BIBLIOGRAPHY

SHRESTHA, RAJU. APRIL 2009. Effect of Tree-Crop Combination on the Pest and Disease Occurrence in Bush Bean (*Phaseolus vulgaris* Linn.). Benguet State University, La Trinidad, Benguet.

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ABSTRACT

The study was conducted to compare the disease and pest incidence on the bush bean grown conventionally and bush bean grown with trees and non-crop plant species.

Bush bean grown in conventional method was significantly infected by disease and pests while the plants grown with tree and non-crop plants showed a low degree of disease and pest incidence. One of the highly contrasting results was that the Fusarium wilt disease incidence in the conventional method was 62% while in the tree-crop combination there not even a single incidence. There was also a significant difference in bean rust, leaf curling, leaf miner, and pod borer incidence.

Significantly higher less non-marketable yield was noted in the tree-crop combination. As a consequence, the Return on Investment (ROI) was much higher in the tree-crop combination.

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INTRODUCTION

Today almost all vegetables and crops are grown with the help of chemicals and are protected with pesticides. As a consequence, the consumers have no options but to consume those highly pesticide-contaminated products. The results of numerous researches related to the effect of pesticides and chemicals have already proved to be negative to the human health and environment. It creates pest control problem through resistance development, and by killing natural enemies of pests.

Economically, in agriculture particularly in monoculture, the burdens include the need to supply crops with costly external inputs; since agroecosystems deprived of basic regulating, functional components lack the capacity to sponsor their own soil fertility and pest regulation. Often the costs involve a reduction in the quality of life due to decreased soil, water, and food quality when pesticide and/or nitrate contamination occurs.

Agriculture implies the simplification of biodiversity and reaches an extreme form particularly in monocultures. The result is the production of an artificial ecosystem requiring constant human intervention. In most cases, this intervention is in the form of agrochemical inputs, which, in addition to boosting yields, result in a number of undesirable environmental and social costs (Altieri, 1994).

Nowhere are the consequences of biodiversity reduction more evident than in the realm of agricultural pest management. As agricultural modernization progresses, ecological principles are continuously ignored or overridden. Hence, modern agroecosystems are unstable and breakdowns manifest themselves as recurrent pest outbreaks in many cropping systems and in the form of salinization, soil erosion, pollution of water systems, etc. The worsening of most pest problems has been experimentally linked to the expansion of crop monocultures at the expense of vegetation diversity, which more often than not, provides key ecological services to ensure crop protection (Altieri and Letourneau, 1982 as cited by Altieri, 1994).

In modern agroecosystem, the experimental evidence suggests that biodiversity can be used for improved pest management (Andow, 1991 as cited by Altieri, 1994). According to these theories, a reduced insect pest incidence in polycultures may be the result of increased predator and parasitoid abundance and efficiency, decreased colonization and reproduction of pests, chemical repellency, masking and/or feeding inhibition from non-host plants, prevention of pest movement or immigration, and optimum synchrony between pests and natural enemies.

This study focuses particularly on the ways in which biodiversity can contribute to the design of pest-stable agroecosystem. The reason for choosing bush bean (*Phaseolus vulgaris* Linn.) as a main crop is, it is one of the most popular vegetable grown commercially by Benguet farmers. It is one of the common and major source of protein and, at the same time improves the soil fertility by fixing Nitrogen. While it is considered as a major crop, the quality is often affected by the pests and diseases.

Pests and diseases are the cause of yield losses in crops around the world. Modern agriculture has been trying to cope up with this problem using pesticides and chemicals, but at the expense of human health and environment. As more farmers practice the tree-crop combination, there is a significant potential for a decrease in traditional pest and disease problem. The diverse vegetation (tree-crop and non-crop) leads to the minimization or complete avoidance of using chemical pesticides, and thereby maintaining a balanced and sustainable ecosystem that is socially just, healthy and environmentally sound.

This study can be used to help the great mass of resource poor farmers by reducing their reliance on scarce and expensive agrochemical inputs, and receive maximum returns under low levels of technology. Economically, it minimizes the cost of pesticides, fertilizers, health risk, labor, and time.

The study aimed to: 1) to compare the incidence of pest and disease occurrence between the bush bean grown with trees and the bush bean grown in conventional method, and, 2) to identify and compare the number and kinds of pest occurrence between bush bean grown with tree and bush bean grown in conventional method.

This research study was conducted at the Agroforestry Experimental Area, College of Agriculture, Benguet State University from December 2008 to April 2009.

REVIEW OF THE LITERATURE

Plant communities that are modified to meet the special needs of humans become subject to heavy pest damage, and generally the more intensely such communities are modified, the more abundant and serious the pests. The effects of the reduction of plant diversity on outbreaks of herbivore pests and microbial pathogens are well documented in the agriculture literature (Andow, 1991 as cited by Collins and Qualset, 1999).

Several studies have shown that it is possible to stabilize the insect communities of agroecosystems by designing and constructing vegetational architectures that support populations of natural enemies or that have direct deterrent effects on pest herbivores (Perrin, 1980; Risch et al., 1983 as cited by Collins and Qualset, 1999).

There are various factors in crop mixtures that help constrain pest attack. A host plant may be protected from insect pests by the physical presence of other plants that may provide a camouflage or a physical barrier. The odor of some plants can also disrupt the searching behavior of pests (Altieri, 1994 as cited by Collins and Qualset, 1999).

Yet, along with the trees might come small wasps that seek out the nectar in the tree flowers. These wasps may in turn be the natural parasitoids of pests that normally attack the crops. The wasps are part of the associated biodiversity. The trees, then, create (direct function) and attract wasps (indirect functions) (Vandermeer and Perfecto, 1995 as cited by Collins and Qualset, 1999).

Certain weeds (mostly Umbelliferae, Legumiosae and Compositae) play an important ecological role by harboring and supporting a complex of beneficial arthropods that aid in suppressing pest populations (Altieri and Whitcomb, 1980 as cited by Altieri, 1994).

Overwhelming evidence suggests that polycultures support a lower herbivore load than monocultures. One factor explaining this trend is that relatively more stable natural enemy populations can persist in polycultures due to the more continuous availability of food sources and microhabitats (Letourneau and Altieri, 1983; Helenius, 1989; as cited by Altieri, 1994). The other possibility is that specialized herbivores are more likely to find and remain on pure crop stands, that provide concentrated resources and monotonous physical conditions (Tahvanainen and Root, 1972 as cited by Altieri, 1994).

However, based on current ecological and agronomic theory, low pest potentials may be expected in farms with a dominant perennial crop component. It is considered to be semi permanent ecosystems, and more stable than annual crop systems. Since it suffer fewer disturbances and are characterized by greater structural diversity, possibilities for the establishment of biological control agents are generally higher, especially if floral undergrowth diversity is encouraged (Huffaker and Messenger, 1976: Altieri and Schmidt, 1985 as cited by Altieri, 1994).

Crops lush from too much Nitrogen are more attractive to pest and fungal diseases. The reproductive rates of most pest insects are proportional to the supply of certain amino acids in their diet. Excess fertility increases the supply of these amino acids and plant tissue and the pest numbers too rapidly, which is true in a conventional farming system. Plants fertilized by the slow release of nutrients from natural decomposition are more resistant to insect and disease than crops fertilized by the highly soluble nutrients provided by the inorganic fertilizers (COG'S Organic field crop handbook, 2008).

Many of the conventional farming practices that enhance yields also contribute to increased pest problems. The wide spread use of a broad-spectrum pesticides kills not only the crop pests but also the insect, mites, and nematodes that functions as natural enemies of pests. Farmers have found that repeated application of pesticides over twenty or more generation of the pest all too frequently results in the development of pest populations that are resistant to the pesticides. These are pests that were held in check by natural enemies and caused no economic damage in a natural habitat (Chrispeels and Sandra, 1994).

Many studies have documented the movement of beneficial arthropods from margins into crops, and higher biological control is usually observed in crop rows close to wild vegetation edges than in rows in the center of the fields (Altieri, 1994).

In general, agroecosystems that are more diverse, more permanent, isolated, and managed with low input technology (i.e., agroforestry systems, traditional polycultures) take fuller advantage of work done by ecological processes associated with higher biodiversity than do highly simplified, input-driven, and disturbed systems (i.e., modern row crops and vegetable monocultures and fruit orchards) (Altieri, 1995 as cited by Collins and Qualset, 1999).

MATERIALS AND METHODS

The study was conducted at the Agroforestry Experimental Area, College of Agriculture, Benguet State University from December 2008 to April 2009. The materials used were bush bean seeds of Kabayan variety (1.5 kg), fertilizer (16-16-16 and compost), pH meter, and farm tools and implements.

Two plots with approximately the same area (i.e. 120 sq. m) were planted with bush bean in two different locations. The first plot was planted with the bush bean in a conventional farming system (monoculture) as Treatment 1 (Fig. 1) and fertilized with inorganic fertilizer (16-16-16). The plant-to-plant distance was 25 cm. In contrast, the second plot was planted with bush bean in combination with existing trees and woody species and other species of plants (wild or domesticated) as Treatment 2 (Fig. 2). The plant-to-plant distance was 25 cm, and was treated with organic fertilizer (compost and compost leachate). Both Treatments were not treated with pesticide. Both treatments were replicated three times. The treatments were as follows:

T_1 = Conventional method: Inorganic fertilizer (16-16-16), weeding, tilling, and no pesticides.

T_2 = Tree-crop combination: Organic fertilizer (compost and compost leachate), no weeding, minimum tillage, and no pesticides.

Figure 1. Bush bean planted in a Conventional method (Treatment 1)

Figure 2. Bush bean planted in a Tree-crop combination (Treatment 2)

Data Gathered

The following data were gathered from the experiment:

A. Incidence of Insect Pest and Diseases (%). A weekly evaluation of the crop was done.

The following formula was used in computing the percentage degree of pest and disease incidence (DOI):

$$DOI = \frac{\text{Total No. of Plants - No. of Infected/Injured Plants}}{\text{Total No. of plants}} \times 100$$

B. Soil Properties

1. Soil pH. The initial and final pH of the soil was determined before planting and after harvest using the pH meter respectively.

2. Organic matter content (%). Organic matter content was analyzed by using the Walkley Black method.

3. Nitrogen content (%). The nitrogen content of the soil was derived from OM content of the media following the formula:

$$\%N = \%OM\ (0.05)$$

Where: 0.05 = constant

4. Phosphorus content (%). The phosphorus content was analyzed using the spectrophotometer.

C. Yield and Yield Component

1. Number of days from planting to harvesting. The number of days from the planting to harvesting of bush bean was recorded.

2. Marketable yield per treatment (kg). Marketable yield per treatment was taken after harvest. Marketable yield was slightly or disease free, no mechanical injury, standard grade and of good quality.

3. Non-marketable yield per treatment (kg). Non-marketable yield per treatment was taken after harvest. Non-marketable yield was disease and pest infected, mechanically injured, poor grade and of poor quality.

4. Total yield per treatment (kg). The total yield per treatment was taken after harvest. The total yield was the sum of marketable and non-marketable product.

D. Inventory of Plant and Insect Species

Different species of trees, weeds, and insects were identified.

E. Growth Increment (cm)

The height of the bush beans grown in both treatments were taken on weekly basis from one month after the sowing of seeds till the first harvest to determine the growth increment.

F. Return on Investment (%). This was computed after the bush bean was harvested by using the formula:

$$ROI = \frac{\text{Gross Sales} - \text{Total Expenses}}{\text{Total Expenses}} \times 100$$

RESULTS AND DISCUSSION

Disease Incidence

Bean Rust (*Uromyces phaseoli*)

Table 1 presents the data on incidence of bean rust disease (Fig. 3) in bush bean grown in the two specified treatments in terms of percentage incidence.

The data shows that in case of Treatment 1 or conventional method the mean degree of incidence was 77.67%, which according to the rating index is very severe. On the other hand, the mean degree of incidence was 14.33% in the tree-crop combination.

We can therefore, observe the significantly large difference in the degree of incidence of bean rust between the two treatments.

The implication of these findings is that planting bush beans with trees and diverse plants mitigates if not significantly prevents the occurrence of bean rust in bush bean.

Table 1. Mean degree of bean rust incidence (%)

TREATMENT	MEAN
Conventional method	77.67
Tree- crop combination	14.33

Fusarium wilt (*Fusarium oxysporum*)

The data on Table 2 presents the incidence of Fusarium wilt disease on bush bean (Fig. 4.a and 4.b) planted in two different conditions.

In the case of Treatment 1, the mean incidence percentage was 62%, which evidently is very high. In the case of bush bean planted with trees and non-crop plants, there was completely no incidence of root rot.

The finding is very significant and given the condition of the experiment, trees along with other domesticated or wild plants near the bush bean prevents the occurrence of Fusarium wilt which is caused by the *Fusarium oxysporum*. One of the reason could be crops lush with too much Nitrogen which was true in the case of Treatment 1 (16-16-16) attracts a fungal diseases (Anonymous).

Table 2. Mean degree of Fusarium wilt incidence (%)

TREATMENT	MEAN
Conventional method	62
Tree- crop combination	0

Leaf Curling (Bean Common Mosaic Virus)

Table 3 shows the data on the incidence of leaf curling disease in bush bean (Fig. 5) grown in conventional method and bush bean grown in tree-crop combination.

The data shows that a mean degree of incidence of leaf curling disease in conventional method was 56.67% while the mean degree of incidence of leaf curling in tree-crop combination was 9.67%, which shows a large difference in leaf curling occurrence between the two treatments. The incidence of leaf curling disease was significantly higher in conventional method than the tree-crop combination. The result shows the probability of leaf curling occurrence is more on the bush bean grown in conventional method.

Table 3. Mean degree of incidence of leaf curling (%)

TREATMENT	MEAN
Conventional method	56.67
Tree-crop combination	9.67

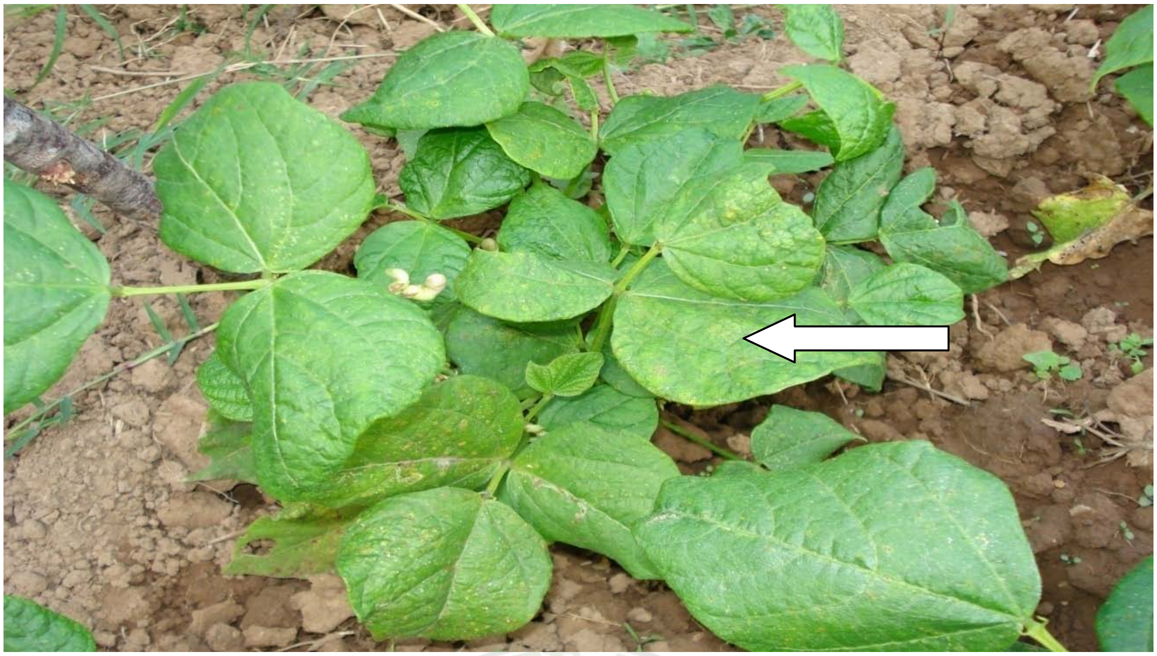

Figure 3. Bean rust (*Uromyces phaseoli*) infected leaves

Figure 4.a. Fusarium wilt (*Fusarium oxysporum*) infected plant

Figure 4.b. Root infected by Fusarium wilt

Figure 5. Leaf curling caused by Bean Common Mosaic Virus

Pest Incidence

Pod Borer (*Maruca vitrata* (Testulasis) Geyer)

The data shows the pod borer occurrence in the conventional method was significantly higher compared to the tree-crop combination (Table 4).

The mean of the pod borer incidence (Figure 6) in conventional method was 45% while the mean pod borer incidence in tree-crop combination was 7.33%. The result indicates that the pod borer is more prone to the bush bean grown in conventional method rather than grown with trees and other non-crop plants. Altieri (1972) reported that specialized herbivores are more likely to find and remain in pure crop stands that provide concentrated resources and monotonous physical condition than in a mixed crop stands.

Table 4. Mean degree of incidence of pod borer (%)

TREATMENT	MEAN
Conventional method	45.0
Tree-crop combination	7.33

<u>Leaf Miner (*Liriomyza huidobrensis* Blanchard)</u>

Significant difference was observed in the incidence of leaf miner among the bush bean in conventional method and bush bean in tree crop combination (Table 5).

The data shows the mean of leaf miner incidence (Figure 7) in conventional method was 65.33% and the mean of leaf miner incidence in tree-crop combination was 25%. This result corroborated the study of Letourneau and Altieri (1983) that the population of natural enemy of pest is relatively more stable in polyculture as it provides continuous food sources and favorable microhabitats. Many other ecological theories also approve the findings of this experiment which exhibited the large difference in pests and diseases occurrence between the bush bean planted in a conventional method (monoculture) and the bush bean planted with trees and non-crop plant species (Agroforestry).

Table 5. Mean degree of incidence of leaf miner (%)

TREATMENT	MEAN
Conventional method	65.33
Tree-crop combination	25.00

Figure 6. Pods infected by pod borer (*Maruca vitrata* (Testulasis) Geyer)

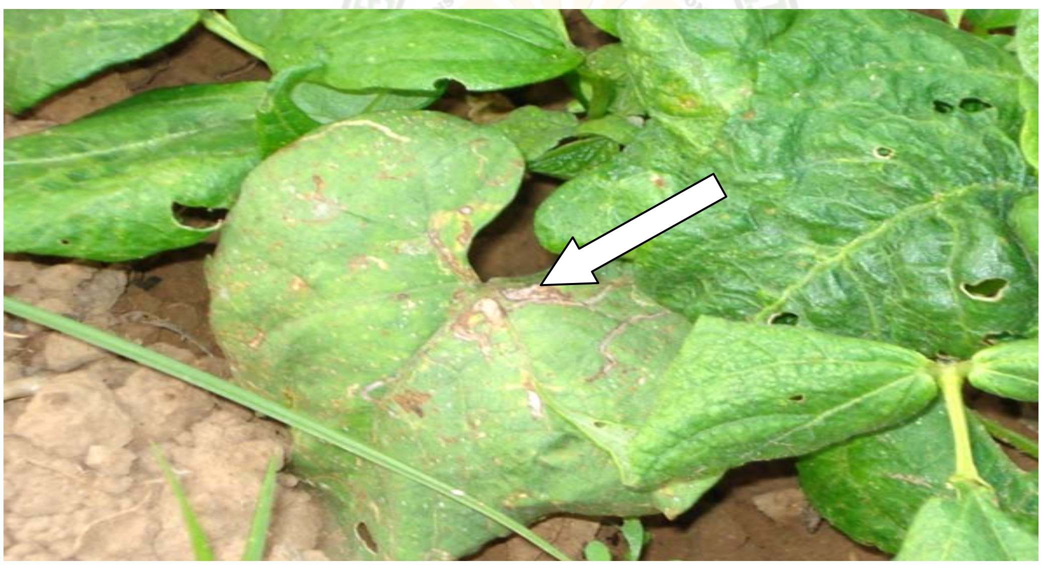

Figure 7. Leaf injured by the larva of leaf miner (*Liriomyza huidobrensis* Blanchard)

Soil Properties

The result (Table 6) of the soil analysis done before planting and after harvesting shows that in the case of the conventional method, there was a slight increase in pH value, organic matter (OM) content and nitrogen (N) content but there was decrease in phosphorous (P) content. In the case of tree-crop combination, the result showed a slight increase in organic matter content and nitrogen content but there was a slight decrease in pH and decrease in the phosphorous content. The decrease in pH in case of tree-crop combination was due to the elevation of the Carbon dioxide (end product of OM) concentration in the soil air can lower the soil pH, by formation and dissociation of carbonic acid (Singer and Munns, 2002). The decreases in Phosphorous content in both treatments were attributed to the higher requirement of Phosphorous by bush bean (50(N)-120(P)-50(K) per ha).

Table 6. Initial and final pH, OM, N and P (%)

TREATMENT	INITIAL				FINAL			
	pH	OM	N	P	pH	OM	N	P
Conventional method	5.685	2.15	0.1075	31.59	6.080	2.18	0.1090	21.12
Tree-crop combination	5.590	2.74	0.1370	63.18	5.365	2.77	0.1385	29.17

Yield and Yield Components

Marketable Yield Per Treatment (kg)

Table 7 presents the marketable yield as affected by the two treatments. Significant differences were observed among the treatments. The mean marketable yield of bush bean produced by the conventional method was 7.7 kg and the mean marketable yield produced by the tree-crop combination was 10.3 kg. In addition, the marketable yield produced by tree-crop combination can be considered of better quality than the marketable yield produced by the conventional method. This is because bush bean obtained from the tree-crop combination was organic, applied with organic fertilizer (compost and compost leachate) and was without any chemicals.

Table 7. Marketable yield (kg)

TREATMENT	MEAN
Conventional method	7.70
Tree-crop combination	10.3

Non-Marketable Yield Per Treatment (%)

Contrasting non-marketable yield was statistically revealed (Table 8). Statistical analysis showed a significant difference in non-marketable yield produced by conventional method and tree-crop combination. The mean non-marketable yield obtained from the conventional method was 4.27 kg while the mean non-marketable yield obtained from tree- crop combination was only 0.42 kg. The high non-marketable yield in case of conventional method was due to the high degree of incidence of Fusarium wilt, root rot, leaf curling, pod borer, and leaf miner. It was also due to the unmarketable shape (curly pod) and size of the bean pods.

Table 8. Non-marketable yield per treatment (kg)

TREATMENT	MEAN
Conventional method	4.27
Tree-crop combination	0.42

<u>Total Yield Per Treatment (kg)</u>

The total yield, which includes both, the marketable yield and non-marketable yield is shown in Table 9. The mean total yield produced by conventional method was 11.97 kg and the mean total yield produced by tree-crop combination was 10.65 kg which shows no significant difference in total yield . But, the data also showed (Table 7 and 8) there was comparable marketable yield but very low non-marketable yield in case of tree-crop combination, while in case of conventional method the non-marketable yield was more than half of the marketable yield. Therefore, from an economical point of view it is concluded that, conventional method will generate less income as compared to the tree-crop combination.

Table 9. Total yield per treatment (kg)

TREATMENT	MEAN
Conventional method	11.97
Tree-crop combination	10.65

Length of Pod (cm)

Shown in Table 10 are the average length of bush been pod. The mean length of pod gathered from conventional method was 15.67 cm and the mean length of pod gathered from tree-crop combination was 16.74 cm. The longer length of pod in tree-crop combination may be attributed to the longer plant height (fig. 8), which allowed the pod to grow vertically downward without being disturbed by the soil surface. Lower sunlight exposure as obstructed by higher plants in the surrounding (Treatment 2) caused the plants to grow higher because the growth hormone (auxin) in the shaded side of the plants were stimulated (Devlin and Witham, 1983).

Table 10. Mean length of pod (cm)

TREATMENT	MEAN
Conventional method	15.67
Tree-crop combination	16.74

Number of Days from Planting to Harvesting

Number of days from planting to the harvesting of bush bean was 62 days.

Height Increment (cm)

The data in Figure 8 presents the weekly height increment of bush bean grown in conventional method and tree-crop combination. There was a significant difference in the height increment. The mean initial height (one month from sowing of seed) of the plant was 18.06 cm and the mean final height at the time of first harvest was 32.06 cm in conventional method. On the other hand, the mean initial height was 27.47 cm and the mean final height at the time of first harvest was 39.04 cm. However, the differences in height of plants were the result of sunlight availability. The plants on the shaded sides (Treatment 2) elongated in much greater rate than on the illuminated side. This differential growth response of the plant to light, was caused by the unequal distribution of auxin, the higher concentration of growth hormone (auxin) being on the shaded side (Devlin and Witham, 1983).

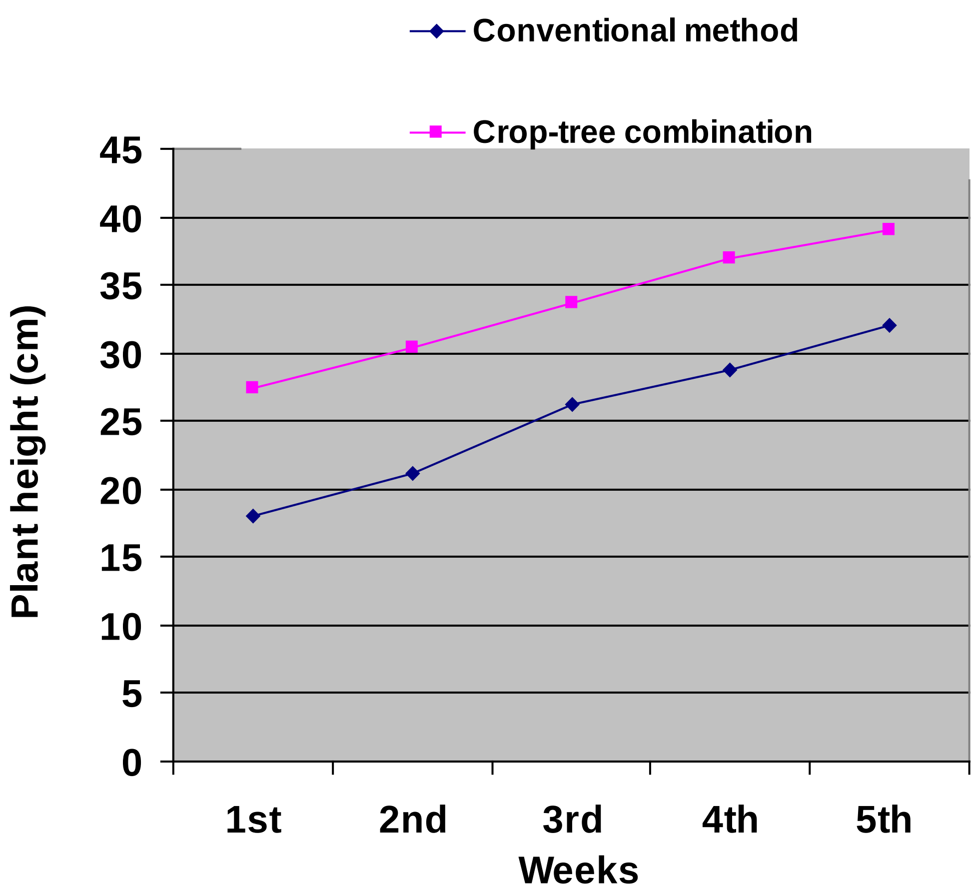

Figure 8. Weekly height increment (cm)

Return on Investment

Table 11 shows the return on investment (ROI) from conventional method and tree-crop combination. The sales of the bush bean produced by the tree-crop combination was considered organic and valued accordingly to the market price of organic beans.

Table 11. Return on investment (%)

TREATMENT	EXPENSES	SALES	ROI (%)
Conventional Method	639.5	693	8.37
Crop-Tree Combination	519.5	959	84.67

Bean = PhP 25/kg

16-16-16 = PhP 40/kg

Been seed = PhP 250/kg

Organic bean = PhP 31.5/kg

Compost = Php 100/bag

Trees (woody) and Non-woody Plant Species

The tree or woody (Fig. 9) and non-woody (Fig. 10) plant species in a tree-crop combination farm were identified and captured in a photograph.

Calliandra-
Calliandra calothyrsus Meissn.

Alumit (Hagimit)-
Ficus minahassae

Bottle brush tree-
Callistemon citrinus

Tibig-
Ficus nota (Blanco) Merr.

Guava –
Psidium guajava L.

Fire tree-
Delonix regia

Figure 9. Woody species found in the Tree-crop combination

Japanese summer grape fruit-
Citrus paradisi

Arabica Coffee-
Coffee arabica

Trumpet flower- *Brugmansia suavolens* (Humb. et Bompl.) Brecht et Presl

Pegion pea-
Cajanus cajan

Rattan-*Calamus merrillii* Becc.

Gmelina – *Gmelina arborea*

Fig. 9. Woody species found in the Tree-crop combination (continued)

Gumamela (Turk's cap)–
Malvaviscus arboreus

Tiesa
Pouteria campechiana (HBK.)

Santol -*Sandoricum koetjape*

Tawa tawa-*Ricinus communis* L.

Dapdap-*Erythrina variegata* Linn.
var. orientalis (Linn.)

Figure 9. Woody species found in the Tree-crop combination

Alternanthera-
Alternanthera sessilis

Carabao grass- *Axonopus compressus* (Sw.) P. Beauv.

Beray -*Bidens pilosa* L. var pilosa

Bandera de español-
Canna indica L.

Taro- *Colocasia esculenta*

Japanese weed-
Crassocephalum crepidioides

Figure 10. Non-woody species found in the Tree-crop combination (continued)

African star grass-
Cynodon nlemfuensis

Spanish drymaria-
Drymaria cordata (L.)

Small flower Galinsoga-
Galinsoga parviflora

Sweet potato-
Ipomea batatas L.

Napier grass-
Pennisetum purpureum Schumach.

Kangingit-
Polygonum perfoliatum L.

Figure 10. Non-woody species found in the Tree-crop combination (continued)

Taingang daga
Oxalis corniculata L.

Wild sunflower -
Tithonia diversifolia

Wild rose-*Rosa philippinensis*

Amti -*Solanum nigrum* L.

Sayote - *Sechium edule* L.

Banana-*Musa* sp.

Figure 10. Non-woody species found in the Tree-crop combination (continued)

Inventory of Insects

Both the beneficial insects and the insect pests from both conventional method area and the tree- crop- combination area were identified and shown in Table 12. It was found out that there was a balance in between the beneficial insects and the insect pests in the tree-crop combination, while in the conventional method there was only the presence of insect pest.

Table 12. List of insects found in the study areas

A. Insects identified from the conventional method	
1. *Leaf miner	*Liriomyza huidobrensis* (Blanchard)
2. *Pod borer	*Maruca vitrata* (Testulasis) (Geyer)
3. *Aphid	*Aphis craccivora*
4. *Cabbage Butterfly	*Pieres rapae* (L.)
5. *Leaf roller	*Sylepta derogate* (Fabricus)
6. *Vinegar fly	*Drosophila melanogaster*
7. *Tussock moth	*Dasychira* spp.

B. Insects identified from the tree-crop combination	
1. *Two spotted spider Mites	*Tetranychus* sp.
2. *Army worm	*Spodoptera litura* (Fabricius)
3. *Mealy bug	*Phenacoccus solani* (Ferris)
4. *Leaf miner	*Liriomyza huidobrensis* (Blanchard)
5. *Tussock moth	*Dasychira* spp.
6. *Pod borer	*Maruca vitrata* (Testulasis) (Geyer)
7. *Semi looper	*Anomis flava* (Fabricius)
8. ■ Ear wigs	*Euborellia annulata*
9. ■ Honey bee	*Apis mellifera*
10. *Legume weevil	*Callosobrochus maculates* (Fabricius)
11. ■ Two spotted coccinelid beetle	*Aphanocephalus bimaculatus*
12. ■ Soldier beetle	*Chauliognathus lugubris*
13. *Aphid	*Aphis craccivora*
14. ■ Jumping spider	*Sandalodes* spp.
15. ■ Wolf spider	*Hogna helluo*
16. ■ Mirid bug	*Stenodema laevigatum*
17. ■ Big eyed bug	*Geocoris punctipes*
18. ■ Tent spider	*Cryptophora cephalotes* (Simon)
19. *Mole cricket	*Gryllotalpa Africana* (Pal de Beauvres)

20. *Cabbage Butterfly	*Pieres rapae* (L.)
21. ■ Pygmy grass hopper	*Aeromachus pygmaeus*
22. ■ Spider ants	*Mallinella shimogianai*
23. *Plant hopper	*Siphanta acuta*
24. ■ Pirate bug	*Orius insidiosus*
25. *Vinegar fly	*Drosophila melanogaster*
26. ■ Long legged fly	*Condylostylus* spp.
27. ■ Brachonid wasp	*Allurus muricatus*
28. *Leaf roller	*Sylepta derogata* (Fabricius)

* = Insect Pest

■ = Beneficial insect

SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

The study was conducted at the Agroforestry Experimental Area, College of Agriculture, Benguet State University, La Trinidad, Benguet from December, 2008 to April, 2009 to compare the pest and disease incidence on the bush bean grown in conventional method (monoculture) and the bush bean grown in tree-crop, and non-crop combination (Agroforestry).

` Statistical analysis showed a significant difference in the disease and pest incidence among the treatments. The bush bean planted in conventional method showed considerably higher percentage of disease (bean rust, Fusarium wilt, and leaf curling) and pest (pod borer and leaf miner) incidence as compared to the bush bean planted with trees combined with the other non-crop plants.

In addition, results also revealed that non-marketable yield from the conventional method was significantly higher than the non-marketable yield from the plants grown with the trees and non-crop plants. However, the marketable and the total yield from both the treatments were not significantly different. Nevertheless, ROI from tree-crop combination was significantly higher compared to the ROI from the conventional method.

Conclusion

Based on the result, it is concluded that planting with trees and different plant species noticeably prevents the disease and pest incidence in the bush bean as compared to the conventional method.

Recommendation

Planting of bush bean in combination with trees and other different plant species is recommended to control the disease and pest occurrence in bush bean. However, studies to understand the contribution of different plant and animal species, and other physical components in controlling the pest and disease in a tree-crop combination are encouraged.

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