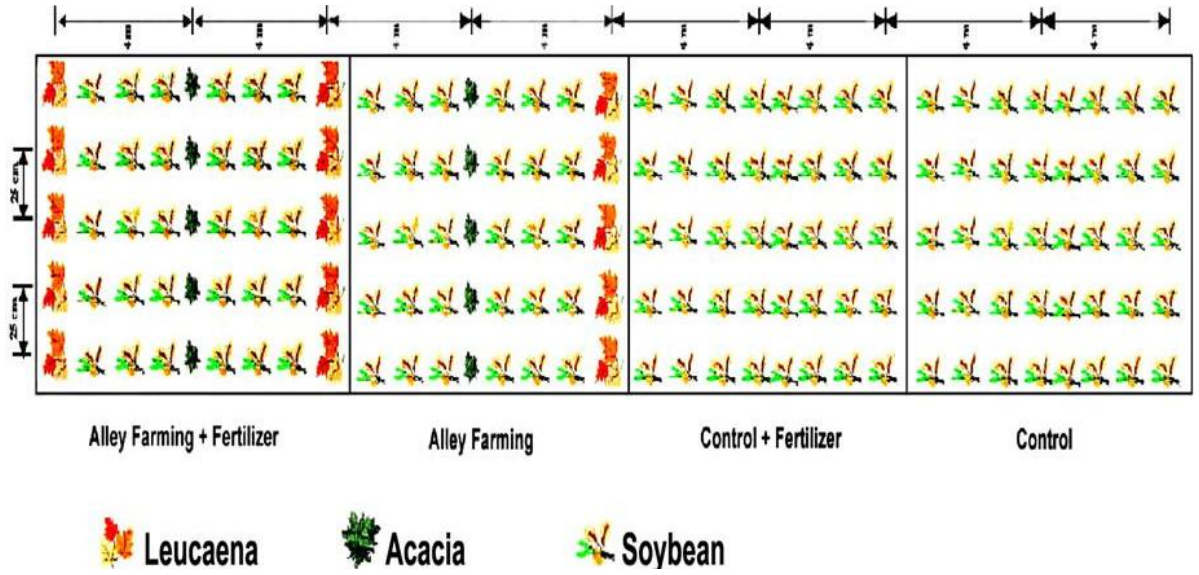
2.12. Second Season

Soybean seeds were planted in all the plots at the end of July 2004. Farmers suggested that soybean should be planted because it was the rainy season. It is the view of the farmers that sweet corn would be stunted if planted in the rainy season. Seeds of *Leucaena* and *Acacia* were first planted in nurseries on February 2004. *Leucaena* and *Acacia* plants were transplanted to the plots with alley farming on May 24–25, 2004, when their heights were more than 50 cm. They were planted four meters apart and 25 cm gaps within each row (Figure 1). Soybean seeds were planted in the alleys between the trees and in all the plots. N-P-K 15-15-15 was applied at 50 kg/ha on the fertilized plots. The hedgerows grew well.

There was heavy rain, which caused flooding of the farm. Consequently, many soybean seedlings were destroyed; only a few seedlings were good. Soybean seedlings were planted again. On

October 5, 2004, the heights of the soybean, *Leucaena* and *Acacia* were measured. The entire plot of soybean was harvested on November 8, 2004. The area occupied by the hedgerows was not included in the calculation of yield.

Figure 1. The arrangement for the alley farming plot trial: with Soybean planted between *Leucaena leucocephala* and *Acacia auriculiformis* hedgerows.



2.13. Third Season

Hybrid corn seeds were planted on the farm. The leguminous trees and hybrid corn grew well. Hybrid corn was harvested on April 3, 2005. On April 25, 2005, the height and diameter of the hedgerows were measured. The area occupied by the hedgerows was not included in the calculation of yield.

2.14. Fourth Season

On July 29, 2005, soybean was planted. The soybean and hedgerows grew well. Hedgerows were pruned, via pollarding, to a height of about 2 m. The prunings were returned to the alley plots in order to serve as mulch to the crops.

We could not complete this trial because of a lack of funding.

3. Results and Discussions

3.1. First On-Farm Trial

In the first on-farm alley farming trial, the sorghum seeds did not germinate due to lack of rain. The stem cuttings of *Leucaena* did not grow. We found that stem cuttings did not work well with *Leucaena* due to the fact that it is difficult to get the stem cuttings of *Leucaena* to root and they cannot produce good stands. It is difficult to get tap root development with stem cuttings, but it is easy to get it from seeds. *Gliricidia* establishes well from stem cuttings, but better root development can be achieved with planting from seeds. The problem with *Gliricidia* is that it is hard to get a lot of good seeds.

Leucaena can be propagated successfully by using seeds. The use of seeds results in tap root development. With *Leucaena*, obtaining seeds was not a problem, because it is a prolific seeder.

3.2. Second On-Farm Trial

Sweet corn grew, but *Leucaena* and *Acacia* did not grow well. Thus, we cannot determine the effect of alley farming on sweet corn yield. The trees failed to establish because *Leucaena* and *Acacia* grow much slower than weeds, and if they are very short, they cannot compete with weeds. When the farmers came to weed, they cut off the *Leucaena* and *Acacia*. Corn emergence could be assessed after one week, but *Leucaena* could only be assessed after three weeks.

3.3. Second Season

In order to insure that the hedgerows are established, seeds of *Leucaena* and *Acacia* were first planted in the nursery. Although they were planted in an optimum environment, they grew slowly. *Acacia* seeds grew slower than *Leucaena* seeds. By the time the *Leucaena* plants' height was 15 cm, the Acacia plants' height was 10 cm. *Leucaena* and *Acacia* plants were transplanted to the plots with alley farming. *Leucaena* grew slowly the first three months, but after that, grew quickly.

As noted earlier, only a few seedlings of soybean were good because the farm was flooded. Soybean was planted again and later harvested on November 8, 2004.

Table 1 shows the heights of soybean, *Leucaena* and *Acacia*, as measured on October 5, 2004. The means are given of five plants. The hedgerows grew slowly. *Acacia* grew slower than *Leucaena* did.

Table 1. The height of soybean, *Leucaena* and *Acacia* plants.

Plot No	**Soyabean Plant Height (cm)**	***Leucaena* Plant Height (cm)**	***Acacia* Plant Height (cm)**
Alley Farming + Fertilizer	-	-	-
Mean	44.8	193.2	129.8
Standard deviation	2.8	57.9	17.2
Alley Farming	-	-	-
Mean	43.2	251.4	153.4
STD DEV	4.6	58.6	6.5
Fertilizer		-	-
Mean	41	-	-
STD DEV	4	-	
Control		-	-
Mean	41.6	-	-
STD DEV	6.5	-	-

The leguminous trees grew taller without fertilizer than with fertilizer.

Before the soybean was harvested, the hedgerows had not grown enough to be pruned. The positive effects of alley farming could not yet be achieved, because no prunings were added to the alley plots. Kang *et al.* said that the initial pruning of hedgerows can be done when they are 2–3 m tall, and that this height is attained usually 12 months after planting for *Leucaena* [10]. Alley farming is like a

balance. On one side are the trees, which are extracting water and nutrients out of the soil that might otherwise be used by the crop. On the other side, are the nutrients and organic matter, which are provided to the crop in the form of mulch. Until the trees are pruned, the effect can only be negative, because nothing is being returned to the system.

The soybean yield on alley farming with fertilizer plot was 656 kg/ha and on the alley farming plot without fertilizer, it was 456 kg/ha. On a fertilizer plot, soybean yield was 584 kg/ha, while the yield on the control plot (no alley farming and no fertilizer) was 464 kg/ha (Table 2). The calculation of yield in alley cropped plots includes the area occupied by the hedgerows. The harvest was obtained from identical areas in the control and alley farming plots. Yield in the alley plot with fertilizer was higher than yields in the other plots. Yield in alley farming without fertilizer application was lower than yield in the control with fertilizer. Yield in alley farming without fertilizer was also lower than yield in the control treatment. From the findings, it was observed that crop yield in the alley farming plot was lower than that of the plots with fertilizer. These results are consistent with results reported by Shannon *et al.* [31]. In their research, which was carried out in Gandajika, Zaire, they found out that initially, crop yield in the control with fertilizer was higher than that of the alley farming plot. However, after a period, yield in the control with fertilizer decreased below that of alley farming plot. Thus, with continuous cropping and repeated additions of prunings over a period of time, the crop yield in the alley farming plot will be higher than that of the other plots, and the crop yield in the other plots will decrease. This is because the benefits from fertilizer alone are short-term, but alley farming is sustainable. Many researchers, for example, Van der Meersch [33], Cramb and Nelson [18], Pandey and Lapar [17], Kang and Shannon [14], and Isaac *et al.* [34], pointed out that alley farming increases crop yield over time.

Table 2. Soybean Yields.

Treatment	**Soybean Yield (Kg/hectare)**
Alley Farming + Fertilizer	656.0
Alley Farming	456.0
Control + Fertilizer	584.0
Control	464.0

3.4. Third Season

Hybrid corn and leguminous trees grew well. Hybrid corn grain yield in the alley plot with fertilizer was 55.0 kg/ha and in the alley farming without fertilizer, the yield was 30.8 kg/ha. In the control plot, hybrid corn yield was 194.0 kg/ha. In the plot with fertilizer alone, the yield was 261.3 kg/ha (Table 3). The yield in the plot with fertilizer alone was the highest, followed by the yield in the control treatment. Yield in the alley plot without fertilizer was the lowest. However, all the yields were very low.

Table 3. Hybrid Corn Yields.

Treatment	Hybrid Corn Yield (Kg/hectare)
Alley Farming + Fertilizer	55.0
Alley Farming	30.8
Control + Fertilizer	261.3
Control	194.0

The benefit of alley farming was not achieved because the biomass from the hedgerows was not added to the soil yet. These results are consistent with Larson *et al.* [35] and Isaac *et al.* [34]. It will take two to three years for the crop yield in the alley farming plot to be higher than that of the other plots. In terms of measurable differences in the soil, repeated additions of biomass over a period of time is needed in order to be able to clearly detect differences in soil organic C and N between the alley farming plot and the other plots. Larson *et al.* [35] and Isaac *et al.* [34] pointed out that the soil organic C and N increased in alley farms when more biomass was added over a period of time. Maize yields increased over time in plots with alley farming and decreased in plots with chemical fertilizers [31]. The benefits of alley farming are not immediate, but are sustainable.

The measurement of the height and diameter of hedgerows, which was taken on the 25 of April 2005, indicated that hedgerows grew slightly taller in the alley farming with fertilizer plot than in the plot without fertilizer (Table 4).

Table 4. Height and Diameter of Hedgerows.

	***Leucena* Plant Height (cm)**	**Diameter of *Leucena* Stem (cm)**	***Acacia* Plant Height (cm)**	**Diameter of *Acacia* Stem (cm)**
Alley Faming + Fertilizer				
Average (n = 10)	339	3.3	328	3.5
SD	58	0.9	40	0.6
Alley Farming				
Average (n = 10)	337	3.4	314	3.4
SD	36	0.5	28	0.4

3.5. Fourth Season

Hedgerows were pruned and prunings were distributed on plots with alley farming. The amount of biomass from the first pruning is very little. Thus, the positive side of alley farming could not be realized. The first pruning mainly aims to reduce competition with the crops and to induce the tree to produce many new branches.

Due to the fact that hedgerows grew well, higher crop yields on alley farming plot are expected the following year. Hedgerows prunings improve the soil fertility. Vanlauwe *et al.* [36] observed that the maize yield correlated most with the N content of prunings, particulate in organic matter N and rainfall.

The project effectively showed that *Leucaena leucocephala* and *Acacia auriculiformis* can be successfully established in Thailand. Farmers were interested in the project. Due to the fact that

farmers participated in decisions about which crops to plant, when to plant, and when to harvest the crops, they were motivated to perform well. Farmers were satisfied with the technology and they participated actively in the project. Farmers' participation promoted cooperation between the farmers and the research team. However, one year is too short a time to realize the benefits of alley farming. Since the project was sponsored for only one year, we could not continue due to a lack of funding. It is needed that more researchers establish alley farms for a longer period of time.

4. Conclusions and Recommendations

4.1. Conclusions

The diameters of *Leucaena* and *Acacia* showed that they grew very well. This indicated that *Leucaena* and *Acacia* are suitable for alley farming in Thailand.

Alley farming increases crops and livestock production and improves soil fertility for a long period of time. The ability of alley farming to maintain continuous cropping as well as improve soil fertility, and the advantage of reducing soil erosion make it a suitable sustainable agricultural technology in Thailand where shortage of land has resulted in permanent field cultivation, land degradation and reduced crop production.

Initially, crop yield in the alley farming plot was lower than that in the chemical fertilizer plot. These results are consistent with results reported by Shannon *et al.* [31]. After a period, yield in fertilizer plot will decrease below that of alley farming plot. Crop yield in alley farming plot was initially low because the hedgerows used part of the water and nutrients in the soil that might otherwise be used by the crop. The positive effect of alley farming can be achieved after hedgerow prunings are added to alley plot. After a period of continuous cropping and repeated additions of prunings over a period of time, the crop yield in alley farming plot will be higher than that in the other plots and the crop yield in the other plots will decrease. Larson *et al.* [35] and Isaac *et al.* [34] pointed out that the soil organic C and N increased in alley farms when more biomass was added over a period of time.

Chemical fertilizer initially increases crop yield for a short time. However, if nothing is done to maintain soil organic matter and sustain soil physical and chemical properties, crop yields will decline over time even with fertilizer. Alley farming increases agricultural productivity without fallow periods. Many researchers, for example Van der Meersch [33], Cramb and Nelson [18], Pandey and Lapar [17], Kang and Shannon [14] and Isaac *et al.* [34], pointed out that alley farming increases crop yield over time.

Alley farming improves livestock production. According to Reynolds and Jabbar [21], it is beneficial to use alley leaves as fodder for livestock. When dairy cattle are fed with *Leucaena*, in early lactation, their milk production is high, especially in the dry season when the nutritive value of grass is low.

Since alley farming is cheaper than chemical fertilizers Thai poor rural farmers can afford it. In contrast to chemical fertilizers, alley trees can gradually increase production with a minimal investment. This is because, ideally, farmers purchase their initial seed stocks at a cheap rate, or they may be given free. Farmers can get their seed supplies from each successive harvest. As a result, they only need to make planting investment and to multiply the seeds. Whereas, in the case of fertilizer,

farmers require more capital to acquire fertilizer due to its high cost. Moreover, fertilizer is a non-seed innovation, and its adoption involves recurring costs, which result from input consumption and replacement requirements.

A constraint to the adoption of alley farming is the time it takes before results become visible to farmers. Farmers need to conserve the fertility of their land, but the initial time lag in deriving benefits that is the time taken for the leguminous trees to grow and be pruned to fertilize the soil may be too long for farmers [31]. This is compensated for by the ability of alley farming to increase soil fertility as well as enhance farm productivity for long periods.

In Thailand, women can inherit land from their fathers. Thai women's access to land may enhance their adoption of alley farming. This is because many of them do not have money to buy land but their access to land through inheritance gives them the opportunity to own land and adopt alley farming. The second farm that was used for the project belonged to a Thai woman farmer.

Ogunlana [25] observed that many alley farming researches focus on participatory farmer-centered approach. Farmers in collaboration with researchers and extension workers are actively involved in decision making. This project utilized farmers' participation. Farmers decided which crops to plant, when to plant and when to harvest the crops. This developed farmers' interest in alley farming and enhanced its adoption.

Alley farming is the best solution in Thailand where, as a result of land shortage, farmers engage in permanent field cultivation, which has resulted in declining land productivity. Alley farming is the best solution because it has combined advantages of increasing farm productivity for long periods continuously while enhancing soil fertility without fallow phase. Unlike chemical fertilizer, alley farming improves soil fertility for a long period of time. From the experiment and interaction with growers, we observed that the growers were willing to plant alley farms. This indicates the potential for alley farming in Thailand.

The results of the on-farm trials were consistent with literature on alley farming. The hedgerows grew well. The project was sponsored for one year and the desired results could not be achieved in one year because one year is too short. Due to lack of funding, we could not continue the project. This project is a preliminary analysis of alley farming in Thailand. More researchers should encourage farmers to practice alley farming for a long period. A longer study is needed for stronger validation.

4.2. Recommendations

To enhance Thai farmers' adoption of alley farming, there is a need to inform them about the benefits of alley farming. We observed that none of the farmers we spoke to had heard about alley farming. Lack of knowledge about the benefits of alley farming is a major hindering factor in the farmers' adoption of this method. Due to the fact that organic farming sustains crop production, produces healthy crops, enhances environmental preservation, increases crop production and could therefore eradicate poverty, there should be a statutory requirement for schools to ensure that benefits of organic farming are included in the curriculum.

To promote the rate of adoption of alley farming by Thai farmers', more researchers should effectively disseminate information on how to establish alley farms to Thai farmers. More researchers should establish alley farms for a longer period of time. Faculty members and researchers in the Asian

Institute of Technology who specialize in organic farming should be informed about alley farming and extend it to farmers in the region.

We suggest that researchers should guide farmers back to the natural methods of farming; methods that promote self-reliance and is the use of available raw materials which are right there on the farm. Moreover, farmers and consumers will be blessed with healthy and natural food and good water conditions.

Leguminous trees naturally fix nitrogen. Since alley farming utilizes natural and sustainable fertility processes by using leguminous trees, researchers should encourage farmers to adopt this method to lead to the production of healthy crops.

Farmer-centered, bottom-up approach should be used to extend these technologies to farmers. Farmers, in collaboration with researchers and extension workers, must be actively involved in decision-making.

In order to avoid problems in technology transfer, alley farms in Thailand should be planted on land with irrigation. Before the majority of Thai rural farmers can enjoy the benefits of alley farming, there is a need to carry out an in-depth research on alley farming in Thailand.

Alley farming can contribute to poverty alleviation in Thailand by increasing crop and animal production at low cost. Its ability to increase soil fertility and reduce weed growth helps rural farmers to eliminate the application of pesticides on their farms. Research on alley farming will enhance Thai farmers' farm productivity and thus improve their quality of life.

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