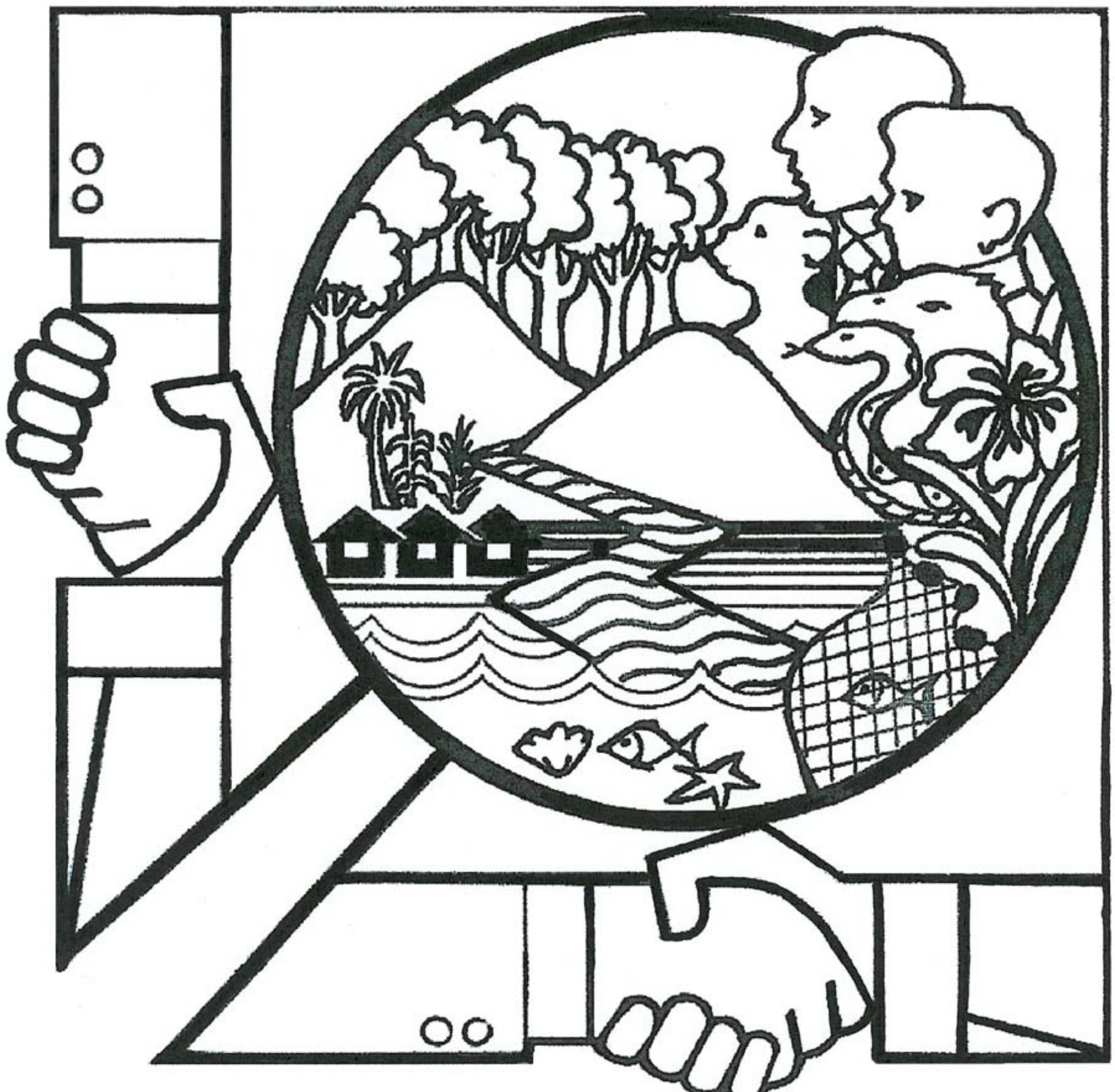
Conserving the Diversity of Selected Arthropods in Cabbage-Growing Areas in Mt. Malindang, Misamis Occidental through Participatory Integrated Pest Management



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SEAMEO SEARCA

In memory of
Dr. Stephen G. Reyes

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Biodiversity Research Programme (BRP) for Development in Mindanao:
Focus on Mt. Malindang and Environs

The Biodiversity Research Programme (BRP) for Development in Mindanao is a collaborative research programme on biodiversity management and conservation jointly undertaken by Filipino and Dutch researchers in Mt. Malindang and its environs, Misamis Occidental, Philippines. It is committed to undertake and promote participatory and interdisciplinary research that will promote sustainable use of biological resources, and effective decision-making on biodiversity conservation to improve livelihood and cultural opportunities.

BRP aims to make biodiversity research more responsive to real-life problems and development needs of the local communities, by introducing a new mode of knowledge generation for biodiversity management and conservation, and to strengthen capacity for biodiversity research and decision-making by empowering the local research partners and other local stakeholders.

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Abstract

This participatory action research was conducted to stop *kaingin* (swidden agriculture) at the Mount Malindang Range Natural Park (MMRNP) and minimize dependence of farmers on chemical fertilizers and pesticides. The latter was achieved by launching Integrated Pest Management (IPM) in cabbage production, which aimed to restore, improve, and maintain biodiversity and productivity of farms in the crater valleys of the two upland communities of Don Victorino, Misamis Occidental, namely, Gandawan and Lake Duminagat.

Farmers preferred planting cabbage and onion because of their high market demand and price. The first field trial showed the diamond back moth or DBM *(Plutella xylostella)* as the major cabbage pest. Minor pests were also identified—common cutworm *(Spodoptera litura)*, black cutworm *(Agrotis ypsilon)*, green peach aphid *(Myzus persicae)*, and otiorrhynchine weevil. Pests that attack onion were cutworms, onion maggot *(Liriomyza* sp*)* and thrips *(Thrips tabaci)*, while the aphid, *Aphis gossypii*, infested sweet pepper. Both IPM and farmers' plots had higher DBM populations under monoculture than in polycuture. Beneficial arthropods were greater in IPM plots than in the farmers' plots, being more diverse in Lake Duminagat; parasitism of DBM larvae and aphids was high in IPM plots but none in the farmers' plots. In the second field trial, agroforestry plots harbored more spiders than IPM plots. Farmers' plots along the slopes had much higher number of spiders because pesticide use was minimal in all plots.

In the first field trial, cabbage yields in IPM plots were comparable with those in the farmers' plots. In the second field trial, yield in the demo plot was highest, followed by the agroforestry and IPM plots. The lowest yields were obtained from farmers' plots. The yield difference was attributed mainly to supplemental use of chicken dung.

IPM plots generally obtained the highest net income due to low production cost in terms of minimal pesticide use. However, agroforestry plot had a higher return of investment (ROI) than IPM plots because of zero pest control. The farmer's plots had the highest production cost due to high cost of chemical inputs.

Better yields in the demo, agroforestry and IPM plots in the abandoned crater valley of Gandawan demonstrated that the area could still be made productive with proper IPM and crop management practices. Moreover, cabbage can be grown without pest management activities during the wet season as long as the farm has a diverse plant cover as refuge and source of food for beneficial arthropods.

The study visit benefited the participating farmers and agricultural technicians. The field days showed non-participants the benefits derived from various approaches to cabbage production, especially IPM and agroforestry.

Technologies and new practices like conserving beneficial organisms such as spiders, the bagging of cabbage seedlings for increased survival during transplanting, and the use of chicken dung as fertilizer supplement were recommended for adoption of upland farmers.

Introduction

Agricultural biodiversity encompasses the variety and variability of plants, animals and microorganisms at the genetic, species and ecosystem level which are necessary to sustain key functions in the agroecosystem (Cromwell 1999). Arthropods are the most diverse group of organisms in most ecosystems. In terms of species richness, they far exceed vascular plants and vertebrates while their biomass within natural ecosystems exceeds that of vertebrates (Lauenroth and Milchunas 1992; Wilson 1987). In agroecosystems, they include pests, parasites, predators and pollinators. Some species are good biological indicators of ecosystem changes. They readily respond to environmental stress such as habitat disturbance, pollution, and climate change (Hawksworth and Ritchie 1993).

Agriculture has a significant impact on biodiversity through a variety of mechanisms: as a political and economic instrument by means of commodity prices or subsidies; as a production technology using pesticides and fertilizers, which may lead to soil disturbance; and as a biological process, which results in habitat fragmentation and species invasions (Carroll 1990). The expansion of agriculture has transformed landscapes into mosaics of either managed or unmanaged ecosystems resulting in habitat loss and fragmentation for many species of flora and fauna. Modern commercial agriculture is dominated by monoculture, which has considerably reduced plant diversity and influenced the composition and abundance of associated biota, such as wildlife, pollinators, insect pests and their natural enemies, soil invertebrates, and microorganisms (Matson *et al.* 1997). Because a less diverse resource base is available, low genetic and species diversity of the crop results in less diversity at higher trophic levels such as herbivores and predators (Power and Flecker 1996).

Monoculture crops are consistently grown in the uplands of Mount Malindang. They are often more vulnerable to pests and diseases; thus, requiring higher inputs of pesticides and chemical fertilizers. Pesticides kill and injure a variety of non-target organisms such as wildlife, pollinators, natural enemies of pests and decomposer organisms. Meanwhile, chemical fertilizers can have significant impacts on the highly diverse community of soil microorganisms and invertebrates like arthropods that regulate nutrient cycling (Matson *et al.* 1997). Biodiversity loss has a range of negative ecological and societal consequences. It can have significant impacts on ecosystem function within agroecosystems and economic returns from the cropping system.

One of the most serious threats to the remaining biological resources of Mount Malindang and its environs is the continuous encroachment of upland communities along the mountain slopes. This eventually will extend to the forestlands.

The accelerated practice of *kaingin* (swidden agriculture), driven by poverty and lack of employment in lowland areas, unfortunately persists as a major causal factor that has contributed to the destruction of upland ecosystems. More often than not, the *kaingin* system promotes monoculture, which renders plant crops highly vulnerable to pests and diseases. Even resource-poor *kaingin* farmers used pesticides, which kill beneficial organisms. When soil fertility has declined, these farmers move somewhere else and clear new areas for crop production, or when possible, they apply chemical fertilizers to supply the nutrient requirements of crops. Unfortunately, such fertilizers can have negative effects on the diverse community of soil microorganisms and invertebrates, which play essential roles in nutrient cycling (Matson *et al.* 1997). Such biodiversity loss owing to excessive pesticide and fertilizer uses can result in a range of long-term negative ecological and societal consequences. These disturbances are aggravated by the cycle of *kaingin*. If left unabated, the remaining landscape of Mount Malindang will be transformed into utter waste as grasslands become prone to erosion and landslides, a total destruction of biodiversity habitats, and breakdown of upland ecosystems. While the government has addressed these serious threats to the survival of Mount Malindang by establishing it as a National Park under NIPAS Law RA 7567 (Cali *et al*. 2004), upland communities have continued to practice farming within the park, perhaps a reflection of the reality that countries with high rural population density, poverty and dependence on farming, will remain a challenge, if not a dangerous threat to biodiversity conservation (Scherr and McNeely 2003).

If biological resources are to be conserved or protected in the Mount Malindang Range Natural Park (MMRNP), strategies need to be developed with a clear-cut long-term goal of managing Mount Malindang's remaining biodiversity. Resident communities should participate in such efforts while allowing them to evolve farming systems that are sustainable and in harmony with biodiversity conservation.

Integrated pest management (IPM) is an effective and efficient approach to this goal. It attempts to promote sustainable, viable and profitable farm production. In the context of Mount Malindang farmers, IPM can be an incentive for them to contain their farmlands to the crater valleys in which they reside without having to encroach steep mountain slopes and forestland. If adopted in these seemingly infertile overutilized lands, IPM can promote the diversity of beneficial organisms needed to manage crop pests and diseases through minimal use of pesticides. Soil nutrient enrichment practices can go hand in hand with IPM in improving soil fertility and at the same time increasing habitats for beneficial organisms through diversified farming, green manuring, planting of border plants and selected fruit trees, ensuring the increase in biodiversity in these farms (Andow 1991). The enhancement and conservation of biodiversity within farms will in turn improve crop productivity (Matson *et al*. 1997; Power and Flecker 1996). In effect, IPM is a tool toward a larger picture of integrated farm management (IFM), which includes soil management, plant health, and diversification of plant cover (vegetation structure) within the farm.

The long-term goal will continue to be challenged by the degree of success of IPM in relation to IFM within the protected areas of MMRNP as a strategy to enhance and sustain biodiversity even in agricultural systems. The prospects remain promising, but will require the mutual trust and genuine participation of all stakeholders, including researchers, local government units (LGUs), upland communities, and the market sector. Other approaches will certainly increase the prospects of renewing the biodiversity of MMRNP.

Review of Literature

Biodiversity or natural habitat resources are dwindling because of urban and agricultural spread and commercial development (La Salle and Gauld 1992). The causes of natural resource degradation are rooted in a prevalent socioeconomic system which promotes monoculture, the use of high input technologies, and agricultural practices. Such degradation is not only an ecological process, but also a social and political-economic process (http://agroeco.org/doc/apply_agroeco_concepts.html).

Agroecosystems, Pesticides, and Biodiversity

In agroecosystems, pollinators, natural enemies of pests, earthworms, and soil microorganisms are all key biodiversity components that play important ecological roles. They mediate in processes such as genetic introgression, natural control, nutrient cycling, decomposition, etc. The type and abundance of biodiversity in agriculture will differ across agroecosystems in terms of age, diversity, community structure, and management. Generally, agroecosystems that are diverse, permanent, isolated, and managed with low input technology (i.e., agroforestry systems or traditional polycultures) are associated with higher biodiversity than highly simplified, input-driven and disturbed systems (i.e., modern row crops and vegetable monocultures) (Altieri 1995). Many agricultural practices have the potential to enhance biodiversity while others may negatively affect it.

Management of agroecosystems for high productivity often result in low plant species richness since only species with relatively high productivity are selected. Traditional agricultural systems tend to be significantly more diverse than conventional and commercial cropping systems. Compared to highly simplified systems such as monocultures, traditionally managed systems with high plant diversity appear to be better buffered against perturbations such as drought or pest epidemics (Power and Flecker 1996).

The diversity and abundance of beneficial organisms like parasitic and predatory insects in agroecosystems are often associated with natural or undisturbed environments. Some common representatives include predatory carabid beetles, ladybird beetles, staphylinid beetles, predatory bugs, lacewings, syrphid flies, ants, and parasitic wasps. These beneficial organisms prey on and reduce phytophagous pests. They can be highly effective at little or no cost, serving as biotic “insecticides” in place of chemicals and providing long-term control without the target pests developing significant resistance to them, and with minimal or no harm to humans or the environment (Wilson and Huffaker 1976).

Field margins/edges and proximity to natural habitats have also been linked to increases in biodiversity in agroecosystems. A study in Hungary found that near the edge of an orchard, the species richness and density of epigeic spiders were higher (Bogya and Marko 1999). Field edges potentially provide shelter and alternative food sources for natural enemies of pests.

One common traditional agricultural system in the Philippines is shifting cultivation (also known as swidden or slash-and-burn agriculture). In shifting cultivation systems, temporary forest clearings are planted with annual or short-lived annual crops for a few years and then allowed to remain fallow for a period longer than the cultivation period (NRC 1993).

While swidden plots can be quite diverse, plant species richness probably rarely approaches the richness of the surrounding forest. In many swidden systems, species richness increases dramatically from the initial stage dominated by annual crops. Hart (1980) and Ewel (1986) suggested that such systems may be designed as analogs of natural forest systems. They tend to mimic successional stages of the forest in structure and presumably in function. Studies of biodiversity in shifting cultivation systems suggest that these systems can support biodiversity.

However, the increase of people relying on shifting cultivation has also interrupted the impacts of shifting cultivation itself. In much of the humid tropics, fallows have shortened and the extent of clearing has increased dramatically. These trends have alarming implications on continued agricultural productivity of shifting cultivation systems and maintenance of biodiversity in the landscape as a whole.

Biodiversity of natural enemies in agroecosystems can also be substantially affected by the use of pesticides. The deleterious effects of pesticides are strongly suggested by the drastic decline of insect fauna on treated crops. Broad spectrum, non-selective pesticides are toxic to predaceous and parasitic arthropods (Bollag *et al*. 1992); thereby, decreasing their populations contributing to pest outbreak. This was experimentally shown by the DBM parasitoid, *Apanteles plutellae* using the chemical exclusion method (Lim *et al*. 1986). Different species of soil-inhabiting insects and predatory larvae are susceptible to many insecticides especially the more active species compared with the non-motile species. This condition leads to upsurges in populations of some pests after sustained insecticide use.

Many insecticides also affect aerial insects, including bees. Bees are extremely important, not only in providing honey, but also in pollination of crops. Likewise, overuse of pesticides leads to chemical resistance, secondary pest outbreaks, and environmental pollution (Rechcigl and Rechcigl 1999). Conservation of beneficial organisms includes modification of environmental factors that are adverse to them like habitat management. It is a type of environmental insect control that manipulates the ecosystem to make it less favorable to the pest and more favorable to the natural enemies, resulting in reduced pest levels (Mayse 1983). Habitat management is geared towards support of populations of natural enemies (Altieri 1983) through crop structure, protective refugia, occurrence of alternative prey/host, and supplementary food resources like nectar and pollen. Sources of food such as nectar and pollen are essential food of hymenopterans parasitoids. Cover crops may harbor pest species, but can also lead to increased numbers of insect natural enemies (Riechert and Bishop 1990).

Effects of Monocultures and Polycultures on Biodiversity

Monoculture, the planting of a single species of crop, is considered an extreme form of biodiversity simplification. This simplification influences the composition and abundance of the associated biota, such as wildlife, pollinators, insect pests and their natural enemies, soil invertebrates, and microorganisms (Matson *et al*. 1997). Monocultures, especially large scale ones, usually result in fewer but increased populations of specialist herbivores (Altieri and Letourneau 1982); thus, requiring higher inputs of pesticides. These pesticides kill and injure a variety of beneficial organisms.

Polycultures, on the other hand, support a lower herbivore population than monocultures. More stable natural enemy populations such as parasitic wasps that may suppress herbivores can persist in polycultures due to continuous availability of food sources and habitats resulting in higher populations of these beneficial organisms (Andow 1991). Moreover, polycultures may reduce herbivorous pests through "associational resistance" where the presence of a variety of plants disrupts orientation of specialist herbivores to their hosts. Several hypotheses lend support to the idea that polycultures encourage higher arthropod biodiversity (Altiere and Letourneau 1982).

1. **Heterogeneity hypothesis**. Complex crop habitats support more species than simple crop habitats: architecturally, more complex species of plants and heterogeneous plant associations with greater biomass, food resources, variety and temporal persistence have more associated species of insects than do architecturally simple crop plants or crop monoculture on an area-for-area basis.

2. **Predation hypothesis**. The increased abundance of predators and parasitoids in rich plant associations (Root 1973) reduce prey densities, at times to such low levels that competition among herbivores is reduced. This reduced competition allows the addition of more prey species, which in turn supports new natural enemies.

3. **Productivity hypothesis**. Research has shown that in some situations crop polycultures

yield more than monocultures. This greater productivity can result in greater insect diversity as the number of food resources available for herbivores and natural enemies increases.

4. **Stability and temporal resource-partitioning hypothesis**. This hypothesis assumes that primary production is more stable and predictable in polycultures than in monocultures. This stability of production, coupled with the spatial heterogeneity of complex crop fields, should allow insect species to partition the environment temporally as well as spatially; thereby, permitting the coexistence of more insect species.

Agroforestry and Biodiversity

Agroforestry, through the replenishment of soil fertility and the domestication of indigenous trees, has been proposed as one way of diversifying and intensifying agroecosystems in a way that is beneficial to the environment by maintaining and enhancing biodiversity (Leakey 1998).

Integrated Pest Management (IPM) as an Option

Few vegetable farmers in Asia integrate a wide range of control tactics for leafy vegetable pests. Many farmers rely solely on chemicals and apply them regularly ranging from two to three times per week (Guan-Soon 1990). Dosages applied basically achieve quick "knock-down" of insect pests.

Another prevalent practice is the use of pesticide "cocktails" where two chemicals are mixed believing that it would make the spray more potent. Magallona (1982) reported that about 50% of the farmers they interviewed in the Philippines used mixtures. Such widespread use of "cocktails" has also been reported to occur in Indonesia (Iman *et al*. 1986) and Thailand (Guan-Soon 1990). According to Guan-Soon (1990), the progressive development of pesticide resistance is the critical problem in vegetable cultivation in Asia. Closer examination revealed that pesticide resistance is the underlying cause in further increasing pesticide use. Farmers are subtly trapped into the cycle of pesticide dependency and constantly forced to seek more potent and effective pesticides. Eventually the "pesticide syndrome" manifests itself and becomes malignant (Doutt and Smithy 1971). The choice of integrated pest management, therefore, in dealing with the current problem of pesticide over-use on vegetables, is clearly the logical option (Guan-Soon 1990).

IPM is a pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible, and maintains pest populations at levels below those causing economically unacceptable damage or less (FAO 1965). It is an ecologically-based pest control strategy that relies heavily on natural mortality factors such as natural enemies of pests and weather, and seeks out control tactics that disrupt these factors as little as possible. Most importantly, IPM seeks to help farmers become better managers, incorporate natural processes into farming, and reduce off-farm inputs resulting in a more profitable and efficient production, and better human and environmental health (Van de Fliert 2002).

The New Paradigm of IPM: Ecological Principles and Decision-making Skills

Like other technologies, IPM has undergone an evolution in the course of time as a result of expressing of successes and failures in IPM programs. The new paradigm of IPM is unconventional with regard to both its technical contents and extension methodology. It introduced four principles rather than teaching sophisticated observation techniques, economic threshold levels (ETL), and a set of possible measures to be applied for control. The four principles are (Van de Fliert 2002):

1. Grow a healthy crop.
2. Conserve natural enemies.
3. Observe fields regularly.
4. Farmers become IPM experts.

The first two principles emphasize the importance of enhancing and maintaining naturally occurring ecological processes and defense mechanisms favoring crop production. Healthy crops can resist pest attack and compensate for incidental damage in a healthy ecosystem with plenty of natural enemies to defend against pest attack.

Regular observation is the main tool used to provide the information needed to make adequate decisions. With these IPM principles, farmers, rather than technologies, become the focal point in IPM programs with regard to both research and development of methodologies, and final field implementation. IPM has evolved into a problem-solving and decision-making strategy in which farmers are perceived as capable ecosystem managers and independent experts in their own fields (Van de Fliert 2002).

A second important aspect of the IPM paradigm shift is the changed perception towards the role of biological control in IPM (Kenmore *et al*. 1995). In the new paradigm, biological control is the core of IPM. It is already naturally existent in the field as long as people do not disturb but rather conserve and enhance the ecological balance.

Benefits of IPM

The benefits of implementing IPM include reduced chemical input costs, reduced on-farm and off-farm environment impacts, and more effective and sustainable pest management. IPM promotes agriculture based on broad ecological principles. Because it is ecology-based, it has the potential of decreasing inputs of fuel, machinery, and synthetic chemicals, which are energy intensive and increasingly costly in terms of financial and environmental impact. Such reductions will benefit the grower and society (Dufour 2001).

IPM enables farmers to make informed decisions to manage their crop. Successful IPM programs replace reliance on most spraying, including calendar spraying of pesticides. It builds on the knowledge of women and men farmers of crop, pest, and predator ecology to increase the use of pest-resistant varieties, beneficial insects, crop rotations, and improved soil management (IAC 2002).

The implementation of IPM has lead to sustainable production and better economic returns for the farmer. Early studies show that farmers use less pesticides, but spend more time in the field monitoring plant health. Higher net returns have been the result (IAC 2002).

Specifically, an IPM approach provides:

a. benefit to farmers in terms of reduced outlays and often increased yields;
b. benefit to governments, which can save on foreign exchange and reduce dependence on foreign supplies;
c. benefit to the environment;
d. more sustainable, knowledge-based agriculture; and
e. an increase in biodiversity.

Finally, IPM offers the best prospects for meeting the developing world's needs for better management in support of increased crop production. It also offers a sustainable future for intensive cropping systems, which currently rely on high levels of chemical inputs in the form of pesticides and fertilizers with their associated costs to consumers and the environment (CABI Bioscience 2002).

Rationale

Gandawan and Lake Duminagat, the two upland communities of Don Victoriano, Misamis Occidental are situated in crater valleys surrounded by steep forest mountains within the proclaimed protected area boundary of Mount Malindang Range Natural Park (MMRNP). These upland communities are important producers of vegetables and root crops supplying the needs of three provinces, namely, Misamis Occidental, Zamboanga del Sur, and Zamboanga del Norte.

Kaingin (shifting cultivation) has been generally practiced by upland farmers in the steep areas of the two communities. They abandoned the crater valleys due to low soil fertility and heavy infestation of insect pests and diseases. Kaingin is the major cause of deforestation of Mount Malindang.

Meanwhile, intensification of vegetable production has led to heavy reliance on high inputs of fertilizers and pesticides to obtain high yields and control pests. Diluted chemical fertilizers were applied weekly. Most of the insecticides target diamondback moths or DBM *(Plutella xylostella),* the major insect pest of cabbage. Farmers depend so much on insecticides without regard for natural enemies of the pests.

This unilateral approach often causes loss of biodiversity of natural enemies of pests, outbreak of secondary pests, development of resistance of pests to chemicals, and contamination of food and environment.

The upland farmers earn little as the cost of chemical fertilizers and pesticides take a significant proportion of their income. Pest avoidance by cultivating newly opened steep areas is a tactic usually employed by farmers who cannot afford to buy chemicals for pest control. They encroach, clear, and plant cabbage on patches of the protected primary forests. Farmers know that cabbage is prone to DBM infestation if they repeatedly plant in the same area. Thus, they move on to new fertile areas to avoid pests. This practice of shifting cultivation is environmentally destructive, unsustainable and causes deforestation, soil erosion, and loss of biodiversity.

Presently, IPM has been implemented in many countries including those in Asia to manage a few key pests on vegetables, including the DBM on crucifers (Guan-Soon 1990). Because of the immense benefits that IPM can provide, its implementation therefore is clearly the best option in dealing with the current pest problem of cabbage production in the upland communities of Mount Malindang. It is hoped that IPM can make vegetable farming, particularly of cabbage, sustainable, environment-friendly, and profitable in MMRNP.

Objectives

The project was implemented to minimize the adverse effects of swidden agriculture, arrest further encroachment of mountain slopes and remaining natural forests, and minimize heavy usage of chemical fertilizers and pesticides in vegetables, particularly, cabbage through the introduction and implementation of integrated pest management (IPM) in the crater valleys of the two upland barangays of Don Victoriano, Misamis Occidental.

With the aim of conserving beneficial arthropod biodiversity, this participatory research initiative was designed to demonstrate that IPM can promote sustainable vegetable production within the crater valleys of Gandawan and Lake Duminagat without the need to open up new surrounding steep areas through forest destruction.

Specifically, the project aimed to: (1) identify the most valuable vegetable in Mount Malindang; (2) document the existing indigenous technical knowledge and pest management strategies for vegetable pests; (3) demonstrate the effect of IPM versus the conventional method of pest control on the diversity of arthropods in cabbage; (4) train selected farmers and technicians in conducting IPM research; and (5) conduct an impact assessment of IPM with participating farmers and technicians.

Methodology

I. Research Activities

Study I.
Economic Value of Vegetable Crops in the Uplands of Mount Malindang

Focus group discussions, in-depth interviews, and a survey were conducted on September 19-22, 2003 to determine the most valuable vegetable crops in Mount Malindang and to find out if the focus on IPM in cabbage was in order. Questionnaires for the survey were pretested on September 8, 2003 in Don Victoriano, Misamis Occidental.

Farmers were asked to enumerate what crops they prefer to grow and why they opted to grow them. The results of this semi-structured interview established the rank of the vegetable crops according to preference, marketability, and profitability.

Basis for Ranking:
1. Not preferred/marketable/profitable
2. Less preferred/marketable/profitable
3. Preferred/marketable/profitable
4. More preferred/marketable/profitable
5. Most preferred/marketable/profitable

Study II.
Indigenous Knowledge and Pest Management Strategies for Vegetable Pests

This study was conducted to document the indigenous knowledge and pest management practices for vegetable pests of the upland farmers in Mount Malindang.

Data were collected through in-depth interviews with selected respondents from Study I who indicated that they used indigenous knowledge for vegetable production with emphasis on pest management practices. Their perceptions of pests and diseases were elicited through matrix ranking. Some of these indigenous pest control practices were tested in Study III to find out their efficacy in controlling cabbage pests.

Study III.
Conserving the Diversity of Arthropods in Cabbage-Growing Areas of Mount Malindang through Participatory Integrated Pest Management

Location and Description of the Field Experimental Sites

The research team, together with nine selected local partners and two agricultural technicians (ATs) in Gandawan and Lake Duminagat, Don Victoriano, Misamis Occidental, conducted a participatory action research (PAR). The experimental site was plain in Gandawan and moderately sloping in Lake Duminagat (11% slope), medium to coarse soil texture, pH of 4.9 to 5.5 and organic matter from 7.67% to 15.17%. Lime was applied at the rate of 200 gm/m^2.

A. First Trial / Dry Season (January-March 2004)

Statistical Procedure and Experimental Layout

Two factors were involved in the first trial. Factor A referred to pest management strategies (IPM and Farmers' Practice or FP). IPM utilized the agroecosystem analysis (AESA) as basis whether or not to control. Physical control, supplemented with the use of microbial pesticide (Bt-Halt), was employed when pest densities reached beyond the economic threshold level (ETL) for DBM. Physical control involved crushing of eggs, handpicking, and destroying of larvae and pupae. Plant extracts with pesticidal properties were used during the first two weeks of sampling. The use of plant extracts, however, was discontinued because of its unavailability and high cost when bought outside the locality.

Farmers' practice relied solely on the use of chemicals for pest control. The pesticides used by the farmers included Ascend for DBM control, Karate for cutworm, Parapest for aphids, and Cupravit for disease control. These pesticides were mixed together forming a pesticide cocktail. Detergent powder (Tide Ultra) was added to the mixture, which acted as a sticker. Factor B referred to cropping pattern, which included cabbage monoculture and polyculture A (cabbage + sweet pepper + onion = CSPO) and polyculture B (cabbage + tomato + onion = CTO).

The first trial design was 2 x 3 factorials in randomized complete block design (RCBD) with six treatment combinations in three replications. Each plot measured 6 x 4.5 m^2 consisting of six rows with 15 plants per row. Crop arrangement varied for each treatment. Cabbage monoculture consisted of six rows of cabbage. Polyculture plots consisted of three rows of cabbage plus two rows of tomato and one row of onion. The distance between rows was 75 cm, but distance between hills varied depending on the kind of crop. Data were analyzed using ANOVA (RCB with data from plot sampling) (Gomez and Gomez 1984). Levels of significance were tested using Duncan's Multiple Range Test (DMRT).

Treatment combinations included the following:
T1 – IPM + cabbage monoculture
T2 – FP + cabbage monoculture
T3 – IPM + polyculture A (CSPO)
T4 – FP + polyculture A (CSPO)
T5 – IPM + polyculture B (CTO)
T6 – FP + polyculture B (CTO)

Cultural Management and Practices

Seeds were sown individually in rolled, small bags of banana leaves that contained mixed garden soil and chicken manure (10:1 ratio). Bagging increased seed germination and field survival during transplanting. Green onion suckers were planted in the field. Row distance of sweet pepper, tomato and cabbage was 40 cm while green onion was 30 cm. Seedlings were enclosed in mesh nylon cloth to prevent infestation of insect pests and diseases. Seedlings were transplanted one month after sowing.

Basal fertilizer application of 14-14-14 was done for cabbage, sweet pepper and tomato 10 grams/seedling plus a handful of chicken dung during transplanting. Onions were fertilized 5 grams/seedling. Side dressing was applied one month after transplanting using the same amounts. Furrows were set at 75 cm apart from each other, but distance between hills varied for each crop. Green onion was directly planted in the field using one sucker per hill.

The conventional plot (farmers' plot) followed the farmers' usual practice of controlling pests through chemicals. IPM technology utilized the agroecosystem analysis (AESA) approach involving weekly monitoring of populations of pests and natural enemies by the local partners and the research team. Collected data were processed and analyzed. Decisions to control were based on the established economic threshold level (ETL) for DBM in cabbage (Morallo-Rejesus *et al*. 1996). The ETLs are two larvae/plant at seedling to mid-vegetative stage [1-4 weeks after transplanting (WAT)] and five larvae/plant at vegetative to heading stage (5-10 WAT). Egg masses, larvae, and pupae were handpicked and destroyed to control DBM when populations exceeded the ETL, supplemented with the application of *Bacillus thuringiensis* (Halt), a microbial pesticide.

One local pest control practice was tested in Study III to assess its effectiveness in controlling cabbage pests. Extracts of one kilogram of *Derris elliptica, Nicotiana tabacum,* and *Capsicum annuum* were mixed with 16 liters of water and sprayed to IPM plots for DBM control two to three weeks after transplanting. This technique was tried based on the result of a survey (Study II), which showed this practice of controlling DBM. However, application of these botanical pesticides was discontinued because it failed to control older larvae of DBM and cutworm. Moreover, these plants were not readily available in Mount Malindang and expensive when bought outside the locality.

Assessment of Arthropod Biodiversity

Arthropod populations were assessed to find out the effects of two pest management practices (IPM vs. FP) when grown under two cropping systems (monoculture vs. polyculture). Weekly assessments of arthropods were done using sweep net and visual counting. Twenty sweeps were made for each treatment. Specimens collected were placed in plastic containers with 80% ethyl alcohol. They were sorted, identified, and counted in the laboratory. Unidentified specimens were sent to the University of the Philippines Los Baños (UPLB) for identification purposes. For visual counting, 10 plants per plot were chosen randomly at the center row of each plot. Arthropods found in various parts of the chosen plants were counted and recorded.

Agroecosystem analysis (AESA) was the method used in determining the appropriate time to make pest management decisions in relation to the different growth stages of the crops. Data taken from visual sampling of various arthropods were tabulated, analyzed, and interpreted. Data interpretation was greatly facilitated by drawings of the different growth stages of the crops made by the local partners and their wives. Based on weekly samplings, decisions were recorded by the local partners in their respective IPM/PAR guide. Data gathered were analyzed using ANOVA for factorial randomized complete black design (RCBD) and (DMRT) for comparing treatment means (Gomez and Gomez 1984).

B. Second Trial / Wet Season (September-November 2004)

The second field trial in Gandawan consisted of three treatments, which included:
T1 - Farmers' plots (FPs)
T2 - IPM plots
T3 - Agroforestry plots (AFs)

The first two treatments were replicated four times while treatment 3 was replicated only twice due to unavailability of area. Treatment 1 consisted of farmers' plots cultivated by the local partners in separate areas using chemical fertilizer and pesticides. Farmers' plots were located on moderately to highly steep, newly opened slopes where organic matter was high.

Treatment 2 referred to IPM plots, which used chemical fertilizers based on the recommended rate for cabbage obtained through soil analysis by the Department of Soils, UP Los Baños, College, Laguna. Mustard and pechay seedlings were transplanted around the IPM plots, which served as trap crops for DBM. The IPM plots were situated in the crater valley of Gandawan where soil organic matter was low.

Treatment 3 included agroforestry plots located in the crater valley with low soil organic matter. Chemical fertilizers were applied with undetermined amount of chicken dung. These plots were designated previously as demonstration plots supposedly to showcase the effect of chicken dung to supplement the commercial fertilizers. However, they were changed to agroforestry plots based on the recommendations of Dr. Arnulfo G. Garcia of SEARCA. Marcotted citrus plants and *Arachis pentoi* served as intercrop, while *Desmodium heterocarpum* and *Wedelia biflora* served as border plants.

Agroforestry plots (AFs) served as a showcase of habitat management, which aimed to support populations of natural enemies of pests through protective refugia and supplementary resources like nectar and pollen, which are sources of food for parasitoids. Leguminous weeds (*A. pintoi* and *D. heterocarpum*) were expected to improve the soil condition of the plot; the flowering weed (*W. biflora*) as an attractant of syrphid flies, which are predators of aphids; and citrus marcotted plants were interplanted as spiders' refugia. Treatments were arranged in complete randomized design (CRD).

A demonstration plot was set up in the crater valley with low soil organic matter to showcase the effect of commercial fertilizer supplemented with 350 grams of chicken manure per plant on the yield of cabbage.

Plots measuring 15 m x 20 m were plowed and harrowed thoroughly. Furrows were set at a distance of 75 cm while cabbage seedlings were planted at 40 cm between hills. The recommended amounts of fertilizers based on the soil analysis provided by the Department of Soils, UPLB were generally followed: Ammonium phosphate (10 grams/plant) was applied on Plot 1, 20 g/plant for Plot 2, and 15 g/plant of complete fertilizer (14-14-14) for Plots 3-6. Urea (46-0-0) was applied as a side dressing at the rate of 20 g/plant for Plot 1 and 25 g/plant for Plots 2-6 one month after transplanting. Farmers applied commercial fertilizers 6-8 times during the entire growth of cabbage plants in their plots. Other practices like care and maintenance of seedlings, and weekly sampling of arthropods were implemented similar to the first trial set-up. Collected specimens were preserved and sent to Dr. Stephen G. Reyes and Ms. Aimee Lynne Barrion for identification. Data were analyzed using ANOVA (CRD with Unequal Replication) and DMRT for comparing treatment means.

Hypotheses

Root (1973) proposed that relatively more stable populations of parasites and predators can persist in habitats with complex vegetation (e.g., crop polycultures) due to the continuous availability of food resources (hosts or prey, nectar, and pollen) and refugia. In view of this hypothesis, it is assumed that in cabbage polycultures, there will be high populations of beneficial arthropods, but lower pest populations compared with cabbage monoculture. Moreover, beneficial arthropods will be conserved in IPM plots while they will be decimated in the conventional ones because of frequent pesticide application.

Study IV. Impact Assessment of Integrated Pest Management on Cabbage-Growing Farmers and Technicians in the Uplands of Mount Malindang

This study was conducted to determine the impact of IPM on 19 participants comprised of local partners, their wives, and two technicians who were involved in the conduct of the field trials. An interview schedule was designed to determine changes in their level of knowledge and degree of agreement and satisfaction on IPM. Data were subjected to statistical analysis.

The local partners, together with their wives, actively conducted the activities of the two field trials. There were also instances when men sent their wives to work on their behalf because of other pressing concerns that needed attention. It was therefore necessary to treat the wives as equal partners and recognized their vital role in this project.

An analytical framework was used to show four related components – inputs, throughputs, outputs, and impact. The inputs refer to the tools and guidelines for integrated impact management. Throughputs are the learning resources like the field/experimental plots, the farmers' plots, study visits and training programs. Outputs include required capabilities and learning of the participants after the throughputs. These outputs are participants' level of awareness, knowledge, and attitude about integrated pest management (IPM) and their sharing of knowledge and skills about IPM. The long-term impact will be biodiversity conservation of arthropods in the upland cabbage-growing areas.

II. Support Activities

Pre-implementation Activities

Orientations conducted on August 18, 2003 in Don Victoriano, Misamis Occidental and on August 25, 2003 in Barangays Mansawan, Gandawan, and Lake Duminagat were designed to inform the stakeholders including local government officials and employees, farmers, and local partners about the project.

Study Visit

A study visit was undertaken to expose the research team and eight male local partners of the project to various places in Mindanao. The farmers were exposed to different technologies used by farmers in other localities, recent developments in research stations, and activities implemented by state universities and colleges (SUCs) and extension organizations. Their levels of awareness and knowledge about IPM and related practices before and after the study visit were assessed using a structured interview schedule.

Training on Pest Identification and Sampling Methods

Local participants of the project and their wives were trained to identify and recognize common insect pests including their life stages and natural enemies. They were also trained how to perform sampling methods for weekly monitoring.

Field Days

Farmers' field days were held on March 30, 2004 in Lake Duminagat and in Gandawan on November 30, 2004 before cabbage was harvested from the experimental plots. The field days provided learning opportunities for non-participating local government officials and farmers of the three upland barangays of Don Victoriano, Misamis Occidental. They also learned about sustainable farming technologies like IPM.

Trip to Baguio

The trip to Baguio was primarily undertaken to acquire the DBM parasitoid, *Diadegma* *semiclausum,* from Benguet State University in La Trinidad, Benguet for possible mass production and mass release in Gandawan, Don Victoriano, Misamis Occidental. Dr. Victor P. Gapud, a member of the BRP-Philippine Working Group, recommended the trip.

Post-implementation Activities

Meetings were held separately for Mansawan, Gandawan and Lake Duminagat cluster groups on February 26, 2005 to present to the upland communities relevant findings of the project for validation purposes.

Results and Discussion

I. Research Activities

Study I.
Economic Value of Vegetable Crops in the Uplands of Mount Malindang

There were 74 respondents in the three upland communities of Don Victoriano, Misamis Occidental. These uplands communities were Mansawan, Gandawan, and Lake Duminagat. Majority of the respondents came from Mansawan (48.6%), followed by Gandawan (29.7%), and Lake Duminagat (21.6%).

Vegetables are important sources of income for upland farmers. Table 1 shows the most valuable vegetable crops based on respondents' preference, marketability, and profitability. These vegetables were cabbage (*B. oleracea* var. *capitata*), Chinese cabbage (*B. oleracea* var. *botrytis*), onion (*Allium cepa*), sweet pepper (*Capsicum annuum*), and chayote (*Sechium edule*).

Cabbage was the most preferred vegetable because of its high economic return, great market demand, and ease of production provided by the favorable climate in Mount Malindang. Next to cabbage was onion because it is easy to grow, requires less labor, offers high economic returns, and has a high market demand. Onion was found to be the most marketable crop followed by cabbage, sweet pepper, and chayote. However, chayote was the most profitable among the four vegetable crops because it does not need any fertilizer or pesticide. The crop thrives well even with minimal care and labor. Other preferred crops included Baguio beans, potatoes, pechay, and root crops.

Results further showed that respondents from the three communities had different preferences for vegetables to be grown. Majority of the respondents from Mansawan and Gandawan preferred onion over cabbage while those from Lake Duminagat preferred cabbage to onion. Previous BRP study showed that there was a higher infestation of the diamondback moth (DBM), *Plutella xylostella*, in cabbage farms in Mansawan and Gandawan than in Lake Duminagat. Spiders fed on DBM in cabbage farms in Lake Duminagat; thus, decreasing pests. The presence of primary forests was the major reason why spiders were abundant in Lake Duminagat. Forests can serve as refuge for spiders in times of adversities (Sabado *et al.* 2004). Thus, farmers in Mansawan and Gandawan preferred leafy onions to cabbage to avoid losses due to DBM infestation.

Even if cabbage was the most preferred crop, statistical analysis using the T-test revealed that there were no significant differences in terms of preference. Most farmers depended on the selling of chayote and leafy onion. Chayote was harvested weekly while leafy onion was harvested every month. The extra money the farmers earned from selling onion was used to finance cabbage production.

Cabbage was considered the main cash crop.

Table 1. Major vegetables in the three upland communities of Don Victoriano, Misamis Occidental based on preference, marketability, and profitability. October 2003.

Crop	Criteria		
	Preference	Marketability	Profitability
Cabbage	4.16a	3.83a	3.93a
Onion	3.9ab	3.90a	3.70a
Chayote	3.80bc	3.23b	3.96a
Sweet pepper	3.58c	3.66c	3.60b

In a column, means followed by a common letter are not significantly different by T-test.

Selling cabbage could make farmers earn as much as PHP80,000.00 for every 50-gram can of seeds. The money they earned from selling cabbage was spent on improving their quality of life with new clothes and house fixtures, education of their children, and other miscellaneous items. Because of these incentives in spite of the risks involved like erratic market price and pest infestation by the DBM (Cali *et al*. 2004; Sabado *et al*. 2004), cabbage will always be grown in the upland communities of Mount Malindang. The survey actually validated the thrust of the project on cabbage since it is the only crop among the valuable vegetables grown in Mount Malindang whose production is greatly constrained by pest infestation.

Study II. Indigenous Knowledge and Pest Management Strategies for Vegetable Pests

Cabbage production at Mount Malindang is synonymous with chemical fertilizers and pesticides because of the ravage caused by the DBM (Cali *et al*. 2004; Sabado *et al*. 2004).

Cabbage is not an indigenous crop at Mount Malindang. Mr. Mark Levin, an American, gave different vegetable seeds in 1987 to Pedro Mali, a Subanen native of Lake Duminagat in Dipolog City. Levin instructed Mali to plant the seeds. Among the different vegetable seeds given by Levin, only cabbage thrived and grew well in Lake Duminagat.

Cabbage was cultivated first by Sergeant Laruza in Gandawan. He used to plant cabbage when he was previously assigned in Cagayan de Oro City. After him, Mr. Narciso Ruiz, the former barangay captain, planted cabbage upon seeing that the crop adapted well in the barangay.

Other crops introduced in the uplands of Mount Malindang include onion, *kanaka* (root crop), and abaca. Abaca production was stopped because of Alcuerez disease, which cause stunting and yellowing of the leaves.

The knowledge, attitudes, and practices of farmers in Mansawan, Gandawan and Lake Duminagat about cabbage production are listed as follows:

A. **Land preparation**
1. Trowel is used to prepare the steep areas.
2. The whole family is involved in the process.
3. The least planting area for cabbage is *tag-isa/napulo ka dupa* (15 x 15 m^2).

B. **Planting materials**
1. Cabbage seeds are directly sown in seedbeds.
2. Seedbeds are covered with mosquito nets for protection against pests.
3. Most farmers plant one tablespoon of cabbage seeds with an approximate germination of 40-50% (1200- 1500 seedlings); enough for *tag-isa* (15 x 15 m^2).

C. **Transplanting**
1. Seedlings are uprooted by hand and transplanted directly to the field.
2. Distance between cabbage plants ranges from 7 to 24 inches with a mean of 12.95 inches.
3. Distance between rows of cabbage ranges from 12 to 24 inches with a mean of 13.48 inches.

D. **Fertilizer application**
1. Fertilizer is applied weekly after transplanting and 78 times during the entire growth of cabbage.
2. One *pignit* (pinch) of fertilizer is applied to each plant.
3. One-half kilogram of fertilizer is dissolved in four liters of water (if the farmer wants to dilute it with water).
4. Fifty grams of “liquid” fertilizer is applied per plant using a *tinapa* (sardine) can.
5. Standard rate of diluted fertilizer is ½ sardine can/plant.

E. **Commercial pesticides**
1. Commercial pesticides are often used to control pests.
2. Some farmers buy pesticides by the cap of the bottle because they do not have enough money and do not want to store pesticides at home.
3. Two caps of pesticides are mixed with water in one full tank of sprayer.
4. Ascend is used for DBM control, Karate for cutworm, Parapest and Bushwhack for aphids, and Cupravit for blight disease.
5. Pesticides (pesticide cocktail) are often mixed with detergent powder (Tide Ultra), which acts as sticker.

F. **Botanical pesticides**

1. Fruits of hot pepper are pounded and the juice extract is mixed with water. This is used as pesticide against DBM.
2. Sixty liters of water mixed with juice extracted from hot pepper (filling up one coconut shell) is believed to be effective.
3. One kilogram of each - *tubli* (*Derris elliptica*) roots, tobacco (*Nicotiana* tabacum) leaves, and hot pepper (*Capsicum annuum*) - are grounded and mixed with water in a 20-liter sprayer. This mixture is sprayed on cabbage.
4. Leaves of madre de cacao (*Gliricidia sepium*) are grounded and mixed with tubli, tobacco, and hot pepper for a stronger pesticide.
5. Leaves of hagonoy (*Chromolaena odorata*) and gabon/sambong (*Blumea balsimefera*) are pounded and mixed with water.
6. Tubli roots are pounded and mixed with detergent powder (Breeze or Tide), grated in a pail half-filled with water.
7. Grated coconut meat is spread or scattered on farm lots to attract cutworms (*Spodoptera litura*) which will then be attacked by predatory ants.
8. Farmers do not grow *tubli*. They rarely use this as botanical pesticide.

G. **Insects**

1. **Beliefs**

a. Spiders kill insect pests so they are useful.
b. Many spiders live in trees. Hence, so it is good to grow cabbage beside the forest.
c. *Lapinig* (vespid wasps) are useful because they eat worms like DBM. However, they are also harmful because they attack sweet pepper.
d. DBM and cutworm are harmful, but can be killed by pesticides.

2. **Local names**

a. DBM is called *bitay-bitay* (to hang). The *ulod* (larva) hangs itself to the plant as a protective mechanism when it is disturbed.
b. Cutworm is called *utlob* (to cut). It destroys the plant by cutting the leaves.
c. Cabbage worm is called *tapok-tapok* (to come together). The larvae aggregate together to feed on the leaves.
d. Cabbage looper is called *dangaw-dangaw* (a unit of measurement equivalent to about eight inches). The larva moves in looping motion.

H. **Weeding**

1. Weeding is a family activity.
2. Farmers weed before the cabbage plant starts head formation to prevent damaging the lateral roots, which may result to production of very small heads.

I. **Harvesting**

1. *Tawas* (alum) is applied on cabbage receptacles to prevent disease infestation during handling and transportion to market.
2. Small heads of cabbage, which weigh from 400 to 500 g, are preferred by consumers. Farmers do not like to produce cabbage weighing beyond 500 g.
3. The stem of the cabbage plant is twisted slightly to prevent cracking of heads. Cracking is a sign of over maturity.

Results of this survey showed that upland farmers did not know about cabbage production including pest management since it was an indigenous crop. After some time, what they know about cabbage production was a result of cumulative experiences, through communication channels such as radio and interaction from middlemen who conduct business in various cities of Mindanao.

Pest control was mainly through the use of pesticides. Pesticides were available in Mansawan, the trading center of vegetables. The price of pesticides was lower in Mansawan than in Ozamiz City, Misamis Occidental and Pagadian City, Zamboanga del Sur based on actual canvas.

Farmers did not regularly use botanical pesticides because they were not readily available. The botanical pesticides were also more expensive than commercial pesticides. The only farmer who claimed to use tubli, tobacco, and hot pepper to control pests was Mr. Sonito Mangue who was the local guide in the BRP first generation research in 2004.

STUDY III.
Conserving the Diversity of Arthropods in Cabbage-Growing Areas of Mount Malindang through Participatory Integrated Pest Management

Arthropods Associated with Vegetables

Three classes of arthropods were found in the area planted with cabbage in Mount Malindang. They belong to Class Crustacea (sowbugs), Arachnida (spiders), and Insecta (insects). Majority of these arthropods were insects, which belong to 11 orders and 62 families. They were classified as phytophagous, parasitic, predatory, and neutral species.

First Trial / Dry Season (January-March 2004)

Phytophagous Insects

The phytophagous pests of cabbage included leafminers, *Liriomyza* sp.; diamondback moth; cutworms, *Spodoptera litura* and *Agrotis ypsilon*; aphids, *Lipaphis* sp.; and otiorrhynchine weevil. Cutworms, onion fly, and thrips (*Thrips tabaci*) infested onion while *Aphis gossypii* and unidentified maggots attacked sweet pepper. Few eggs of *Helicoverpa armigera* were laid on the leaves of the tomato, but these did not cause any damage on the tomato fruits.

DBM Population

The DBM was the major insect pest attacking cabbage from the first week of transplanting until maturity. Generally, there were more DBM in cabbage farms in Gandawan than in Lake Duminagat. Another cabbage farm with high DBM infestation near the experimental plots of Gandawan was the likely source of the pests. In Lake Duminagat, the experimental site was mainly surrounded by various weeds without any source of infestation. This result supports the hypothesis that cabbage can be spared from serious DBM infestation when grown in areas without any probable source of infestation. Likewise, results also explain why cabbage farmers in Mount Malindang did not plant in areas with neighboring cabbage crops. They usually avoid DBM infestation by planting cabbage in newly cultivated areas.

DBM larval populations were generally high in cabbage monoculture than in polyculture in Gandawan (Figure 1) and Lake Duminagat (Figure 2) for eight sampling periods. This observation supports the report of Altieri and Letourneau (1982) that monoculture results in fewer but increased populations of specialist as exemplified by the DBM in this study. Analysis of variance (ANOVA) showed that the number of DBM larvae and pupae on the third and fourth sampling dates were significantly higher in IPM plots than in farmers' plots. DBM larval populations in IPM polyculture where cabbage was grown with tomato and onion was basically lower compared with cabbage grown together with sweet pepper and onion. Tomato, when intercropped with cabbage, reduces pests because of its chemical repellent mechanisms. Solanine and alpha-tomatine are the two main toxins present in tomatoes (Sullivan 2003).

In spite of high larval DBM populations, cabbage yield was not significantly affected. The IPM agroecosystem analysis (AESA) approach enabled the team and the local partners to manage the pest effectively. Likewise, weekly monitoring of the pests and their natural enemies reduced the frequency of pesticide applications in the IPM plots in Lake Duminagat.

Pesticides were sprayed weekly to control DBM populations in the farmers' plots. The farmers used a pesticide cocktail - a mixture of Ascend, Karate, Parapest, Cupravit, and detergent powder (as sticker). According to Magallona (1982), Iman *et al*. (1986), and Guan-Soon (1990), this "pesticide cocktail" is a widespread practice in the Philippines, Indonesia, and Thailand.

Population of Beneficial Arthropods

Examples of predatory arthropods were anthocorid bugs, assassin bugs, ladybird beetles, ants, syrphid flies, robber flies, and spiders. Spiders were the dominant insects. The identified parasitoids were *Diadegma* sp., *Bracon* sp., *Aphidius* sp., and *Gronotoma* sp.

Results showed that beneficial arthropods were less diverse in Gandawan than in Lake Duminagat. The diversity of vegetation within and around the agroecosystem can affect the degree of biodiversity. The diversity of weeds surrounding the experimental site in Lake Duminagat probably contributed to the diversity of beneficial arthropods found both in IPM plots

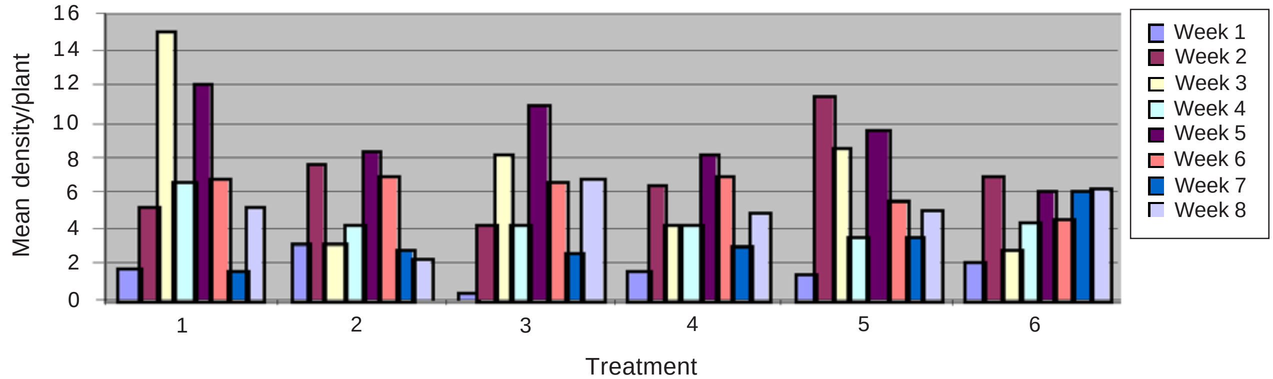

Figure 1. Mean density of DBM larvae / plant on cabbage. 1st trial. Gandawan, Don Victoriano, Misamis Occidental. January-March 2004.

and farmers' plots in Lake Duminagat (Altieri 1984). According to Bogya and Marko (1999), field margins/edges and proximity to natural habitats increase the biodiversity in agroecosystems by providing shelter and alternative food sources for natural enemies of pests.

The populations of beneficial arthropods were higher in IPM plots than in farmers' plots in Gandawan, clearly indicating that pesticides affected the beneficial arthropods in Gandawan due to the weekly spraying for DBM control than in Lake Duminagat. Pesticides are known to be toxic to predaceous and parasitic arthropods (Bollag *et al*. 1992). The absence of *Aphidius* sp. on farmers' plots further supports the claim about the harmful effects of pesticides on natural enemies. The percent parasitism of the aphids, *Lipaphis* by the parasitoid, *Aphidius,* ranged from 1.78 to 6.42% in IPM plots, but zero in farmers' plots. Parasitized aphids became mummified and turned silver brown. Populations of spiders, likewise, were higher in IPM than in farmers' plots. IPM, therefore, conserved beneficial arthropods while pesticides decimated them.

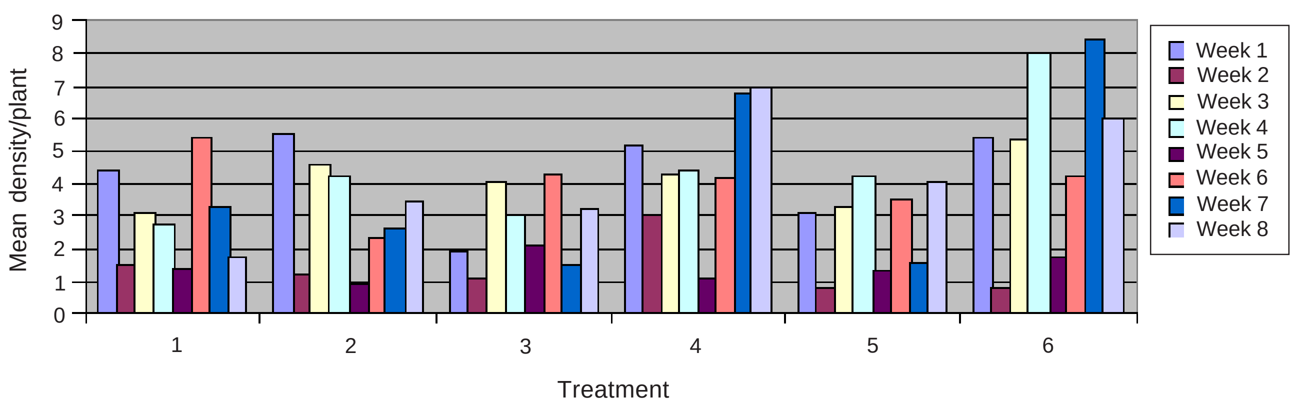

Figure 2. Mean density of DBM larvae / plant on cabbage. 1st trial. Lake Duminagat, Don Victoriano, Misamis Occidental. January-March 2004.

Vegetable Yields

Figure 3 shows the yields in IPM and farmers' plots were comparable, although the return on investments (ROI) was higher in IPM plots. Pesticides greatly accounted for the high production cost in farmers' plots. In polyculture plots, cabbage grown with onion and sweet pepper had higher ROI than those grown with onion and tomato, primarily due to higher market price of sweet pepper (Table 2).

Results of the first trial showed that the diversity of beneficial arthropods in Mount Malindang could be enhanced through the practice of cabbage polyculture. It has been shown that cabbage and sweet pepper combination is more appropriate due to high economic return, but the latter should be planted ahead of cabbage due to its delayed growth and development under Mount Malindang conditions. Tomato intercropped with cabbage decreased DBM population, but developed fruits were adversely affected by strong winds that always prevailed in the crater valleys of Mount Malindang. Cabbage and onion were both infested by *Liriomyza* spp. Hence, they should not be grown together.

Second Trial / Wet Season (September-November 2004)

Phytophagous Insects

Cabbage pests included leafminers, common cutworm, black cutworm, aphids, DBM, cabbage worm (*C. pavonana*), cabbage looper (*Trichoplusia ni*), leaf feeding beetles, (*Aulacophora indica*), and otiorrhynchine weevil.

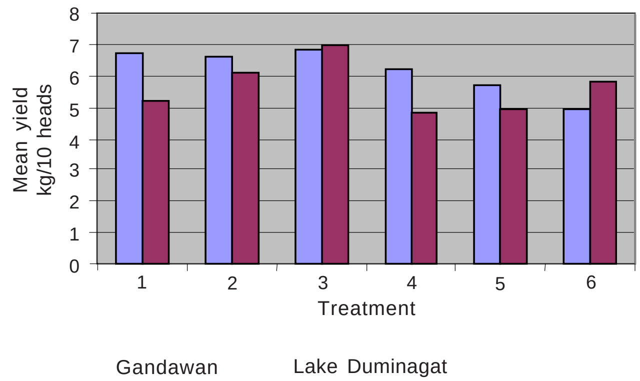

Figure 3. Mean yield of cabbage (kg / 10 heads). 1st trial. Gandawan and Lake Duminagat, Don Victoriano, Misamis Occidental. March 2004.

DBM infestation was minimal because of constant rains. Instead, black cutworms, aphids, and cabbage worms caused more problems than DBM during the rainy season.

DBM Population

Generally, DBM populations were low during heavy and constant rains (Table 3). Consequently, farmers reduced the use of pesticide from weekly applications to just two times during the entire growth of cabbage. Pesticides were only sprayed to control the cutworms and aphids. IPM plots were sprayed once with Karate immediately after transplanting to control black cutworms, which devoured most of the mustard and pechay plants planted ahead of cabbage for trapping DBM. The mass release of *Diadegma* sp. was most beneficial during the dry season when DBM populations tend to

Table 2. Mean yield of cabbage (kgs / head). 1st cropping. Gandawan and Lake Duminagat, Don Victoriano, Misamis Occidental.

Treatment	Mean yield (kgs / 10 heads)	
	Gandawan	Lake Duminagat
1	6.70a	5.20cd
2	6.60a	6.10b
3	6.80a	7.00a
4	6.20ab	4.80d
5	5.70b	4.90d
6	4.90b	5.80bc

In a column, means followed by a common letter are not significantly different by T-test.

Table 3. Cost of inputs, yield, and income of cabbage. 1st trial. Gandawan and Lake Duminagat, Don Victoriano, Misamis Occidental. March 2004.

GANDAWAN									
Treatment	Yield (kg)	Ave. Price/kg	Gross Income	Production Cost				Net Income	ROI (%)
				Fertilizer	Pest Control	No. of spray	Total		
T1	60.30	5.00	301.5	50.48	126.00	7X	176.48	125.02	70.84
T2	60.12	5.00	300.6	50.48	175.00	7X	225.48	75.12	33.26
T3	30.78	5.00							
	8.795	10.00							
	1.013	10.00	251.99	47.12	63.00	7X	110.12	141.87	128.8
T4	28.12	5.00			87.90				
	12.565	10.00							
	1.10	10.00	277.15	47.12		7X	135.02	142.13	105.3
T5	25.74	5.00			63.00				
	14.15	10.00						99.92	
	1.06	10.00	210.04	47.12		7X	110.12		90.7
T6	22.41	5.00							
	14.42	10.00							
	1.5	10.00	198.79	47.12	87.90	7X	135.02	63.77	47.2

LAKE DUMINAGAT									
Treatment	Yield (kg)	Ave. Price/kg	Gross Income	Production Cost				Net Income	ROI (%)
				Fertilizer	Pest Control	No. of spray	Total		
T1	47.43	5.00	237.15	50.48	126.00	7X	176.48	60.67	34.38
T2	55.35	5.00	276.75	50.48	175.00	7X	225.48	51.27	23.74
T3	31.64	5.00							
	10.66	10.00							
	1.06	10.00	275.4	47.12	63.00	7X	110.12	165.25	150
T4	21.60	5.00							
	11.61	10.00							
	0.657	10.00	230.67	47.12	87.50	7X	134.62	96.05	71.34
T5	22.10	5.00							
	15.41	5.00							
	1.28	10.00	200.35	47.12	63.00	7X	110.12	90.23	81.9
T6	26.41	5.00							
	15.93	5.00						86.68	
	0.96	10.00	221.3	47.12	87.50	7X	134.62		64.38

increase and cause great damage to cabbage. Larval populations of DBM were high on farmers' plots and agroforestry plots, but were low on IPM plots.

Population of Beneficial Arthropods

Arthropods that attack cabbage pests include predators - *Coccinella transversa*, *Ischiodon* sp., *Ropalidia*, *Euagoras* sp., spiders - and parasitoids - *Aphidius* sp. and *Diadegma* sp. Field parasitism of *Aphidius* sp. on aphids was highest in IPM plots, followed by agroforestry and farmers' plots. Similarly, *Diadegma* sp. parasitism on the DBM was high in IPM plots, followed by agroforestry and farmers' plot.

Likewise, results showed that the presence of calamansi plants, *W. biflora*, *A. pintoi,* and *D. heterocarpum* contributed to the increase of spiders in agroforestry plots compared with those from the IPM plots. The highest number of spiders, however, was recorded from the farmers plots because of diverse shrubs and weeds that surrounded them. This result confirmed the report of Bogya and Marko (1999) that the density of spiders were higher in agroecosystems near natural habitats like an orchard and field margins/ edges, which provide shelter and alternative food sources for natural enemies of pests. Fallen logs in farmers' plots, served as refuge for spiders (Figure 4). Reduction of pesticide use greatly contributed to the increase of parasites during the second trial and to the conservation of beneficial arthropods in general.

Cabbage Yields

Figure 5 shows the cabbage yields of the different plots. The demonstration plot (DP), located in the crater valley, which was treated with a combination of commercial fertilizer and chicken dung at 350 g/plant, obtained the highest yield. This was followed by the agroforestry plots applied with commercial fertilizers with residues of chicken dung and IPM plots applied solely with commercial fertilizers. The lowest yield was obtained by the farmers' plots despite having much higher soil organic matter than the other plots. Based on comparative yields of the various plots, the crater valley, which had not been utilized for some time owing to low soil fertility, showed that crop productivity could be restored and even improved with appropriate crop and pest management approaches.

As a result of these experiments, upland farmers themselves observed that profitable and sustainable vegetable production is still possible in their old farms. Unaware, the local partners were applying commercial fertilizers way below the recommended rate based on the soil analysis of their plots (Table 4).

Based on economic analysis, IPM plots had the highest net income due to less cost for pest control, while farmers' plots obtained the least income. Agroforestry plots had the highest investment return compared with IPM plots because of zero pest control and long-term effects of increasing the plant diversity in these plots with soil improvement and more habitats for beneficial organisms.

Study IV. Impact Assessment of Integrated Pest Management on Cabbage-Growing Farmers in the Uplands of Mount Malindang

Significant changes were noted regarding the local farmer participants' level of knowledge of what they learned before and after the project.

The impact of IPM to the local partners was best gauged by the application of knowledge they acquired from the project to their own farms to improve their production. Mr. Roberto Sencio, the local partner from Mansawan started using chicken dung to improve the yield of white potato, which he planted in his farm. Mr. Carlito Ubas, a local partner from Gandawan started bagging cabbage seedlings to ensure higher germination of seedlings once they are transplanted in the field. Mr. Janito Tamon, a local partner from Lake Duminagat, started handpicking, crushing, and destroying egg masses and larvae of pests attacking his cabbage plants.

These local partners apparently learned and were willing to know more about other farm practices that would be useful for their farms. The experimental plots became a primary learning resource for them. They eventually applied such practices to their own farms.

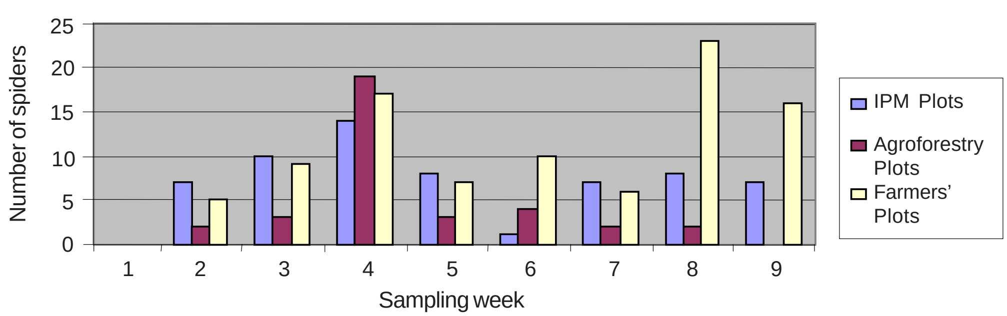

Figure 4. Total number of spiders. 2nd trial. Gandawan, Don Victoriano, Misamis Occidental. September-November 2004.

Table 4. Soil properties of experimental sites and fertilizer recommendations. 2nd trial (analysis by Department of Soil Science, UPLB).

Treatment	pH	% Organic matter	P	K ppm cmol (+)/kg soil	Recommended fertilizer & rate of application	Method of application
IPM 1	5.6	7.05	5.8	0.66	Ammophos @ 10 g/plant Urea @ 20 g/plant	basal top dressing
IPM 2	5.9	6.10	3.5	0.53	Ammophos @ 10 g/plant Urea @ 25 g/plant	basal top dressing
IPM 3	5.8	4.58	3.5	0.42	Complete @ 15 g/plant Urea @ 25 g/plant	basal top dressing
IPM 4	5.7	5.11	3.9	0.22	Complete @ 15 g/plant Urea @ 25 g/plant	basal top dressing
AF 1	5.7	5.66	3.9	0.38	Complete @ 15 g/plant Urea @ 25 g/plant	basal top dressing
AF 2	5.7	5.66	3.9	0.38	Complete @ 15 g/plant Urea @ 25 g/plant	basal top dressing
Demo	5.7	5.66	3.9	0.38	Complete @ 15 g/plant Chicken dung @ 350 g/plant	basal top dressing
FP 1*	5.6	14.85	4.9	0.84	Ammophos @ 20 g/plant	basal
FP 2*	5.7	12.75	3.5	0.40	Complete @ 20 g/plant	basal
FP 3*	5.6	8.38	4.9	0.64	Ammophos @ 20 g/plant	basal
FP 4*	5.6	23.06	1.7	0.72	Ammophos @ 15 g/plant	basal

* Actual rate applied by farmers:
FP 1 – Diluted complete @ 13.90 g/plant
FP 2 – Diluted complete @ 10.84 g/plant
FP 3 – Diluted complete @ 16.33 g/plant
FP 4 – Diluted complete @ 12.74 g/plant

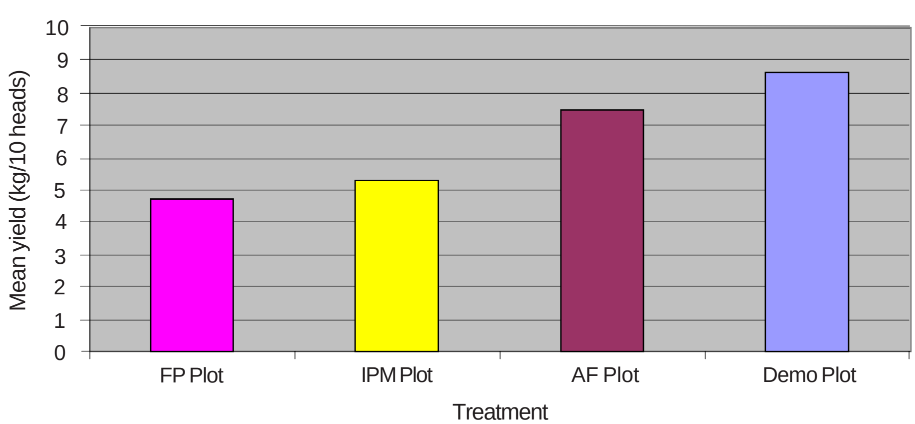

Figure 5. Mean yield of cabbage (kgs/10 heads). 2nd trial. Gandawan, Don Victoriano, Misamis Occidental. November 2004.

The farmers appreciated the sampling sessions and found their interactions with researchers useful. They believed their status in the community improved because of their participation in the project. This participation increased their concern for the environment.

Two agricultural technicians from the Municipal Agriculture Office of Don Victoriano joined the project as collaborators. As technicians for the three upland barangays, they needed to be trained in IPM as trainors who can facilitate the vegetable IPM training of farmers in Farmer Field Schools (FFS) after the termination of the project.

The agricultural technicians considered the problem of vegetable pests very serious and agreed this could be addressed through IPM. They noted that the attitudes, values, and diligence of farmers would still matter as far as the adoption of a new technology is concerned. They may have been previously aware of IPM before the project, but claimed that they acquired a much deeper understanding and appreciation of IPM through the project. They can now use their knowledge on techniques in pest monitoring, recognizing the different stages of pests, selection of IPM sites, establishment of field experiments, sampling procedures, data collection, and data analysis.

Moreover, the agricultural technicians found their interactions with the researchers from the university and local farmers very useful. They signified their willingness to teach other farmers what they learned from the project. Their participation in the project had not changed their standing or stature in their agency but this definitely heightened their concern for the environment, specifically for Mount Malindang.

II. Support Activities

Pre-implementation Activities

The project was formally presented in 2003 through orientation meetings with the Sangguniang Bayan (SB) members of Don Victoriano, Misamis Occidental, key local officials, and selected farmers of Mansawan, Gandawan on August 18, and Lake Duminagat on August 25. The goals of the project were presented by the team leader, followed by discussion of the individual studies by the team members. The two project collaborator technicians from the Department of Agriculture, Don Victoriano, Misamis Occidental served as facilitators of the two meetings. These meetings aided the research team in securing entry permits and building rapport with the local people.

Study Visit

The research team, two technicians, and eight male local partners participated in a study visit to different institutions in Mindanao in October 2003. They had to learn about the varied farming techniques in upland systems. They visited the Mindanao State University (MSU) in Marawi City; Mindanao Baptist Rural Life Center (MBRLC) in Kinuskusan, Bansalan, Davao del Sur; Regional Crop Protection Center (RCPC) in Bangcud, Malaybalay City; Northern Mindanao Agricultural Research Center (NOMIARC) in Dalwangan, Malaybalay City; Central Mindanao University (CMU) in Musuan, Bukidnon; Mountain View College (MVC) in Valencia City; the vegetable farm of Henry Binahon in Songco, Lantapan, Bukidnon; and several cabbage, broccoli, and cauliflower farms in Kibanggay, Bukidnon. Except for one, all male participants were married. Six were Subanen while two claimed they were *Libug* (combination of Subanen and Cebuano). Their ages ranged from 18 to 48. On the average, they have been planting cabbage for almost 10 years. Three participants did not belong to any organization in their barangays. Three participants were serving as *barangay kagawad* (councilor).

T-test results showed that the changes in the participants' levels of perception of pests and their management were significant, particularly in the use of onion extract as fungicide, proper application of fertilizer, contour farming for vegetables, bagging of seedlings, use of organic fertilizer for seedling establishment, and reasons for putting up a Sloping Agricultural Land Technology (SALT) project.

Training on Pest Identification

The training on pest identification and field sampling was conducted in Mansawan, Don Victoriano, Misamis Occidental in October 2003 with 13 local participants. The participants were the local partners in the project. Their wives were also included because they assumed the responsibilities of their husbands in some occasions.

Prof. Bernadita Gutos lectured on the cultural practices and management of cabbage, onion, sweet pepper, and tomato. Dr. Emma Sabado discussed the pests that attack these crops including their natural enemies. Fresh specimens of pests and their natural enemies collected from the field were shown to facilitate easy recognition. One week later, the partners in Gandawan were trained how to recognize the different life stages of the pests and how to take samples from plants.

Field Days

Farmers' field days were held twice, the first in Lake Duminagat on March 26, 2004 and the second in Gandawan on November 30, 2004, to present the results of the field experiments. The highlights were:

- viewing the different life stages of cabbage pests like DBM, cutworm, and cabbage worm; *Diadegma* and *Aphidius* parasitoids; assassin bugs, spiders, and *lapinig* (vespid wasps) as predators of DBM;
- demonstration on the proper mixture of growth media using soil and chicken dung and proper technique of bagging cabbage seedlings using banana leaves; and
- visit to the site to see the effects of IPM.

Trip to Baguio

The trip enabled the project leader to arrange the shipment of DBM parasites, *Diadegma* sp. from the rearing house at Benguet State University, La Trinidad, Benguet to Mount Malindang. Attempts to mass release them in cabbage fields did not materialize because of delivery problems. Nevertheless, the trip was not entirely wasted because the project leader learned many aspects of cabbage production aside from pest management. Plans for mass rearing and mass release of this parasitoid in Gandawan were envisioned.

Post-implementation Activity

Validation meetings were held in Mansawan on February 26, 2005. Relevant findings about the project and recommendations were presented to representatives of the three upland communities.

Summary and Conclusions

One of the most serious threats to the biodiversity of the Mount Malindang Range Natural Park (MMRNP) was the unabated practice of *kaingin* (swidden agriculture). Vegetable production, largely of cabbage and onions, had been a profitable means of livelihood among upland farmers. Since these crops were introduced into the area less than 20 years ago, farmers resorted to the use of commercial pesticides to control pests and diseases, and chemical fertilizers to augment the rapidly declining soil fertility of these farms. Once a *kaingin* area had lost its productivity, a forested area was opened, perpetuating the cycle many times over, resulting in the destruction and loss of habitats of important biological resources of the park.

In order to address the two-fold concern of conservation of the biodiversity of MMRNP and the need to ensure the sustainability of upland agriculture for the welfare of its upland communities, the project on Integrated Pest Management (IPM) in vegetable production, mainly cabbage, was launched in Gandawan and Lake Duminagat. The project aimed to restore, improve, and maintain the productivity of former farms in the crater valleys as an incentive; to discourage farmers from encroaching on mountain slopes and forested land; and to encourage them to stop the *kaingin* system of farming. The project systematically gathered information on the economic value of vegetable crops and any available indigenous technological knowledge on farmers' pest management practices. It also initiated experiments on conserving arthropod diversity in cabbage farms through participatory IPM involving selected local farmers. The farmers were also trained on how to implement vegetable IPM. At the same time, they were exposed to several experiments on pest management approaches through IPM and using farmers' practice (FP), and how they differed under monoculture and polyculture conditions. Finally, impact assessments on the effectiveness of IPM in cabbage farms were conducted through meetings with local stakeholders and holding of field days during cabbage harvest.

Pertinent information and results from surveys and IPM experiments are summarized as follows:

- Cabbage and onion were the most preferred vegetables owing to their high market demand and price.

- Indigenous pest management practices had not evolved since cabbage was introduced into MMRNP.

- The first phase (trial) of the participatory action research with selected farmers demonstrated the responses of vegetable pests and their natural enemies to both IPM and FP approaches in both cabbage monoculture and polyculture.

- The diamondback moth or DBM, *Plutella xylostella,* was the major cabbage pest. Minor pests included common cutworm (*Spodoptera litura*), black cutworm (*Agrotis ypsilon*), green peach aphid (*Myzus persicae*), and otiorrhynchine weevil. Onion pests included cutworms, onion maggot (*Liriomyza* sp.) and thrips (*Thrips tabaci*), while the aphid, *Aphis gossypii,* infested sweet pepper.

- DBM populations were higher in Gandawan than in Lake Duminagat probably because the latter had a more complex vegetation allowing for more natural enemies of DBM to thrive.

- Both IPM and FP plots had higher DBM populations under monoculture than in polyculture.

- Beneficial arthropods were greater in IPM plots than in FP plots, being more diverse in Lake Duminagat; parasitism of DBM larvae and aphids was high in IPM plots but none in FP plots.

- Results of the first phase trial showed that the diversity of beneficial arthropods in cabbage farms can be enhanced through polyculture.

- Cabbage and sweet pepper combination is more appropriate due to high economic return.

• Tomato can be intercropped with cabbage to lessen DBM population, but fruit development would be adversely affected with strong winds, which always occur in the crater valleys of Mount Malindang.

• Onion, which was also attacked by *Liriomyza* sp., should not be grown with cabbage because its presence would only encourage abundance of pests.

• In the second phase (trial) of the participatory action research, agroforestry plots and IPM plots were set up in the crater valley of Gandawan while the plots of farmers along the slopes were used as FP plots, the latter had relatively high soil organic matter.

• Agroforestry plots established with citrus trees, green manure, and border plants harbored more spiders than IPM plots, but FP plots along the slopes had much higher number of spiders; pesticide use was minimal in all plots.

• In the first phase, cabbage yields in IPM plots were comparable with those in FP plots.

• In the second phase, cabbage yields in the demo plots were highest, followed by the agroforestry and IPM plots; lowest yields were obtained from FP plots.

• IPM plots generally obtained the highest net income due to low production cost in terms of minimal pesticide use. However, agroforestry plots had a higher return of investment (ROI) than IPM plots because of zero pest control, while FP plots had the highest production cost due to high cost of chemical inputs.

• The relatively better yields in the demo, agroforestry, and IPM plots in the abandoned crater valley of Gandawan demonstrated that the area could still be made productive with proper IPM and crop management practices. In contrast, the FP plots along the slopes had the lowest yields despite the higher soil organic matter.

• During the wet season where DBM populations were much lower, cabbage can be grown without pest management activities as long as the farm has a diverse plant cover as refuge and source of food for beneficial arthropods.

• Establishing rapport among the research team, local government officials, and local farmer partners was essential to the success of the project planning and implementation, which were made possible through orientation meetings.

• Study visits to agricultural institutions promoting new approaches to upland agriculture benefited the participating farmers and agricultural technicians. Study visits were deemed necessary and useful to the actual conduct of the participatory action research with the farmers.

• Field days in Gandawan showing the benefits derived from various approaches to cabbage production, especially IPM and agroforestry, provided valuable first-hand information to local officials, nonparticipating farmers, and members of the community.

• Farmers and their wives were able to apply their knowledge on IPM for cabbage in their own farms, especially the use of agroecosystem analysis (AESA). They stopped spraying to conserve beneficial organisms such as spiders. Farmers also covered cabbage seedlings with bags for increased survival during transplanting. They also applied chicken dung as fertilizer.

Recommendations

The following recommendations aim to tie the need to promote biodiversity conservation in Mount Malindang and the need to alleviate the extreme poverty in upland communities. The researchers hope that these recommendations would be addressed by concerned policy makers, institutions, various government and nongovernment agencies, and conservation-committed individuals:

- Institution of an IPM Farmer Field School (FFS);
- Promotion of polyculture to increase diversity of beneficial arthropods and crop rotation to minimize pest infestation;
- Biological studies on *Aphidius* sp. and *Diadegma* sp. in Mount Malindang;
- Mass rearing and release of *Aphidius* sp. and *Diadegma* sp. in Mount Malindang to control aphid and DBM during the dry season;
- Use of organic fertilizer, like chicken dung, and exploration of locally available sources of organic matter;
- Training on compost making and vermiculture;
- Planting of *Desmodium heterocarpum* and other locally available leguminous plants to rehabilitate the nutrient-deficient, abandoned crater valleys of Gandawan and Lake Duminagat;
- Staggered planting of cabbage and other vegetables in smaller plots throughout the year to minimize oversupply, which brings down the market price of these produce; and
- Formulation of a policy by LGUs for people to patronize locally-grown crops and products.

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Appendix

Appendix Figure 1. Analytical framework showing the relationship of inputs, throughputs, outputs, and impact of integrated pest management.

INPUTS	THROUGHPUTS	OUTPUTS	IMPACT
Tools and guidance for IPM: • Growth stages of cabbage • Growth stages of insect • Pests like diamondback moth, cabbage worm, cutworm, cabbage looper • Natural enemies of insect pests • Data collection • Sampling procedures • Mechanical and physical control of insect pests • Use of organic fertilizer	Learning resources: • Field/experimental plots • Farmers' plots • Study visits • Training programs • Interaction with researchers • Interaction with farmers	Level of awareness on IPM: • Knowledge about IPM • Attitudes toward IPM • Sharing knowledge and skills about IPM	Biodiversity conservation of arthropods in upland cabbage-growing areas

Appendix Table 1 . Total number of sampled spiders. 1st trial. Gandawan and Lake Duminagat, Don Victoriano Misamis Occidental. January-March 2004. (visual sampling).

Treatment	Lake Duminagat	Gandawan
T1 – IPM-MONO	20	15
T2 – IPM-CSPO	13	5
T3 – IPM-CTO	20	16
T4 – FP-MONO	17	3
T5 – FP-CSPO	22	11
T6 – FP-CTO	8	6

Appendix Table 2 . Mean population of DBM per cabbage plant. 1st trial. Gandawan, Don Victoriano, Misamis Occidental. January–March 2004.

STAGE / TRT	SAMPLING WEEK							
EGG	1	2	3	4	5	6	7	8
T1 IPM-MONO	0.67^{ns}	0.97^{ns}	1.90^{ns}	0.17^{ns}	0.37^{ns}	0.00^{ns}	0.00	0.00
T3 IPM-CSPO	1.83^{ns}	1.23^{ns}	1.80^{ns}	0.15^{ns}	0.17^{ns}	0.10^{ns}	0.00	0.00
T5 IPM-CTO	0.73^{ns}	1.73^{ns}	1.87^{ns}	0.07^{ns}	0.23^{ns}	0.13^{ns}	0.00	0.53
T2 FP-MONO	1.60^{ns}	0.80^{ns}	0.57^{ns}	0.01^{ns}	0.23^{ns}	0.13^{ns}	0.00	0.03
T4 FP-CSPO	1.20^{ns}	2.10^{ns}	1.47^{ns}	0.02^{ns}	0.00^{ns}	0.03^{ns}	0.03	0.07
T6 FP-CTO	1.53^{ns}	2.93^{ns}	0.23^{ns}	0.27^{ns}	0.20^{ns}	0.00^{ns}	0.00	0.50
LARVA								
T1 IPM-MONO	1.67^{ns}	5.17^{ns}	11.80a	6.50a	12.10^{ns}	6.73^{ns}	1.50^{ns}	5.23^{ns}
T3 IPM-CSPO	0.33^{ns}	4.17^{ns}	8.13b	4.07b	10.90^{ns}	6.53^{ns}	2.53^{ns}	6.63^{ns}
T5 IPM-CTO	1.37^{ns}	3.90^{ns}	8.43c	3.50c	9.53^{ns}	5.60^{ns}	3.40^{ns}	5.03^{ns}
T2 FP-MONO	3.10^{ns}	7.57^{ns}	3.07e	4.07c	8.30^{ns}	6.90^{ns}	2.60^{ns}	2.23^{ns}
T4 FP-CSPO	1.57^{ns}	6.33^{ns}	4.10d	4.13bc	8.13^{ns}	6.80^{ns}	2.90^{ns}	4.83^{ns}
T6 FP-CTO	2.07^{ns}	6.87^{ns}	2.77f	4.40b	6.03^{ns}	4.47^{ns}	5.97^{ns}	6.17^{ns}
PUPA								
T1 IPM-MONO	0.00^{ns}	0.27^{ns}	0.33^{ns}	0.40b	1.57^{ns}	0.33^{ns}	0.00^{ns}	0.13^{ns}
T2 IPM-CSPO	0.07^{ns}	0.00^{ns}	0.03^{ns}	0.33b	0.67^{ns}	0.17^{ns}	0.03^{ns}	0.03^{ns}
T5 IPM-CTO	0.03^{ns}	0.00^{ns}	0.03^{ns}	0.27b	0.53^{ns}	0.03^{ns}	0.03^{ns}	0.00^{ns}
T2 FP-MONO	0.07^{ns}	0.43^{ns}	0.47^{ns}	1.43a	1.23^{ns}	0.57^{ns}	0.17^{ns}	0.00^{ns}
T4 FP-CSPO	0.13^{ns}	0.37^{ns}	0.50^{ns}	1.37a	1.13^{ns}	0.27^{ns}	0.40^{ns}	0.07^{ns}
T6 FP-CTO	0.00^{ns}	0.27^{ns}	0.33^{ns}	1.23a	0.33^{ns}	0.60^{ns}	0.00^{ns}	0.03^{ns}
ADULT								
T1 IPM-MONO	0.00	0.00	0.10	0.00	0.27	0.77	0.03	0.03
T3 IPM-CSPO	0.03	0.00	0.03	0.13	0.27	0.03	0.07	0.03
T5 IPM-CTO	0.00	0.07	0.03	0.13	0.00	0.07	0.07	0.03
T2 FP-MONO	0.10	0.17	0.00	0.10	0.10	0.37	0.10	0.03
T4 FP-CSPO	0.03	0.00	0.00	0.03	0.03	0.03	0.23	0.13
T6 FP-CTO	0.10	0.10	0.03	0.07	0.00	0.33	0.00	0.03

Means with different letters are statistically significant ($P \leq 0.05$)

^{ns} Not significant ($P \geq 0.05$)

Appendix Table 3. Mean population of DBM per cabbage plant. 1st trial. Lake Duminagat, Don Victoriano, Misamis Occidental. January–March 2004.

STAGE / TRT	WEEK							
EGG	1	*2*	3	4	5	6	7	8
T1 IPM-MONO	0.10 ns	0.17 ns	0.00 ns	0.00 ns	0.00 ns	0.00 ns	0.07 ns	0.20 ns
T3 IPM-CSPO	1.00 ns	0.03 ns	0.03 ns	0.00 ns	0.00 ns	0.00 ns	0.07 ns	0.07 ns
T5 IPM-CTO	0.03 ns	0.13 ns	0.03 ns	0.00 ns	0.07 ns	0.00 ns	0.00 ns	0.03 ns
T2 FP-MONO	0.10 ns	0.00 ns	0.00 ns	0.00 ns	0.00 ns	0.00 ns	0.00 ns	0.00 ns
T4 FP-CSPO	0.00 ns	0.00 ns	0.00 ns	0.00 ns	0.00 ns	0.03 ns	0.00 ns	0.00 ns
T6 FP-CTO	0.00 ns	0.03 ns	0.00 ns	0.03 ns	0.00 ns	0.00 ns	0.00 ns	0.00 ns
LARVA								
T1 IPM-MONO	4.40 ns	1.47 ns	3.13 ns	2.73 ns	1.43 ns	5.37 ns	3.23c	1.73f
T3 IPM-CSPO	1.87 ns	1.07 ns	4.07 ns	2.97 ns	2.10 ns	4.30 ns	1.53d	3.17e
T5 IPM-CTO	3.10 ns	*0.80* ns	3.27 ns	4.20 ns	1.30 ns	3.57 ns	1.57d	4.13c
T2 FP-MONO	5.50 ns	1.20 ns	4.60 ns	4.23 ns	0.93 ns	2.40 ns	2.63c	3.43d
T4 FP-CSPO	5.17 ns	2.97 ns	4.37 ns	4.43 ns	1.10 ns	4.17 ns	6.80b	6.97a
T6 FP-CTO	5.43 ns	0.77 ns	5.30 ns	8.00 ns	1.80 ns	4.23 ns	8.43a	6.07b
PUPA								
IPM-MONO	0.10 ns	0.00 ns	0.40 ns	1.23b	0.37 ns	0.30c	0.10 ns	0.07 ns
IPM-SCTO	0.00 ns	0.03 ns	0.47 ns	0.13c	0.60 ns	0.50b	0.07 ns	0.03 ns
IPM-CTO	0.00 ns	0.20 ns	0.27 ns	1.13bc	0.53 ns	0.97b	0.27 ns	0.13 ns
FP-MONO	0.10 ns	0.17 ns	0.90 ns	2.03a	1.57 ns	0.67bc	0.33 ns	0.23 ns
FP-SCTO	0.00 ns	*0.20* ns	0.57 ns	1.77ab	1.33 ns	0.50b	0.27 ns	0.10 ns
FP-CTO	0.00 ns	0.17 ns	0.20 ns	2.13a	1.63 ns	1.77a	0.30 ns	0.23 ns
ADULT								
IPM-MONO	0.00 ns	0.00 ns	0.13 ns	0.03 ns	0.00 ns	0.33 ns	0.07 ns	0.13 ns
IPM-SCTO	0.00 ns	0.03 ns	0.10 ns	0.03 ns	0.00 ns	0.37 ns	0.10 ns	0.17 ns
IPM-CTO	0.00 ns	0.00 ns	0.10 ns	0.10 ns	0.00 ns	0.20 ns	0.00 ns	0.00 ns
FP-MONO	0.03 ns	0.00 ns	0.23 ns	0.00 ns	0.57 ns	0.63 ns	0.03 ns	0.10 ns
FP-SCTO	0.03 ns	0.00 ns	0.10 ns	0.10 ns	0.00 ns	0.23 ns	0.07 ns	0.33 ns
FP-CTO	0.00 ns	0.22 ns	0.11 ns	0.33 ns	0.80 ns	0.20 ns	0.11 ns	0.41 ns

Means with different letters are statistically significant ($P \leq 0.05$)

ns Not significant ($P \geq 0.05$)

Appendix Table 4. Result of soil analysis done by the Department of Soils, UP Los Baños, College, Laguna. November 2003.

Barangay	pH	% OM	P ppm	Cmol(+)/kg soil
Mansawan	5.4-5.5	12.13-12.89	2.7- 4.0	0.20
Gandawan	5.4-5.5	12.79-15.17	2-3.3	0.57-.59
Lake Duminagat	4.9-5.2	7.67-9.35	3.3-8.5	0.35-0.75

Appendix Table 5. Fertilizer recommendation based on the soil analysis.

Fertilizer Recommendation		
Crop	**Basal**	**Topdress**
1. Cabbage	15 g 14-14-14/plant	-
2. Sweet pepper	8 g 14-14-14/plant	-
3. Green onion	10 g 14-14-14/plant	5 g urea/plant
4. Tomato	15 g 14-14-14/plant	

Appendix Table 6. Cabbage yield (kgs/10 heads). 2nd trial. Gandawan, Don Victoriano, Misamis Occidental.

TRT	MEAN YIELD (kg/10 heads)
IPM 1	4.28e
IPM 2	7.85ab
IPM 3	5.71bcd
IPM 4	4.60de
AF1	7.25bc
AF2	7.12bcd
FP 1	4.85bcd
FP 2	5.62bcd
FP 3	6.12bcd
FP 4	5.45bcd
Demo	9.78a

Means with different letters are statistically significant ($P \leq 0.05$)

Appendix Table 7. ANOVA for mean population of DBM egg masses per cabbage plant. 1st trial. Gandawan, Don Victoriano, Misamis Occidental, January–March 2004.

AOV1	**Egg**			
SV	DF	SS	MS	Fc
REP	2	1.49	0.74	0.56
TRT	5	2.93	0.59	0.44
Eerror	10	13.37	1.34	
Serror	162	66.15	0.41	
Total	179	83.94		
AOV2				
SV	DF	SS	MS	Fc
REP	2	3.01	1.51	1.79
TRT	5	4.21	0.84	1.00
Eerror	10	8.42	0.84	
Serror	162	106.04	0.65	
Total	179	121.68		
AOV3				
SV	DF	SS	MS	Fc
REP	2	2.24	1.12	2.61
TRT	5	7.03	1.41	3.27
Eerror	10	4.30	0.43	
Serror	162	90.37	0.56	
Total	179	103.95		
AOV3				
SV	DF	SS	MS	Fc
REP	2	2.24	1.12	2.61
TRT	5	7.03	1.41	3.27
Eerror	10	4.30	0.43	
Serror	162	90.37	0.56	
Total	179	103.95		
AOV4				
SV	DF	SS	MS	Fc
REP	2	0.40	0.20	3.37
TRT	5	0.09	0.02	0.30
Eerror	10	0.59	0.06	
Serror	162	22.40	0.14	
Total	179	23.48		
AOV5				
SV	DF	SS	MS	Fc
REP	2	1.40	0.70	10.10
TRT	5	0.42	0.08	1.20
Eerror	10	0.69	0.07	
Serror	162	8.93	0.06	
Total	179	11.44		

Appendix Table 7. ANOVA for mean population of DBM egg masses per cabbage plant. 1st trial. Gandawan, Don Victoriano, Misamis Occidental, January–March 2004 *(continued)*.

AOV6				
SV	DF	SS	MS	Fc
REP	2	0.23	0.12	4.91
TRT	5	0.19	0.04	1.57
Eerror	10	0.24	0.02	
Serror	162	2.28	0.01	
Total	179	2.93		
AOV7				
SV	DF	SS	MS	Fc
REP	2	0.0030	0.0015	1.0
TRT	5	0.0075	0.0015	1.0
Eerror	10	0.0150	0.0015	
Serror	162	0.2649	0.0016	
Total	179	0.2904		
AOV8				
SV	DF	SS	MS	Fc
REP	2	0.20	0.10	0.65
TRT	5	0.46	0.09	0.61
Eerror	10	1.51	0.15	
Serror	162	19.62	0.12	
Total	179	21.79		

AOV1 - Analysis of variance for the 1st week sampling
AOV8 - Analysis of variance for the 8th week sampling
SV - Source of variation
REP - Replication/block
TRT - Treatment/Crop arrangement (A), Pest Management Strategies (B)
DF - Degree of freedom
SS - Sum of squares
MS - Mean squares
Fc - F value computed

Appendix Table 8. ANOVA for mean population of DBM larvae per cabbage plant. 1st trial. Gandawan, Don Victoriano, Misamis Occidental, January–March 2004.

AOV1	Larva			
SV	DF	SS	MS	Fc
REP	2	3.24	1.62	2.11
TRT	5	10.52	2.10	2.74
Eerror	10	7.67	0.77	
Serror	162	72.86	0.45	
Total	179	94.29		
AOV2				
SV	DF	SS	MS	Fc
REP	2	10.76	5.38	2.33
TRT	5	14.52	2.90	1.26
Eerror	10	23.05	2.30	
Serror	162	134.07	0.83	
Total	179	182.39		
AOV3				
SV	DF	SS	MS	Fc
REP	2	2.19	1.10	0.49
TRT	5	65.44	13.09	5.80*
Eerror	10	22.56	2.26	
Serror	162	120.24	0.74	
Total	179	210.44		
AOV4				
SV	DF	SS	MS	Fc
REP	2	0.17	0.09	0.29
TRT	5	7.47	1.49	5.07*
Eerror	10	2.95	0.29	
Serror	162	85.06	0.53	
Total	179	95.65		
AOV5				
SV	DF	SS	MS	Fc
REP	2	22.34	11.17	4.43*
TRT	5	17.27	3.45	1.37
Eerror	10	25.22	2.52	
Serror	162	97.97	0.60	
Total	179	162.79		
AOV6				
SV	DF	SS	MS	Fc
REP	2	87.00	43.50	36.26**
TRT	5	4.19	0.84	0.70
Eerror	10	12.00	1.20	
Serror	162	133.72	0.83	
Total	179	236.90		

Appendix Table 8. ANOVA for mean population of DBM larvae per cabbage plant. 1st trial. Gandawan, Don Victoriano, Misamis Occidental. January–March 2004 *(continued)*.

AOV7				
SV	DF	SS	MS	Fc
REP	2	7.78	3.89	1.17
TRT	5	19.18	3.84	1.15
Eerror	10	33.27	3.33	
Serror	162	90.32	0.56	
Total	179	150.55		
AOV8				
SV	DF	SS	MS	Fc
REP	2	0.16	0.08	0.03
TRT	5	21.52	4.30	1.36
Eerror	10	31.55	3.15	
Serror	162	89.64	0.55	
Total	179	142.88		

AOV1 - Analysis of variance for the 1st week sampling
AOV8 - Analysis of variance for the 8th week sampling
SV - Source of variation
REP - Replication/block
TRT - Treatment/Crop arrangement (A), Pest Management Strategies (B)
DF - Degree of freedom
SS - Sum of squares
MS - Mean squares
Fc - F value computed
* - Significant at 5% level DMRT
** - Highly significant at 5% level DMRT

Appendix Table 9. ANOVA for mean population of DBM pupae per cabbage plant. 1st trial. Gandawan, Don Victoriano, Misamis Occidental. January–March 2004.

AOV1	Pupa			
SV	DF	SS	MS	Fc
REP	2	0.07	0.04	5.21*
TRT	5	0.06	0.01	1.59
Eerror	10	0.07	0.01	
Serror	162	2.08	0.01	
Total	179	2.28		
AOV2				
SV	DF	SS	MS	Fc
REP	2	0.50	0.25	1.77
TRT	5	1.11	0.22	1.59
Eerror	10	1.40	0.14	
Serror	162	9.97	0.06	
Total	179	12.97		
AOV3				
SV	DF	SS	MS	Fc
REP	2	0.38	0.19	1.14
TRT	5	1.35	0.27	1.63
Eerror	10	1.66	0.17	
Serror	162	11.35	0.07	
Total	179	14.74		
AOV4				
SV	DF	SS	MS	Fc
REP	2	0.77	0.38	0.84
TRT	5	7.71	1.54	3.38*
Eerror	10	4.57	0.46	
Serror	162	28.84	0.18	
Total	179	41.89		
AOV5				
SV	DF	SS	MS	Fc
REP	2	0.16	0.08	0.14
TRT	5	4.51	0.90	1.55
Eerror	10	5.81	0.58	
Serror	162	33.99	0.21	
Total	179	44.48		
AOV6				
SV	DF	SS	MS	Fc
REP	2	2.79	1.40	10.65**
TRT	5	1.01	0.20	1.54
Eerror	10	1.31	0.13	
Serror	162	16.55	0.10	
Total	179	21.66		

Appendix Table 9. ANOVA for mean population of DBM pupae per cabbage plant. 1st trial. Gandawan, Don Victoriano, Misamis Occidental. January–March 2004 *(continued)*.

AOV7				
SV	DF	SS	MS	Fc
REP	2	0.03	0.01	0.40
TRT	5	0.35	0.07	2.02
Eerror	10	0.34	0.03	
Serror	162	8.65	0.05	
Total	179	9.37		
AOV8				
SV	DF	SS	MS	Fc
REP	2	0.02	0.01	0.58
TRT	5	0.07	0.01	0.95
Eerror	10	0.14	0.01	
Serror	162	2.63	0.02	
Total	179	2.85		

AOV1 - Analysis of variance for the 1st week sampling
AOV8 - Analysis of variance for the 8th week sampling
SV - Source of variation
REP - Replication/block
TRT - Treatment/Crop arrangement (A), Pest Management Strategies (B)
DF - Degree of freedom
SS - Sum of squares
MS - Mean squares
Fc - F value computed
* - Significant at 5% level DMRT
** - Highly significant at 5% level DMRT

Appendix Table 10. ANOVA for mean population of DBM adult per cabbage plant. 1st trial. Gandawan, Don Victoriano, Misamis Occidental. January–March 2004.

AOV1	Adult			
SV	DF	SS	MS	Fc
REP	2	0.01	0.01	0.45
TRT	5	0.08	0.02	1.27
Eerror	10	0.13	0.01	
Serror	162	1.82	0.01	
Total	179	2.05		
AOV2				
SV	DF	SS	MS	Fc
REP	2	0.08	0.04	1.52
TRT	5	0.19	0.04	1.39
Eerror	10	0.27	0.03	
Serror	162	1.98	0.01	
Total	179	2.53		
AOV3				
SV	DF	SS	MS	Fc
REP	2	0.01	0.00	0.45
TRT	5	0.05	0.01	1.09
Eerror	10	0.10	0.01	
Serror	162	1.39	0.01	
Total	179	1.55		
AOV4				
SV	DF	SS	MS	Fc
REP	2	0.01	0.00	0.06
TRT	5	0.11	0.02	0.42
Eerror	10	0.51	0.05	
Serror	162	3.32	0.02	
Total	179	3.94		
AOV5				
SV	DF	SS	MS	Fc
REP	2	0.4199	0.2099	2.38
TRT	5	0.4926	0.0985	1.12
Eerror	10	0.8800	0.0880	
Serror	162	4.6901	0.0290	
Total	179	6.4825		
AOV6				
SV	DF	SS	MS	Fc
REP	2	1.84	0.92	4.46*
TRT	5	1.69	0.34	1.64
Eerror	10	2.06	0.21	
Serror	162	13.62	0.08	
Total	179	19.21		

Appendix Table 10. ANOVA for mean population of DBM adult per cabbage plant. 1st trial. Gandawan, Don Victoriano, Misamis Occidental. January–March 2004 *(continued)*.

AOV7				
SV	DF	SS	MS	Fc
REP	2	0.09	0.05	1.01
TRT	5	0.21	0.04	0.91
Eerror	10	0.46	0.05	
Serror	162	3.74	0.02	
Total	179	4.51		
AOV8				
SV	DF	SS	MS	Fc
REP	2	0.03	0.01	0.71
TRT	5	0.07	0.01	0.71
Eerror	10	0.19	0.02	
Serror	162	2.01	0.01	
Total	179	2.29		

AOV1 - Analysis of variance for the 1st week sampling
AOV8 - Analysis of variance for the 8th week sampling
SV - Source of variation
REP - Replication/block
TRT - Treatment/Crop arrangement (A), Pest Management Strategies (B)
DF - Degree of freedom
SS - Sum of squares
MS - Mean squares
Fc - F value computed
* - Significant at 5% level DMRT

Appendix Table 11. ANOVA for mean population of DBM egg masses per cabbage plant. 1st trial. Lake Duminagat, Don Victoriano, Misamis Occidental. January – March 2004.

AOV1	Egg			
SV	DF	SS	MS	Fc
REP	2	0.67	0.34	1.05
TRT	5	1.34	0.27	0.83
Eerror	10	3.22	0.32	
Serror	162	16.34	0.10	
Total	179	21.57		
cv(%)S	0.32	41.50		
cv(%)E	0.02			
	0.15	19.42		
AOV2				
SV	DF	SS	MS	Fc
REP	2	0.001	0.001	0.008
TRT	5	0.259	0.052	0.612
Eerror	10	0.845	0.084	
Serror	162	7.270	0.045	
Total	179	8.375		
cv(%)S	0.212	28.333		
cv(%)E	0.004			
	0.063	8.418		
AOV3				
SV	DF	SS	MS	Fc
REP	2	0.02	0.01	0.59
TRT	5	0.05	0.01	0.68
Eerror	10	0.15	0.02	
Serror	162	2.28	0.01	
Total	179	2.50		
cv(%)S	0.1187	16.47		
cv(%)E	0.0001			
	0.0102	1.41		
AOV4				
SV	DF	SS	MS	Fc
REP	2	0.00298	0.00149	1.00
TRT	5	0.00744	0.00149	1.00
Eerror	10	0.01489	0.00149	
Serror	162	0.24115	0.00149	
Total	179	0.26646		
cv(%)S	0.04	5.43428		
cv(%)E	0.00			

Appendix Table 11. ANOVA for mean population of DBM egg masses per cabbage plant. 1st trial. Lake Duminagat, Don Victoriano, Misamis Occidental. January–March 2004 *(continued)*.

AOV5				
SV	DF	SS	MS	Fc
REP	2	0.012	0.006	1.00
TRT	5	0.030	0.006	1.00
Eerror	10	0.060	0.006	
Serror	162	0.429	0.003	
Total	179	0.530		
cv(%)S	0.0514	7.216		
cv(%)E	0.0003			
	0.0182	2.5514114		
AOV6				
SV	DF	SS	MS	Fc
REP	2	0.003	0.001	1.000
TRT	5	0.007	0.001	1.000
Eerror	10	0.015	0.0015	
Serror	162	0.241	0.0015	
Total	179	0.266		
cv(%)S	0.039	5.434		
cv(%)E	0.000			
AOV7				
SV	DF	SS	MS	Fc
REP	2	0.012	0.006	0.455
TRT	5	0.048	0.010	0.727
Eerror	10	0.131	0.013	
Serror	162	0.857	0.005	
Total	179	1.048		
cv(%)S	0.073	10.124		
cv(%)E	0.001			
	0.028	3.888		
AOV8				
SV	DF	SS	MS	Fc
REP	2	0.00	0.00	0.06
TRT	5	0.12	0.02	1.42
Eerror	10	0.17	0.02	
Serror	162	3.61	0.02	
Total	179	3.91		
cv(%)S	0.15	20.42		
cv(%)E	0.00			

AOV 1 - Analysis of variance for the 1st week sampling
AOV8 - Analysis of variance for the 8th week sampling
SV - Source of variation
REP - Replication/block
TRT - Treatment/Crop arrangement (A), Pest Management Strategies (B)

DF - Degree of freedom
SS - Sum of squares
MS - Mean squares
Fc - F value computed

Appendix Table 12. ANOVA for mean population of DBM larvae per cabbage plant. 1st trial. Lake Duminagat, Don Victoriano, Misamis Occidental. January–March 2004.

AOV1	**Larva**			
SV	DF	SS	MS	Fc
REP	2	2.35	1.17	0.44
TRT	5	13.87	2.77	1.04
Eerror	10	26.68	2.67	
Serror	162	153.87	0.95	
Total	179	196.76		
cv(%)S	0.97	51.00		
cv(%)E	0.17			
	0.41	21.69		
AOV2				
SV	DF	SS	MS	Fc
REP	2	1.63	0.82	1.40
TRT	5	7.52	1.50	2.59
Eerror	10	5.82	0.58	
Serror	162	47.65	0.29	
Total	179	62.63		
cv(%)S	0.54	43.85		
cv(%)E	0.03			
	0.17	13.71		
AOV3				
SV	DF	SS	MS	Fc
REP	2	41.47	20.74	12.07**
TRT	5	3.71	0.74	0.43
Eerror	10	17.18	1.72	
Serror	162	108.33	0.67	
Total	179	170.70		
cv(%)S	0.82	42.66		
cv(%)E	0.10			
	0.32	16.90		
	B1	B2	B3	
	13.65401	18.494724	25.353462	
AOV4				
SV	DF	SS	MS	Fc
REP	2	2.58	1.29	1.07
TRT	5	15.71	3.14	2.62
Eerror	10	12.01	1.20	
Serror	162	138.45	0.85	
Total	179	168.75		
cv(%)S	0.92	46.28		
cv(%)E	0.03			
	0.19	9.32		

Appendix Table 12. ANOVA for mean population of DBM larvae per cabbage plant. 1st trial. Lake Duminagat, Don Victoriano, Misamis Occidental. January–March 2004 *(continued)*.

AOV5				
SV	DF	SS	MS	Fc
REP	2	0.25	0.12	0.54
TRT	5	2.11	0.42	1.87
Eerror	10	2.27	0.23	
Serror	162	59.19	0.37	
Total	179	63.82		
cv(%)S	0.60	47.94		
cv(%)E	-0.01			
AOV6				
SV	DF	SS	MS	Fc
REP	2	12.92	6.46	3.60
TRT	5	5.99	1.20	0.67
Eerror	10	17.92	1.79	
Serror	162	140.32	0.87	
Total	179	177.15		
cv(%)S	0.93	49.60		
cv(%)E	0.09			
	0.30	16.22		
	B1	B2	B3	
	19.7379	21.450203	15.108133	
AOV7				
SV	DF	SS	MS	Fc
REP	2	2.10	1.05	0.76
TRT	5	58.78	11.76	8.46**
Eerror	10	13.89	1.39	
Serror	162	128.07	0.79	
Total	179	202.85		
cv(%)S	0.89	48.18		
cv(%)E	0.06			
	0.24	13.26		
AOV8				
SV	DF	SS	MS	Fc
REP	2	2.18	1.09	0.63
TRT	5	36.39	7.28	4.18*
Eerror	10	17.42	1.74	
Serror	162	97.71	0.60	
Total	179	153.69		
cv(%)S	0.78	39.34		
cv(%)E	0.11			
	0.34	17.09		

AOV 1 - Analysis of variance for the 1st week sampling
AOV8 - Analysis of variance for the 8th week sampling
SV - Source of variation
REP - Replication/block
TRT - Treatment/Crop arrangement (A), Pest Management Strategies (B)

DF - Degree of freedom
SS - Sum of squares
MS - Mean squares
Fc - F value computed
* - Significant at 5% level DMRT
** - Highly significant at 5% level DMRT

Appendix Table 13. ANOVA for mean population of DBM pupae per cabbage plant. 1st trial. Lake Duminagat, Don Victoriano, Misamis Occidental, January–March 2004.

AOV1	**Pupa**			
SV	DF	SS	MS	Fc
REP	2	0.10	0.05	2.49
TRT	5	0.10	0.02	1.00
Eerror	10	0.19	0.02	
Serror	162	1.40	0.01	
Total	179	1.79		
cv(%)S	0.09	12.85		
cv(%)E	0.00			
	0.03	4.52		
AOV2				
SV	DF	SS	MS	Fc
REP	2.00	0.04	0.02	0.57
TRT	5.00	0.18	0.04	0.97
Eerror	10.00	0.37	0.04	
Serror	162.00	5.88	0.04	
Total	179.00	6.47		
cv(%)S	0.19	25.00		
cv(%)E	0.00			
	0.01	0.81		
AOV3				
SV	DF	SS	MS	Fc
REP	2.00	0.52	0.26	1.64
TRT	5	1.57	0.31	2.00
Eerror	10	1.57	0.16	
Serror	162	17.80	0.11	
Total	179	21.45		
cv(%)S	0.331	36.12		
cv(%)E	0.005			
	0.069	7.50		
AOV4				
SV	DF	SS	MS	Fc
REP	2	1.71	0.86	1.38
TRT	5	12.17	2.43	3.94*
Eerror	10	6.18	0.62	
Serror	162	52.75	0.33	
Total	179	72.81		
cv(%)S	0.57	48.02		
cv(%)E	0.03			
	0.17	14.39		

Appendix Table 13. ANOVA for mean population of DBM pupae per cabbage plant. 1st trial. Lake Duminagat, Don Victoriano, Misamis Occidental, January–March 2004 *(continued)*.

AOV5				
SV	DF	SS	MS	Fc
REP	2	2.88	1.44	1.65
TRT	5	4.68	0.94	1.07
Eerror	10	8.72	0.87	
Serror	162	41.10	0.25	
Total	179	57.37		
cv(%)S	0.50	46.56		
cv(%)E	0.06			
	0.25	22.98		
AOV6				
SV	DF	SS	MS	Fc
REP	2	8.14	4.07	15.33**
TRT	5	4.44	0.89	3.35*
Eerror	10	2.65	0.27	
Serror	162	31.80	0.20	
Total	179	47.03		
cv(%)S	0.44	43.59		
cv(%)E	0.01			
	0.08	8.18		
	B1	B2	B3	
	8.31	13.14	9.04	
AOV7				
SV	DF	SS	MS	Fc
REP	2	0.11	0.05	0.31
TRT	5	0.36	0.07	0.42
Eerror	10	1.72	0.17	
Serror	162	9.69	0.06	
Total	179	11.88		
cv(%)S	0.24	30.45		
cv(%)E	0.01			
	0.11	13.19		
AOV8				
SV	DF	SS	MS	Fc
REP	2	0.16	0.08	2.43
TRT	5	0.27	0.05	1.66
Eerror	10	0.32	0.03	
Serror	162	5.68	0.04	
Total	179	6.43		
cv(%)S	0.1873	24.45		
cv(%)E	-0.0003			

AOV 1 - Analysis of variance for the 1st week sampling
AOV8 - Analysis of variance for the 8th week sampling
SV - Source of variation
REP - Replication/block
TRT - Treatment/Crop arrangement (A), Pest Management Strategies (B)

DF - Degree of freedom
SS - Sum of squares
MS - Mean squares
Fc - F value computed
* - Significant at 5% level DMRT
** - Highly significant at 5% level DMRT

Appendix Table 14. ANOVA for mean population of DBM adult per cabbage plant. 1st trial. Lake Duminagat, Don Victoriano, Misamis Occidental. January–March 2004.

AOV1	Adult			
SV	DF	SS	MS	Fc
REP	2	0.00	0.00	0.29
TRT	5	0.03	0.01	1.18
Eerror	10	0.05	0.01	
Serror	162	0.96	0.01	
Total	179	1.05		
cv(%)S	0.08	10.74		
cv(%)E	0.00			
AOV2				
SV	DF	SS	MS	Fc
REP	2	0.027	0.013	2.143
TRT	5	0.031	0.006	1.000
Eerror	10	0.063	0.006	
Serror	162	0.670	0.004	
Total	179	0.790		
cv(%)S	0.064	8.984		
cv(%)E	0.000			
	0.015	2.033		
AOV3				
SV	DF	SS	MS	Fc
REP	2	0.19	0.09	3.26
TRT	5	0.09	0.02	0.65
Eerror	10	0.29	0.03	
Serror	162	6.71	0.04	
Total	179	7.29		
cv(%)S	0.20	26.95		
cv(%)E	0.00			
AOV4				
SV	DF	SS	MS	Fc
REP	2	0.08	0.04	2.34
TRT	5	0.06	0.01	0.69
Eerror	10	0.17	0.02	
Serror	162	2.21	0.01	
Total	179	2.53		
cv(%)S	0.12	15.97		
cv(%)E	0.00			
	0.02	2.58		

Appendix Table 14. ANOVA for mean population of DBM adult per cabbage plant. 1st trial. Lake Duminagat, Don Victoriano, Misamis Occidental. January–March 2004 *(continued)*.

AOV5				
SV	DF	SS	MS	Fc
REP	2	0.62	0.31	2.42
TRT	5	1.47	0.29	2.31
Eerror	10	1.27	0.13	
Serror	162	13.67	0.08	
Total	179	17.04		
cv(%)S	0.29	37.69		
cv(%)E	0.00			

AOV 1 - Analysis of variance for the 1st week sampling
AOV8 - Analysis of variance for the 8th week sampling
SV - Source of variation
REP - Replication/block
TRT - Treatment/Crop arrangement (A), Pest Management Strategies (B)

DF - Degree of freedom
SS - Sum of squares
MS - Mean squares
Fc - F value computed

Appendix Table 15. ANOVA for cabbage yield. 2nd trial. Gandawan, Don Victoriano, Misamis Occidental. September-November 2004.

SV	DF	SS	MS	Fc
TRT	10	2.67	0.27	9.26**
Error	99	2.85	0.03	
Total	109			
cv (%)	27.19			

Appendix Table 16. Mean scores on level of awareness and knowledge of respondents before and after study visits. October 2003.

ITEM	LEVEL OF AWARENESS		LEVEL OF KNOWLEDGE	
	Pretest (Mean)	Post-test (Mean)	Pre-test (Mean)	Post-test (Mean)
Meaning of SALT	1.00	1.50	1.0	1.50
Reasons for using Sloping Agricultural Land Technology (SALT)	1.00	2.37	1.0	1.20
Steps in Sloping Agricultural Land Technology (SALT)	1.00	2.37	1.0	1.62
Causes of soil erosion	2.37	3.50	2.5	4.12
Trichogramma	1.00	1.50	1.0	1.25
Diadegma	1.00	1.50	1.0	1.25
Plants for hedgerows	3.00	3.5	3.0	3.50
Organic fertilizer for seedling establishment	1.5	3.5	1.37	3.62
Onion extract for fungicide	1.0	4.5	1.0	4.25
Proper application of fertilizer	1.50	3.87	1.37	4.00
Crop combinations	2.0	3.5	1.87	2.75
Contour farming for vegetables	1.87	4.62	1.75	4.62
Bagging of seedlings	1.0	5.0	1.0	5.00
MEAN	1.48	3.17	1.45	2.99

Legend:
1.0-1.5 (none)
1.51-2.5 (poor)
2.51-3.5 (satisfactory)
3.51-4.5 (very satisfactory)
4.51-5.0 (excellent)

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