THE DEVELOPMENT OF A STICKY TRAP MONITORING SYSTEM FOR THE DIAMONDBACK MOTH, PLUTELLA XYLOSTELLA, ON CABBAGES AND ITS IMPACT ON WOMEN'S ROLES IN CABBAGE PRODUCTION IN TOMOHON, INDONESIA

by

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Title of Thesis/Project/Extended Essay

The development of a sticky trap monitoring system for the diamondback moth, Plutella xylostella, on cabbages and its impact on women's roles in cabbage production in Tomohon, Indonesia.

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Abstract

Experiments on the development of a sticky trap monitoring system for the diamondback moth (DBM), and surveys of gender roles in cabbage production and pest management, were carried out in North Sulawesi, Indonesia. It was determined that: 1. DBM do not appear to fly above the canopy when searching for mates and oviposition sites; 2. horizontal traps with the sticky side facing up, placed below the crop canopy are most effective; 3. most moth activity is between 2000 and 0300 h; 4. saturated green traps (with about 60% reflectance in the 500-550 nm range) are more attractive than blue, yellow, UV white or white traps; 5. DBM appears to respond to colours with wavelength maxima confined to a narrow band (450-550 nm) of the insect-visible spectrum; 6. larval populations can be predicted by trap catches of DBM 2 wks previously; 7. green sticky traps may possibly be used as an effective mass trapping system within a field; 8. male farmers have a higher participation rate in fieldwork than females; 9. women are involved in all tasks in cabbage production except the spraying of insecticides; 10. women participate mostly in planting seeds, weeding, and transplanting seedlings to the field; 11. no gender-based differences exist in terms of pest management knowledge, contrary to expressed beliefs that men are more knowledgeable; 12. women seem to perceive greater female involvement in decision-making than men do; 13. village differences in gender of hired labourers appear to be due to the level of commercialization and novelty of cabbage production; 14. levels of biological knowledge about cabbage pests are very high, but knowledge concerning proper pest management practices is low. A regionally-based sticky trap monitoring system for DBM is proposed, in conjunction with mass trapping in problem fields. This proposal may avoid many of the problems commonly associated with the introduction of new technologies.

Dedication

To Lawrence

For his unfailing support and love

and

To the people of Minahasa

Who gave freely of their time and hospitality

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Chapter I

Introduction

Twenty years ago the focus of agricultural development projects was on increasing agricultural production in developing countries through the introduction of modern technology: high yielding varieties (HYVs), fertilizers, pesticides, and machinery (Bunting & Harrison 1968). Agricultural extension programs were established in many countries with funding from the United Nations (von Blanckenburg 1984), and increases were made in agricultural production. However, the farmers who were able to take advantage of and benefit from improved services and inputs were typically those with large land holdings and access to credit (Meadows et al. 1972; Karl 1984a,b). In addition, much emphasis was placed on increasing cash crop production for export (in part to reduce foreign debts), and food crops, particularly those of subsistence-level farmers (male and female), were neglected. As a result, the great majority of farmers in developing countries were unable to benefit from the 'Green Revolution' (Sofranko 1984).

The success of the Green Revolution has been diminished by the negative social and cultural impacts that have accompanied it. It is now becoming apparent that technologies from developed countries are not always appropriate (socially, culturally, economically, or physically) for introduction to the developing world.

Indeed, the well-intentioned introduction of new technologies has sometimes resulted in the widening of existing social and economic inequalities and brought unforeseen hardships to the intended beneficiaries (Saouma 1984; World Commission on Environment and Development 1987). By adopting a holistic approach to development, and evaluating all impacts of a technology prior to its introduction, it is possible to ensure that it is "the technology most appropriate for a given place at a given time" (Karl 1984c). In order to avoid negative repercussions following the introduction of a new agricultural technology, the social characteristics of the target area must be taken into account beforehand, and the target farmers must be included in decisions regarding its development and introduction.

In adopting a systems approach, it has become evident that the cooperation and participation of women farmers is also a prerequisite for successful development. Rural women throughout the world are responsible for a considerable proportion of food production, processing and marketing (Loutfi 1980), and their contributions to agricultural production must be recognized if their work is also to benefit from the introduction of new technologies. The actual and perceived participation of women in agriculture, and the tasks that they perform, are particularly important to the design and impact of new agricultural technologies, development projects and extension services.

The ability of women to adopt improved technologies is constrained by their traditional responsibilities, culturally and socially acceptable norms of behaviour, and their level of control over and access to capital and education. In developing new technologies that are intended to be used by farmers, it is important to be aware of the respective roles of female and male farmers, so that the new technology can be targeted appropriately. It is therefore necessary to undertake baseline studies in order to determine their respective levels of knowledge, roles, and labour force participation rates before the introduction of a new technology to the agricultural system in question.

In this study I have undertaken research both towards the development of a technology to be used in agricultural pest management and sociological studies to determine in advance the appropriateness of the introduction of this technology to the target area in Indonesia. While the research disciplines may seem quite distinct, they are both critical to the development and successful adoption of the technology, a sticky trap monitoring system for the diamondback moth, *Plutella xylostella* L. (Lepidoptera: Yponomeutidae), a serious worldwide pest of cabbage. Thus, the objectives of this study were two-fold: 1. to determine what colour of sticky trap is most effective, and to establish basic practices for the use of a sticky trap monitoring system for the diamondback moth (DBM); and, 2. to obtain baseline data on current pest management practices, levels of pest management knowledge, and the roles of women and men in cabbage production in the study area. In this way it would be possible to determine how the monitoring system might be most successfully introduced and how its introduction might impact on women's involvement in cabbage production. This multidisciplinary approach was taken because I believe that researchers in the field of pest management, although concerned primarily with the development of pest monitoring methods and control, should also concern themselves with the sociological factors present in the target farming system that will influence the success with which the pest management system can be adopted.

Women's Roles in Agriculture in Developing Countries

In this review I have chosen to highlight the inequalities and problems faced by women farmers, particularly as a consequence of the intensification of agriculture and the introduction of agricultural technologies. I have adopted this approach in order to emphasize the necessity of including women in agricultural development policies and projects and to stress the importance of undertaking a multidisciplinary approach in agricultural research and planning. Some of the situations discussed are also characteristic of the inequalities experienced by small subsistence-level farmers, regardless of gender, when agricultural planning fails to take their contributions and roles into account.

Women in the agricultural labour force.

While the labour force statistics for women in agriculture vary between and within countries, on average women make up 38% of the agricultural labour force (Weidemann 1987), and are responsible for 40 to 80% of all agricultural production in developing countries (Weekes-Vagliani & Grossat 1980). However, in both developing and developed countries (Armstrong & Armstrong 1987), there is generally a consistent undercounting of women's participation in agriculture due to: poor definitions of labour force participation; poor quality and/or biases of interviewers; biases of male respondents and/or lack of knowledge on the part of proxy respondents; and, poorly constructed questionnaires (Anker et al. 1988).

Dixon (1982) undertook an analysis of census data from the International Labour Office (ILO), the Food and Agriculture Organization (FAO), and national censuses for 82 countries in order to standardize the estimates and establish accurate estimates of female participation in the agricultural labour force. Dixon concluded that women accounted for 46% of the agricultural labour force in sub-Saharan Africa, 31% in North Africa and the Middle East, 45% in South and Southeast Asia, and 40% in the Caribbean. Dixon's estimates are considered to be the most accurate available (Cloud 1985), and in all cases they are higher than those derived by other organizations.

Factors constraining women's participation in agricultural development.

In developing countries, women have multiple roles: as mothers, housekeepers, wage labourers, agricultural producers and processors, market traders, and entrepreneurs (Cloud 1985). As a result, women are responsible for a large number of domestic and agricultural tasks, many of which are extremely time-consuming and laborious (Stevens & Date-Bah 1984). Women's responsibility for agricultural production is related to sociocultural factors and to the prevailing farming system and, thus, varies according to region. However, women are generally responsible for planting, weeding, harvesting and carrying produce to the home, in addition to its processing and preparation for family consumption (Stevens & Date-Bah 1984). In general, women specialize in subsistence food crop production, as opposed to nonfood or cash crop farming, and as a result they are rarely the beneficiaries of improved agricultural technologies (Kumar 1987). In fact, the introduction of cash cropping often means both that women have less help from men and that they become responsible for tasks in cash crop production as well as in subsistence production (Stevens & Date-Bah 1984).

Many women are unable to participate in training sessions, cooperatives, and other activities that would help to increase their productivity, as "the scarcest resource for most low-income women is time" (Overholt et al. 1985). In Indonesia, poor women often do not even have the time to become involved in formal women's activities, such as the Applied Family Welfare Program (*Pembinaan Kesejahteran Keluarga*, PKK), provided in their village (Pyle 1985).

Women are also constrained by a society's expectations of their behaviour and roles. Typically, rural societies are structured so that women are provided some guarantee of security through obedience, self-sacrifice and submission to men (Loutfi 1980). Traditionally, women were not intended to be self-sufficient, and labour divisions evolved in accordance with this belief (Stevens 1984). Women often perform farm duties that are more time-consuming than men's, but they are not compensated for their time. Okorji (1988) concludes that the maintenance of sex roles is largely responsible for the poverty and low standard of living of rural women. Traditional social structures vary according to country and region, however. In contrast to other Muslim societies, women in Java have essentially the same rights as men in terms of marriage, divorce, inheritance and property rights, and consequently, have a considerable degree of economic independence and initiative (Pyle 1985).

Some argue that women's lack of access to and control over money is the greatest limiting factor to rural development (Dulansey & Austin 1985). Since women are generally responsible for subsistence rather than market production, they are rarely able to obtain the money or advice that would help them to improve the efficiency of their production (Huffman 1987). In Indonesia, access to credit is, in theory, equally available to men and women. In practice, however, men generally receive credit from formal institutions, while women rely on informal sources (Pyle 1985). The constraints faced by women heads of households are even more severe than those felt by rural women as a whole, usually because they lack the legal status to act as decision-makers and managers of their farms (FAO 1984), and may even be ineligible for direct membership in cooperative credit systems (Traore & Thiongane 1984; Dulansey & Austin 1985). Due to the low availability of women's time without being household heads, female-headed households are often labour constrained and consequently they are often unable to adopt advanced agricultural technologies (Kumar 1987). These women are rarely given special consideration, and often lack family and community support (FAO 1984).

When women have access to land it is most often provided to them after their husband has decided how much land and what fields he is going to cultivate. Consequently, women's landholdings are often quite small and are not of the best quality. The quantity of land under production has significant effects on the ability of farmers to adopt innovations. The larger the quantity of land, the lower the average cost of adopting a new technology per unit of land, and the higher the net benefits obtained per unit of land (Jamison & Lau 1982).

In many developing countries, it is the sociocultural norm to send boys to school in preference to girls, and for girls to work on family farms or as paid seasonal labourers, to make up for the absence of boys (Dixon 1982). As a result, women's understanding of improved agricultural techniques and principles is often limited (Weidemann 1987). It has been demonstrated that education increases productivity, and also that the formal education of rural women enhances the productivity of all farm inputs, including the time spent by their husband's in-farm production (Cloud 1985).

Jamison & Lau (1982) undertook a study to determine the relationship between education and the adoption of chemical inputs by Thai farmers. They found that more than four years of education was necessary before the probability of adopting the new technology was affected; the level of education of the household head and the availability of agricultural extension had significant effects on the adoption of technology. Larger landholdings, which correspond to higher levels of assets, were found to imply the greatest ability or willingness for the household to take risks. Because female-headed farms and female-managed fields are likely to be small and of poor quality, female farmers, like small farmers, are least *able* rather than least *willing* to take risks (Donovan 1987). In north India, the incentives of the Green Revolution technologies were equally apparent to males and females, but females were least likely to respond due to the cultural constraints that they experienced (Zarkovic 1987).

Traditionally women farmers have been overlooked by conventional agricultural extension programs, in part because of their emphasis on market crops and cash cropping for export, rather than the subsistence crops traditionally produced by women (Mollett 1984; von Blanckenburg 1984; FAO 1987). Additional problems with agricultural extension include the rarity of female extension agents, who would be able to make easy contact with rural women (Mollett 1984), and cultural traditions and biases which inhibit the flow of information from male extension agents to female farmers. There is also an idea that information will 'trickle down' to small farmers and women from progressive farmers. Whether or not this occurs in practice is debatable, as large farmers often have little interest in conveying extension messages to other farmers (von Blanckenburg 1984).

The appropriateness of technological introductions.

The introduction of agricultural technology to developing countries affects every part of these agriculturally-based societies. For example, the introduction of a new technology will affect and be affected by traditional roles and family power balances (Donovan 1987). As a result, women may experience unanticipated impacts of development projects and agricultural policies. This occurs both when women have been targeted as the beneficiaries of technological innovations and when their roles have been ignored.

The introduction of a technology may have several effects on women's roles. Any technology that alters the responsibilities of women and men in production may cause changes in status, access to and control over resources and income, and demands upon time (Anderson 1985). This may result from the introduction of a technology that divides a task into separate components in such a way that gender roles are altered (Anderson 1985). Rather than helping small farmers, labour saving devices may replace them and farm labourers (Mollett 1984). Many women are also displaced by the introduction of machinery, as tasks involving machinery are generally taken over by men (Zarkovic 1987). Technological changes may also increase demands upon women's time. This is particularly true when improved technologies, such as ploughs, high yielding varieties and fertilizer, are used, since these technologies must be accompanied by increased weeding if full benefits are to be achieved (FAO 1987).

The undertaking of pre- and post-introduction studies should help to reduce the negative impacts of introduced technologies. One must keep in mind that societies are not static, however, and that the severity of impact of a technology may alter over time as societies change. In

Indonesia, harvesting of traditional rice varieties was performed by women using hand-knives (*ani-ani*), but with the introduction of HYVs that must be harvested and threshed in the field to reduce losses by shattering, ani-ani were replaced by sickles and women by men as harvesters (Hardjono 1983). It has been estimated that with the ani-ani 200 person days were required to harvest 1 ha (Collier 1981). The introduction of sickles reduced this to 75 person days/ha, but also displaced a large number of female farm labourers. A subsequent study has revealed, however, that "as with many other aspects of technological change, men first use the new equipment, then it passes into women's hands and women are now harvesting with sickles as men have moved into other sectors" (World Bank 1985, cited in Berger & Horenstein 1987).

Women and Agriculture in Indonesia

The Republic of Indonesia is made up of 13,500 islands with a total land mass of 200 million ha (Birowo & Hansen 1981). Of this, about 30% is suitable for agriculture. In 1988 Indonesia's population was 175.58 million with an overall population density of 85 people/km^2 (Government of Indonesia 1990). The majority of Indonesia's population lives on the islands of Java (60.9%) and Sumatra (19.9%), with Java's population density (755 people/km^2) being among the highest in the world. Indonesia's average rate of population growth is 1.9%, among the lowest in the developing world, and the result of intensive family planning and population control programs (Government of Indonesia 1990).

Indonesia has also made quite significant advances in education; the adult literacy rate has increased about 20% since 1970 (Government of Indonesia & UNICEF 1989). In 1961, 69% of females and 44% of males over the age of 10 years were unable to read and write (Government of Indonesia 1985b). By 1985 these figures had decreased to 26% and 12%, respectively (Government of Indonesia & UNICEF 1989). The higher rate of illiteracy among women than among men should be noted, however. Boys and girls have the same rates of primary school attendance. After this, however, the percentage of boys attending school is 6-12 % higher than for girls, and this gap continues to widen throughout the upper levels of school (Government of Indonesia & UNICEF 1989).

In Indonesia, agriculture contributes more than a quarter of the Gross Domestic Product (GDP) and is the main source of livelihood for over half of the population (Berger & Horenstein 1987). Since 1967 Indonesian agricultural policy has focussed on increasing rice production in order to achieve self-sufficiency (Barbier 1989). This target was achieved for the first time in 1984, through the introduction of HYVs, expansion of irrigated lands and land under rice production, and increased usage of fertilizers and pesticides (Barbier 1989). The rice intensification program, which was heavily subsidized by the Indonesian government, made some spectacular gains in these areas. Annual rice production in Indonesia increased by about 3.5 million tonnes between 1975 and 1986 (FAO 1979; Barbier 1989). The total harvested area increased from 7.7 million ha in 1966 to nearly 10 million ha in 1986, and has contributed about a quarter of the increase in rice production (Conway & McCauley 1983; Jayasuriya & Shand 1986). The greatest contributor to the remarkable growth in rice production has been increased yields, which contributed 67% of the growth since 1963 (Herdt 1982). Rice now occupies 69% of the total area harvested under food crops, much of that in the fertile lowlands of Java, Bali, South Sulawesi and South Sumatra (Barbier 1989). Agricultural extension policies in Indonesia over this time have focussed almost entirely on rice production and pest management practices for rice. However, in 1990 the national integrated pest management (IPM) program (*Program Nasional Pengendalian Hama Terpadu,* PNPHT) began training for extension agents on IPM practices for non-rice food crops and vegetables.

Indonesian women's economic participation is considered to be quite high by Southeast Asian standards, and is increasing rapidly. In 1985, about 38% of women were active in the labour force, an increase of 5% over the 1980 labour force participation rate for women (Government of Indonesia & UNICEF 1989). This percentage compares to about 69% of men active in the labour force. Women's share of the labour force is also increasing and it is projected that by 1998 women will make up over 40% of the total labour force (Government of Indonesia & Unicef 1989). Women are already reported to make up 32% of the agricultural labour force (Berger & Horenstein 1987).

The number of women employed in agriculture increased 38% from 1961-1971 and a further 20% from 1971-1980 (Berger & Horenstein 1987). Similar, but higher increases in male employment in agriculture were reported over the same period. Despite the increased numbers of people employed in agriculture in Indonesia, the agricultural sector's share of the labour force has been steadily declining as Indonesia becomes a more industrially-oriented society. In 1985, about 54% of women active in the labour force worked in the agriculture sector, a decline of almost 5% since 1971 (Government of Indonesia & Unicef 1989). The percentage of men in the labour force working in agriculture declined from 65.5% to 55.3% in the same time period. There appear to be some discrepancies in the literature regarding women's participation in agriculture, however, which may arise from the inconsistent use of labour force definitions. For example, Sudjahri (1980) cites Government of Indonesia censuses stating that 81.9% of women worked in agriculture in 1961 and 67.9% in 1971. The 1980 census shows, however, that 70% of *rural* women were involved in agriculture (Government of Indonesia 1985a).

The Basic Guidelines of State Policy for 1978, 1983 and 1988 have stated that Indonesian women have the same rights, responsibilities and opportunities as men to participate fully in all development activities (Government of Indonesia 1985a; Government of Indonesia & UNICEF 1989). In addition, it is stated that women's roles and responsibilities in development will be "enhanced by improving their knowledge and skills in various fields according to their needs and capabilities" (Government of Indonesia 1985a). Particular emphasis is also placed on increasing women's activities in improving family welfare through the PKK movement.

The Government of Indonesia (1985a) has formally recognized the need to take into account and enhance the roles of farm women in strengthening village economies and their participation in food production, in order to further national development. The Ministry of State for the Role of Women has identified several obstacles that need to be overcome if women are to be full partners in the development process:

1. low education and skill levels among women;
2. prevailing cultural biases that degrade the social status of women and that suggest that women are limited by their nature;
3. the attitudes of women themselves, which limit their aspirations;
4. the displacement of female wage earners by modern agricultural technologies which are more accessible to male than female workers;

5. lack of community awareness concerning the significant role played by women farmers; and,

6. sociocultural practices which limit women's rights to land ownership (Government of Indonesia 1985a; Government of Indonesia & UNICEF 1987).

However, the Basic Agrarian Law of 1960, which is largely modelled on western property laws, stressed a shift away from the corporate ownership of property toward the individualized registration of land in the names of men (Wazir 1987).

The government has proposed to employ a variety of strategies to help change this situation:

1. the granting to women of full and effective rights to land ownership, in accordance with prevailing agrarian legislations and laws;

2. improved policy implementation to guarantee the integration of women at all levels and to ensure that women benefit in accordance with their contributions;

3. the promotion of increased involvement of women in agriculture and food research; and,

4. increased education of fisheries and farm women in agroeconomics, agrobusiness, agrotourism and agroforestry. (Government of Indonesia & UNICEF 1987).

Despite these aims and realizations, however, the government programs targeted at poor and rural women have largely been social welfare programs (such as PKK and P2KSS, the 'Program for Enhancing the Role of Women in Fostering a

Healthy and Prosperous Family') that have continued to address rural women more in their roles as wives and mothers than as producers (Berger & Horenstein 1987).

The Diamondback Moth in Indonesia

The diamondback moth, *Plutella xylostella* L. (Lepidoptera: Yponomeutidae), is a worldwide pest of cruciferous crops. Due to the close relationship between this moth and the crucifers, it is assumed that it originated in Asia Minor, the centre of origin of the Brassicaceae (Chu 1986; Simpson & Conner-Ogorzaly 1986).

Serious damage by the diamondback moth was reported from Java, Bali, Sumatra, North Sulawesi and other parts of Indonesia in the early 1900s, but major research efforts only began in 1968 when there was a severe outbreak of this pest in West Java (Sastrosiswojo & Sastrodihardjo 1986). Since that time the DBM has been the most destructive insect pest of cruciferous crops in Indonesia. Yield losses due to DBM are considered to be one of the two most important factors (the other being lack of availability of high quality seed) that limit production of cruciferous crops in Indonesia (Sastrosiswojo 1990). Other factors limiting vegetable production include the high cost of production, and land erosion due to the practice of growing vegetable crops in highland areas (Sastrosiswojo 1990).

Within the last few years, the cabbagehead caterpillar *Crocidolomia binotalis* Zell., has started to displace DBM as the most important pest of cabbages in Java (S. Sosromarsono[1], pers. comm.).

Early research on DBM in Indonesia included the introduction of the ichneumonid parasite *Diadegma eucerophaga* Horstm., from New Zealand to parts of Java and North Sumatra (Vos 1953). Since that time re-releases of the parasite in these areas have been made as well as new introductions to Bali, North and South Sulawesi and Irian Jaya (Sastrosiswojo & Sastrodihardjo 1986; D. Sembel & N. Nortje Wanta[2], pers. comm.). In Java, Bali and Sumatra, *D. eucerophaga* has been able to establish itself quite successfully and has been able to expand into surrounding areas. Larval parasitism averages 70-82% where *D. eucerophaga* has become well established (Sastrosiswojo & Sastrodihardjo 1986). However, *D. eucerophaga* is unable to keep DBM populations below injurious levels, due to several possible factors, including the use of nonselective insecticides, which are harmful to the parasite, and the discontinuity of cruciferous host plants through both space and time in some Indonesian farming systems (Sastrosiswojo & Sastrodihardjo 1986).

Current research on biological control in Indonesia includes the importation of *Apanteles* and *Trichogramma* spp.

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[2]Departemen Pertanian, Universitas Sam Ratulangi, Manado, North Sulawesi, Indonesia.

from Taiwan (S. Sastrodihardjo[3], pers. comm.). There is also an indigenous species of *Apanteles* in Indonesia but it is not important as a biological control agent for DBM (S. Sastrodihardjo and S. Sosromarsono, pers. comm.).

Resistance problems.

The diamondback moth has a remarkable ability to develop resistance to insecticides. Resistance has been documented to compounds in each of the four major insecticide groups: synthetic pyrethroids, carbamates, organophosphates, and tertiary amines (Cheng 1986; Sun et al. 1986). The synthetic pyrethroids are the most effective insecticidal compounds for controlling DBM (Liu et al. 1982). However, resistance develops very quickly in DBM and high levels of resistance have already been documented in the field (Iman et al. 1986; Sastrodihardjo 1986; Sastrosiswojo et al. 1989).

In Indonesia, DBM resistance to DDT was first reported in 1953 (Ankersmit 1953). Since then studies indicate that DBM has developed resistance to organophosphates, carbamates and synthetic pyrethroids (Sastrosiswojo & Sastrodihardjo 1986; Sastrosiswojo 1990). A recent Javanese study found that DBM had developed resistance levels of 1972-fold, 31-fold, and 267-fold to acephate, triaphos and decamethrin,

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[3]Pusat Antar Universitas- Bidang Ilmu Hayati, Institut Teknologi Bandung, Bandung 40132, Indonesia.

respectively, in comparison to permethrin (Sastrosiswojo et al. 1989).

Control of DBM is particularly difficult in tropical countries, where the development of resistance is accelerated by continuous cropping of host plants, multiple and overlapping generations of DBM, and intensive insecticide spray programs (Liu et al. 1982). These conditions occur in the highland vegetable growing regions of Indonesia, where control programs still very much rely on the use of insecticides. While formulations of *Bacillus thuringiensis* Berl. and insect growth regulators (IGRs) were reportedly introduced to vegetable growers by 1984 (Sastrosiswojo 1990), they are not yet available in all areas of Indonesia and farmers continue to use the organophosphates and synthetic pyrethroids.

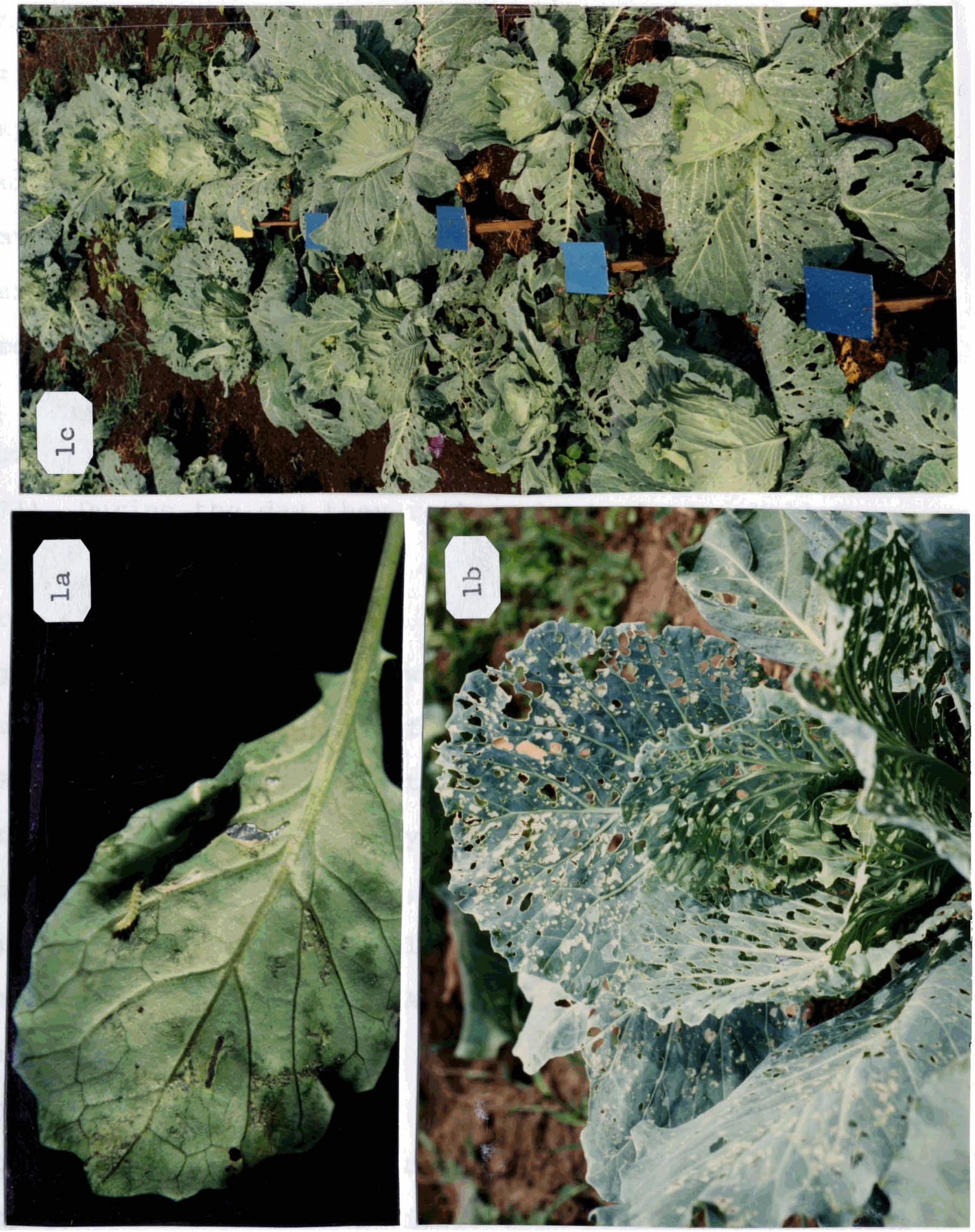
One study in West Java found that pesticides accounted for 30% of the total variable costs of cabbage production (Woodford et al. 1981, cited in Sastrosiswojo 1990). Both the inability of many farmers to cope with such high pesticide costs and problems of insecticide-resistance make the development and promotion of an integrated management program for DBM in Indonesia essential. The foundations of a successful IPM program have been laid already through the fairly widespread release of *Diadegma eucerophaga*, and research that has been undertaken concerning cultural control practices and the identification of selective insecticides (Sastrosiswojo & Sastrodihardjo 1986;

Sastrosiswojo 1990). What is required to develop these elements into an effective and complete IPM program is the promotion of selective insecticides in order to help protect parasite populations, and the development of monitoring systems or threshold levels that can be used by farmers to reduce pesticide sprays and to time them more effectively. While research has established control thresholds, this information has not yet been effectively conveyed to or widely adopted by growers of cruciferous crops.

Life cycle and ecology.

The eggs of DBM are laid singly or in groups of 2-8, generally on the uppersides of host plant leaves (Harcourt 1961; Beirne 1971; Tabashnik & Mau 1986). There are four larval instars. The first instar burrows into the leaf from the lower surface and mines in the mesophyll (Beirne 1971). At this stage the larvae and mines are very small and difficult to discern with the naked eye. The older instars are surface feeders, although they may feed with their head and thorax buried into the leaf tissue (Harcourt 1961). The older larvae generally feed on the lower leaf surface, causing a characteristic windowing effect (Beirne 1971) (Fig. 1a,b). If population densities are high, the older larvae may also feed on the florets of broccoli and cauliflower and bore into the heads of cabbage (Beirne 1971; Kirby & Slosser 1984). The larvae wriggle backwards when disturbed and drop from the host plant on a silken thread.

Figure 1. (a) Diamondback moth larva on underside of leaf of cabbage seedling. (b) Damage to cabbage plant caused by diamondback moth. (c) Arrangement of traps of one replicate (blue shade series) within a group of cabbages.


1c
1a
1b

The distribution of DBM larvae on cabbage plants is contagious and has been described with both the negative binomial distribution (Harcourt 1960) and the mean crowding ratio (Sivapragasam et al. 1986). First instar larvae will disperse from crowded to less crowded plants. Thereafter there is little or no larval migration, until mature larvae leave crowded plants to search for suitable pupation sites (Harcourt 1960). Pupation occurs in a delicate open-meshed cocoon on the host plant or nearby surface (Beirne 1971).

Adult moths are most active at dusk. Feeding on wild flowers, mating and oviposition occur at this time (Beirne 1971). During the day they rest on host plants. Moller (1988) observed that 44% of copulations occurred in the first 2 h of darkness, with oviposition almost always beginning immediately afterwards. Harcourt (1957) found that females mated only once in field conditions, whereas Moller (1988) observed multiple matings in the laboratory. The total number of eggs laid by a female is dependent primarily upon her weight at pupation, as well as the food plant on which she was reared, larval density, temperature and photoperiod (Moller 1988). An average of 160 eggs may be laid (Beirne 1971). Pivnick et al. (1990) also found that exposure of both female and male moths to the host plant after emergence affected ovarian development, the onset of mating, and the number of viable eggs produced by a mating pair.

Male and female adults can reportedly be distinguished by their wing markings. Wings of male moths are brown with white triangular patterns along the lower edge; at rest, these triangles form the diamonds for which the moth is named. The diamond pattern is not obvious on the wings of the female, which are greyish in colour and of more uniform patterning (Moriuti 1986). I found in North Sulawesi that these colour and pattern differences are not absolute and are not reliable for sexing specimens.

In a study of the major mortality factors affecting DBM populations in Ontario, Harcourt (1963) found that rainfall caused an average of 56% mortality from hatching to the middle of the fourth instar, and an additional 9% before cocoon formation. The small larvae are readily dislodged by rainfall and are washed or wriggle into leaf axils or water pockets on the ground where they drown. In humid weather, early instars may even drown if trapped in a droplet of dew. The death of adult females prior to laying their full complement of eggs, due to inclement weather, is the critical factor in the population dynamics of this moth in Ontario.

In tropical climates, however, adult mortality due to cool weather is unlikely to limit the growth of a DBM population. In laboratory studies in Malaysia, the intrinsic rate of increase (r_m) was found to be highest at 30°C (Sivapragasam & Heong 1984). In Malaysia DBM field populations are larger during the hottest part of the year

(24°-32°C), and in the highlands where temperatures are slightly cooler (20°-24°C), the populations are advantaged by intensive cultivation of their host plants (Sivapragasam & Heong 1984). In addition, the optimum temperature range for cabbage is 15.6°-18.3°C (Lorenz & Maynard 1988). Thus, in the tropics, temperature conditions will favour the DBM over its host plant. Because rainfall is a limiting factor for DBM populations, outbreaks in Indonesia appear to be triggered by dry conditions in the months of September and October (Sastrodihardjo 1986).

The potential of sticky trap monitoring systems.

The need for effective action or economic threshold levels has already been identified. In North America, partial plant sampling procedures, action thresholds and visual damage thresholds have been developed and proposed for monitoring lepidopterous pests of cabbage, including *Plutella xylostella* (Chalfant et al. 1979; Workman et al. 1980; Shelton et al. 1983; Sears et al. 1985; Cartwright et al. 1987; Stewart & Sears 1988). In Indonesia, however, the implementation of this type of threshold level is limited by low levels of education among farmers, by the difficulties in effectively providing extension information to most farmers, and by the time constraints experienced by farmers. Thus, a monitoring system that relies upon a tool, such as a sticky trap, could be more effectively utilized than one based upon regular field sampling of larval populations. In a Texan study, the reason most commonly given by farmers for not employing recommended economic threshold levels for key sorghum pests was uncertainty about their ability to sample the insects accurately (Merchant 1989). It would seem, therefore, that a sticky trap monitoring system would both relieve farmers' uncertainties regarding sampling, and be more easily explained and promoted among farmers with low levels of education and high demands on their time. Such a system would be particularly effective with an insect pest such as DBM, that has small, difficult to detect, larvae.

There is a critical absence of baseline information that can be used in establishing a sticky trap monitoring system for DBM in Indonesia. The potential for using such a system to forecast adult DBM populations was demonstrated in a study by Sivapragasam & Saito (1986), in which the number of moths caught on traps was found to be significantly correlated (r=0.83) with the mean number of emerged moths per day. Yellow sticky traps were used by Butts & McEwen (1981) to monitor the flight periods of DBM populations in Ontario. However, there is still a need for refinements, e.g. for optimal trap height and orientation to be established, for the most effective colour trap to be identified, and especially for relationships between trap catches and larval populations or damage levels to be determined.

The attractiveness of different hues of sticky traps to DBM were evaluated by Sivapragasam & Saito (1986) in a manipulated system. DBM was trapped in highest numbers on yellow traps. However, differences in the apparent attractiveness of certain trap hues could have been explained by differences in the intensity and saturation of the hues used. Research into the visual responses of the onion fly, *Delia antiqua* Meigen, has demonstrated that it is not only the dominant wavelengths or hue of the sticky trap which affect the visual behaviour of the insect, but that other spectral components also affect insect behaviour (Judd et al. 1988). Onion fly alightment on traps was negatively correlated with the percent UV (350 nm) and green (540-580 nm) reflectance, and positively correlated with percent blue reflectance (430-470 nm). In addition, alightment on traps was found to vary in relation to the proportion of reflected 'stimulatory' and 'inhibitory' wavelengths. A similar study with western flower thrips, *Frankliniella occidentalis* Pergande, found that thrips preferred traps that were bright blue, violet, yellow or white (Vernon & Gillespie 1990). However, green, orange and UV-reflecting white hues were not attractive. Reduced reflectance intensity and desaturation of the attractive hues was found to result in decreased alightment by thrips. As well as providing information about insect colour vision and behavioural responses, these studies emphasize the need for all components of colour (hue, intensity and saturation) to be evaluated when trying to establish the most appropriate colour of trap to be used in a monitoring system.

Chapter II

The Study Area

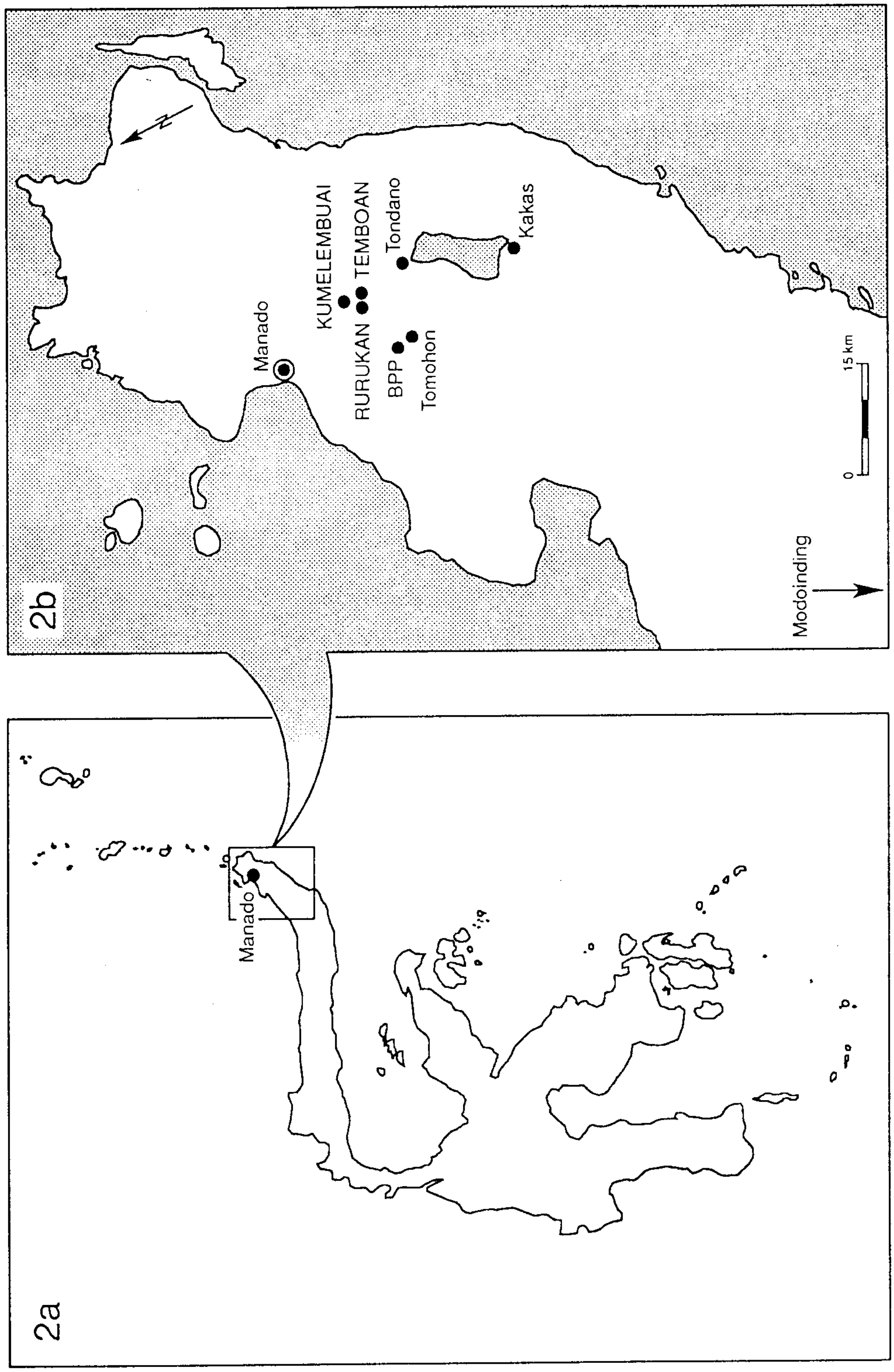
The research for both aspects of this study was conducted from July 1990 to May 1991 in *Kecamatan* (sub-district) Tomohon, a major vegetable-growing region in the province of North Sulawesi.

The island of Sulawesi (formerly Celebes) (Fig. 2a) makes up 9.9% of Indonesia's land area, and in 1985 supported 7.0% of the population (Government of Indonesia 1990). In North Sulawesi, coconuts and cloves are the major commercial crops, and the major food crops are rice, corn and peanuts (Government of Indonesia 1990).

Since temperature is relatively constant year-round, the climatic descriptions of Sulawesi are based upon rainfall (Whitten et al. 1988). In North Sulawesi there are less than 3 consecutive dry months in the year and 2000-3000 mm of rain annually (Whitten et al. 1988; Government of Indonesia 1990). In Manado, the capital, there is usually a short dry season between August and October, and much of the surrounding area falls into an agroclimatic zone characterized by 7-9 consecutive wet months and 3 or less consecutive dry months, where a 'wet' month receives >200mm of rain and a 'dry' month receives <100mm (Oldemann & Darmiyati 1977, cited in Whitten et al. 1988).

Kecamatan Tomohon is located in the hills about 25 km south of Manado, within the administrative and cultural

Figure 2. (a) Map of Sulawesi. (b) Map of Minahasa, North Sulawesi. (BPP= *Balai Penyuluhan Pertanian*, Kakaskasen II, Kecamatan Tomohon).


2b
Manado
KUMELEMBUAI
RURUKAN
TEMBOAN
Tondano
Kakas
BPP
Tomohon
0
15 km
Modoinding
2a
Manado

district (*kabupaten*) of Minahasa (Fig. 2b). Kecamatan Tomohon is composed of a town-like center, actually composed of several *desa's* (villages), and a number of other desa's that are more rural in character. The soils in Tomohon are ferrasols (Whitten et al. 1988), and soil fertility levels are occasionally increased by emissions of ash and debris from Gunung Lokon, a still active volcano. Temperatures in Tomohon range from 18-30°C (Kecamatan Tomohon 1988).

Kabupaten Minahasa is fairly unusual in that about 91% of its population are Christians, whereas Indonesia as a whole is about 88% Muslim (Mai & Buchholt 1987; Sudjahri 1980). This is due to the influences of both the Portugese, who introduced Catholicism in the 1560s, and the Dutch missionaries, who introduced Protestantism in the 19th century (Mai & Buchholt 1987; Whitten et al. 1988). The Dutch missionaries are also credited with the traditionally high standards of education in Minahasa. Literacy levels in Minahasa continue to be above the national average; in 1981 the literacy rate in Minahasa was 97.9% (Mai & Buchholt 1987).

Historically, women in Minahasa have been recognized legally as people in their own right, and have informally shared equal rights to property shared with their husbands, autonomous rights over private property, and an 'equal say' in family matters (van Bemmelen 1987). Legal changes made to marital and property laws by the Dutch colonial government in the late 19th and early 20th centuries eroded women's status (van Bemmelen 1987). However, it appears that Minahasan women still have a relatively liberated status in comparison to women in some other cultures.

While *Bahasa Indonesia*, the national language, is spoken widely in Minahasa, many villagers continue to speak in one of the 5 regional languages (in Tomohon, *Bahasa Tombulu*), which belong to the Malayo-Polynesian language group and are closely related to the Filipino languages (Geertz 1963). A sixth regional language, *Bahasa Manado*, is often used for communication between speakers of different regional languages within Minahasa.

In a study of another Minahasan kecamatan (Kakas), Mai & Buchholt (1987) found that 82% of village households derived their income from agriculture. There is considerable overlap in income sources, however, as trading provided income to 36% of households, the civil service to almost 20%, and fishing to 12%. All of these activities, with the exception of fishing, are also important sources of income for inhabitants of Kecamatan Tomohon. In Tomohon, 74% of the labour force are farmers (Kecamatan Tomohon 1988).

In 1973, the average landholding in North Sulawesi was 1.62 ha, but nearly half of all farmers owned less than 1 ha (University of British Columbia 1979). In Kakas, 92% of households own land; the majority (80%) of households own less than 1 ha, 6% own more than 4 ha, and 8% own no land at all (Mai & Buchholt 1987). In comparison, in Java about 30% of households are landless, about 30% own less than 0.25 ha, 20% own 0.25-0.50 ha and about 20% own more than 0.50 ha (White 1985).

Tomohon is one of two important centers of vegetable production in North Sulawesi. The only other area where vegetable crops are widely grown is Modoinding, about 70 km to the southwest of Tomohon. Thus, vegetables grown in Tomohon are used not only to feed the local population, but are also sold in many other parts of the province. In addition, some vegetables, including cabbage are shipped for sale to Irian Jaya and other islands. In 1990, of the 13 vegetable crops grown in Tomohon, carrots (149 ha), cabbage (127 ha), and petsai (124 ha) were grown over the largest areas (Kecamatan Tomohon 1991). Of the vegetables grown, cabbage has the highest level of production (approximately 1905 tonnes). Cabbage production in Tomohon requires a fairly high investment in comparison to other vegetable crops, as it is necessary to purchase imported seeds and fertilizer. Due to the instability of the market, cabbage growers can either gain or lose a large amount of money on their crop.

I conducted research in four desa's in Kecamatan Tomohon. Sticky trap studies, except for those carried out in farmers' fields, were conducted in Kakaskasen II; the remaining studies were conducted in Rurukan, Temboan, and Kumelembuai. In Kakaskasen II my experiments were carried out at the Kecamatan's agricultural extension center (*Balai Penyuluhan Pertanian-Tomohon*, BPP). This village lies on fairly flat land at the foot of Gunung Lokon, at an elevation of about 720 m above sea level. Fields at BPP that are not being used for research or demonstration are rented to farmers in the area. It was at this location that the first release of *Diadegma eucerophaga* was made in May-June 1990, in a study designed to examine the speed with which *D. eucerophaga* is able to spread.

Rurukan, Temboan and Kumelembuai are all located at an elevation of about 1000 m above sea level, 12 km from the administrative center of Tomohon. These three villages had the 3 largest areas under cabbage production in the kecamatan in 1990 (collectively 43.5 ha) (Kecamatan Tomohon 1991). Prior to 1960 the primary food crop grown in these villages was corn. Vegetable production was introduced to Rurukan in the 1940s, and has since become the major type of production in Rurukan and Temboan. In Kumelembuai, a large proportion of farmers still grow corn as their primary crop, and only over the last 2-5 years have farmers begun to cultivate vegetables, including cabbage.

Rurukan and Temboan were once a single village, but in 1984 were divided for administrative purposes. Kumelembuai is about 2 km from Rurukan-Temboan, and can only be reached by vehicle through these villages. These three villages have similar populations (Rurukan 1461, Temboan 1019, Kumelembuai 1147) and similar religious compositions (a large proportion of Protestants and a smaller component of Catholics).

Rurukan and Temboan are connected by road to Tomohon center and to Tondano, the administrative center of Minahasa. There is frequent service by public transport to Tomohon, particularly on main market days (Mondays, Wednesdays, and Fridays). Due to the lack of transport from Kumelembuai, most residents walk to Rurukan and then get public transport down to Tomohon in order to go to the market or school. There are primary schools in both Rurukan and Kumelembuai, but junior and senior high school students must attend school in the center of Tomohon. High schools specializing in agriculture, teacher training, and technical skills are all present in Tomohon.

Chapter III

Experiments Towards the Development of a Sticky Trap Monitoring System for Plutella xylostella

A number of experiments towards the development of a sticky trap monitoring system for the diamondback moth were performed in both experimental and farmers' fields. The specific objectives were to:

1. determine the appropriate trap orientation and trap height to be used in a monitoring system;
2. determine patterns of moth activity;
3. evaluate comprehensively the relative attractiveness of different hues of trap to DBM, and of shade and tint for each of the hues examined;
4. evaluate the attractiveness of traps of different hues at different crop stages;
5. evaluate the attractiveness of traps of different hues in the presence and absence of host odours;
6. determine DBM population fluctuations throughout a growing season;
7. determine whether host plant condition (in terms of level of pest damage) affects the attractiveness of traps of different hues;
8. examine the relationship between DBM populations (as measured by trap catch) and pest management practices; and,
9. determine the relationship between trap catch and larval DBM populations.

Unless otherwise noted, experiments were carried out on two adjacent fields, each approximately 0.25 ha in size, at BPP. These fields were cultivated following the same practices employed by cabbage growers in this region.

Methodology and Analyses

1. Cabbage cultivation.

Seedlings were raised in a nursery enclosed by fine netting in an attempt to protect them from attack by DBM. On 20 July 1990, the seeds (K-K Cross, a hybrid cabbage suitable for lowland tropical regions) were planted in small plastic bags that contained a 1:3 mixture of chicken manure:soil, and were watered three times per week. The nursery was sprayed with Sumicidin 5EC insecticide (fenvalerate 44.5 g/L) at a concentration of 1 mL Sumicidin: 1 L water three weeks after sowing of the seeds.

The seedlings were transplanted to the first field one month after seeding, and were planted in two rows per bed with a distance of 60 cm between plants and 50 cm between rows. The beds were 1 m wide, 70 m long and separated by a 50 cm wide alley. Within each bed, groups of twenty cabbages were formed by increasing the 60 cm interplant distance to 1 m between every tenth plant in the row. There were 11 such groups of cabbages in each of the 20 beds, for a total of 4,400 plants. Three days before transplanting, chicken manure and tri-super phosphate were mixed into the soil at the location of each plant. Furadan 3G (carbofuran) granules were applied to each hole at the time of transplanting to protect the seedlings from cutworm damage. Each seedling was protected from the sun for 5 days by a leaf 'tent' of *Cordyline terminalis* (Liliaceae). Due to the absence of rain the field was watered 2-3 times a week during August and September. Cabbage seedlings that died due to cutworm damage or lack of water were replaced with seedlings from the nursery at 1-2 weeks after transplanting. At 3 weeks after transplanting, cabbages were moved from the 'buffer' rows to replace cabbages that had died within the experimental cabbage groups. Urea (20 kg) was applied at 2 weeks after transplanting and a mixture of urea:TSP:KCl fertilizer (20:10:10 kg) was applied at 3.5 weeks after transplanting. At 3 weeks after transplanting, insect pests and eggs (DBM, aphids, other Lepidoptera) were removed by hand from each cabbage. The cabbage beds were hand-weeded and weeds were also cleared from the alley ways at 3.5 weeks after transplanting.

Seeds for the second 0.25 ha field were planted in the nursery on 25 August 1990, and seedlings were transplanted to the field 26-27 September. The methods employed were the same as for the preceding field, except that it was not necessary to water the cabbages once they had been transplanted. Seedlings that died were replaced with seedlings from the nursery at 4 days, 1 week, or 3 weeks after transplanting. Fertilizer was applied at 1 and 4 week after transplanting, and the beds and alleyways were weeded at 4 weeks after transplanting. No handpicking of larvae or eggs was done in the second field.

2. Sticky trap materials.

All coloured cards used in the sticky trap experiments were prepared in Canada, by painting white bristol board with paints (Cloverdale Paint & Chemicals, Surrey, B.C., Canada; UV white paint from Carter Chemicals, Montreal, Que., Canada) of 5 saturated reference hues (yellow 776, green 785, blue 871, and non-UV and UV white), tints (increasing amounts of non UV- and UV-reflecting white paint added to the reference hues), and shades (increasing amounts of black added to the reference hues). The reference hues and tint and shade series, and spectral reflectance curves correspond to those reported by Vernon & Gillespie (1990). The painted sheets were cut into rectangles (8.5 x 14 cm and 10.5 x 14 cm). The sticky traps were prepared by coating the top of each coloured card with Stickem Special (Seabright Enterprises, Emeryville, California, USA), a colourless substance that has a negligible effect upon the percent spectral reflectance of the trap hue (R.S. Vernon[1], pers. comm.).

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[1]Vancouver Research Station, Agriculture Canada, 6660 NW Marine Drive, Vancouver, B.C., Canada V6T 1X2.

3. Trap height and trap orientation experiments.

Two experiments were carried out in a farmer's field (50 x 20 m) adjacent to BPP on August 15-16 and August 24-25, 1990. The cabbages in this field were of two different sizes that corresponded to approximately one month's difference in growth. In both experiments yellow 776 sticky traps (10.5 cm x 14 cm) were used.

The first experiment was designed to examine the differences between moth catches on horizontally-oriented, and north- or south-facing, vertically-oriented traps at two different heights in the two different sized cabbage patches. This experiment had a 3-way factorial design (3 trap orientations x 2 trap heights x 2 cabbage sizes) and was replicated twice. Trap heights were 20 and 35 cm (measured from the middle of the trap for vertically oriented traps). Traps were systematically positioned in the field so that the different trap heights and orientations were evenly distributed throughout the field. The traps were examined five times over the course of 30 h. Due to the large number of traps that did not attract any moths, a $\log_{10}(x+1)$ transformation of total trap catches was made before analysis with a three-way ANOVA (Á = 0.05 in all statistical analyses).

Due to the vulnerability of horizontal traps to damage by rain, a second experiment with a 2-way factorial design (2 trap orientations x 2 cabbage sizes), replicated four times, was undertaken in the same field to determine whether there were any differences in the attractiveness of horizontal traps that had their sticky side facing upwards or downwards. Yellow traps were systematically placed in the field for 24 h. Trapping height was 20 cm in the smaller cabbages and 23 cm in the larger cabbages. $Log_{10}(x+1)$ transformed data were analysed by two-way ANOVA.

4. Times of peak moth activity.

One yellow trap (10.5 x 14 cm) was placed 13 cm high in the centre of each of five randomly chosen groups of cabbages at 0900 h on 20 September, 1990 (5 weeks after transplanting) in the first field at BPP. The traps were checked hourly for 24 h; captured moths were removed and their sex determined. The sun set at approximately 1740 h on 20 September and rose at 0530 h on 21 September (Badan Meteorologi dan Geofisika 1990). On the night of 20 September the moon was a quarter full and waning, and the sky was clear.

All traps used in this and subsequent studies were horizontally-oriented, and placed at a standard height of 10 cm below the crop canopy (determined by measuring the tallest leaf on 10 plants). Sticky traps were placed between the two rows in a group of cabbages so that each trap was surrounded by 4 live cabbage plants (Fig. 1c). Immediately adjacent groups of cabbages in the same row or adjacent rows as a selected group of cabbages were not included in subsequent selections for replicates of experiments carried out during the same time period.

This and all subsequent experiments were initially analysed by ANOVA. If transformations did not improve the homoscedasticity of the data, and if only one factor was found to be significant (or nearly so), Kruskal-Wallis tests were conducted to confirm the ANOVA results. Differences between treatments were then determined with Student-Newman-Kuels test.

5. Hue comparisons.

A 5x5 Latin square experiment with the reference hues (yellow 776, green 785, blue 871, white and UV-reflecting white), was carried out on 20-21 September, 1990 (5 weeks after transplanting) in the first field of cabbages. Each row of the Latin Square (i.e. a 'replicate') was placed in a randomly selected group of cabbages. Trap size was 10.5 x 14 cm and trap height was 13 cm.

Unless otherwise noted, in this and all subsequent experiments, intertrap distance within a replicate was 60 cm, trapping duration was 24 h, and the sex of all moths captured was determined. If abdomens were missing or in poor condition, the moth was included in the total number of moths, but not in either sex. With the exception of this experiment all colour studies used 8.5 x 14 cm traps.

The data from one trap, on which 5 females and 22 males were captured, were removed from all analyses. On other traps the total number of moths caught ranged from only 0-12. The presence of five, possibly attractive, females on this trap may explain the disproportionately large number of males caught on this trap.

Due to low trap catches, data for all traps of reference hues occurring in all colour experiments (with the exception of the yellow shade series) were pooled and analysed by ANOVA and the Student-Newman-Kuels test in order to emphasize the differences between hues. It was assumed that the presence of a yellow trap as a standard in each of these experiments would minimize differences due to the experiments being carried out on different dates.

6. Tint series of the reference hues.

Between 27 September and 1 October 1990, 7x7 Latin square experiments were conducted in the first field at 6 weeks after transplanting to examine the attractiveness of traps in a graded tint series of three reference hues: yellow 776, green 785, and blue 871. Experiments with the complementary UV- and non UV-reflecting tint series for each reference hue were carried out on the same day. Each experiment consisted of the reference hue, 4 tints (5 in the case of the yellow series), either white or UV-white, as appropriate, and a standard yellow 776 trap. Trap height was 14 (yellow and green series) or 19 cm (blue series).

A UV-white tint series (75%, 90%, 95%, 97%, and 100% of UV-white) experiment was carried out 6-9 November, 1990 in the second cabbage field (6 weeks after transplanting). Trap height was 22 cm and the trapping duration was 72 h.

7. Achromatic shade series.

On 2-3 October, 1990, two grey shade series (UV- and non-UV reflecting) experiments were carried out. The 7x7 Latin squares consisted of 5 shades, either white or UV-white, and a standard yellow 776. Trap height was 19 cm.

8. Shade series of reference hues

Non-UV reflecting shade series, Latin square experiments for the reference hues yellow 776, green 785, and blue 871 were carried out 3-4 October, 1990 on the first cabbage field. Treatments consisted of the reference hue and 3-5 shades. The blue and green shade series included yellow 776 as a standard. Trap height was 19 cm.

9. Other experiments.

Experiments designed to determine the attractiveness of different trap hues at 3 crop stages, the effect of host plant condition on trap catch, and the attractiveness of trap hues at different heights in the presence and absence of the host plant were also conducted. However there were no useable results, due to very low moth populations.

10. Monitoring Plutella populations in farmers' fields.

Experiments were conducted in the fields of farmers from the villages of Rurukan, Temboan and Kumelembuai. A subsample of cabbage growers was selected from those that participated in the surveys carried out in these villages (see Chapter IV). After the preliminary questionnaire, growers were categorized as spraying insecticides in their fields at either high (>1 spray/wk) or low (<1 spray/wk) frequencies. One married couple from each category was selected from each of the three villages according to the following criteria:

(i) cabbage seedlings had been transplanted to the field between 1-3 weeks previously, or (in one case) had been directly seeded 6 weeks previously; and,

(ii) both members of the couple were reported as being active in cabbage production.

Since no couples from Kumelembuai satisfied these criteria, two single men whose crops fulfilled the first criteria were selected.

Four yellow sticky traps were placed in the center of four randomly selected 5x5 m quadrats in each of the selected fields for the duration of the growing season (25 February-22 April, 1991). The traps were checked and replaced once weekly, and the sex of all moths caught was determined. In addition, weekly counts of all larvae present on the outer leaves and first head leaf of 6 randomly selected plants per quadrat were performed nondestructively. Initial trap height was 5 cm for all fields, except field #3 in Temboan (10 cm). Trap heights were adjusted on 25 March (Fields #1 and 4, 10 cm; #2 and 3, 18 cm; #5, 19 cm; #6, 14 cm).

Through a series of questionnaires the timing and dosages of all insecticide applications were recorded. Cabbage growers were also asked about decision-making processes and other activities in their cabbage fields.

Data were analyzed by regression analyses to determine the relationships between captured females and males; catches of adult DBM and larval populations; and, the relationship between trap catch and larval population/plant plus distance between traps and sample plants. Field and date effects upon trap catches and larval populations were analyzed by ANOVA and the Student-Newman-Kuels test.

Results

1. Trap orientation and trap height.

Horizontal traps captured significantly more moths than vertical traps, and traps with sticky sides upwards caught significantly more moths than those oriented downwards (Table 1). Traps within or at the crop canopy (20 cm) attracted significantly more moths than traps just at or above the crop canopy (35cm). Host plant size had no effect on the number of moths captured.

Table 1. Numbers of diamondback moths captured on yellow sticky traps of different heights, orientations and in stands of cabbage plants of different sizes.

Expt. no.	Treatment	N	No. DBM caught (mean±SE)	ANOVA p level [a]
1	Traps horizontal	8	3.4±0.9	
	Traps North-facing vertical	8	0.3±0.2	
	Traps South-facing vertical	8	0.0±0.0	0.001
	Trap height 20 cm	12	1.8±0.8	
	Trap height 35 cm	12	0.7±0.4	0.036
	Host plant small	12	1.0±0.5	
	Host plant large	12	1.4±0.7	NS
2	Sticky side up	8	2.1±0.7	
	Sticky side down	8	0.0±0.0	0.001
	Host plant small	8	1.6±0.8	
	Host plant large	8	0.5±0.3	NS

[a]Data transformed by $\log_{10}(x+1)$; NS= not significant, ANOVA, $p > 0.05$.

2. Activity patterns of DBM.

DBM was most active between 2000 and 0300 h (Fig. 3). Significant variations in activity levels over time were found for males and both sexes combined. Despite the lack of significance found for activity of females, they exhibited the same general activity patterns as males.

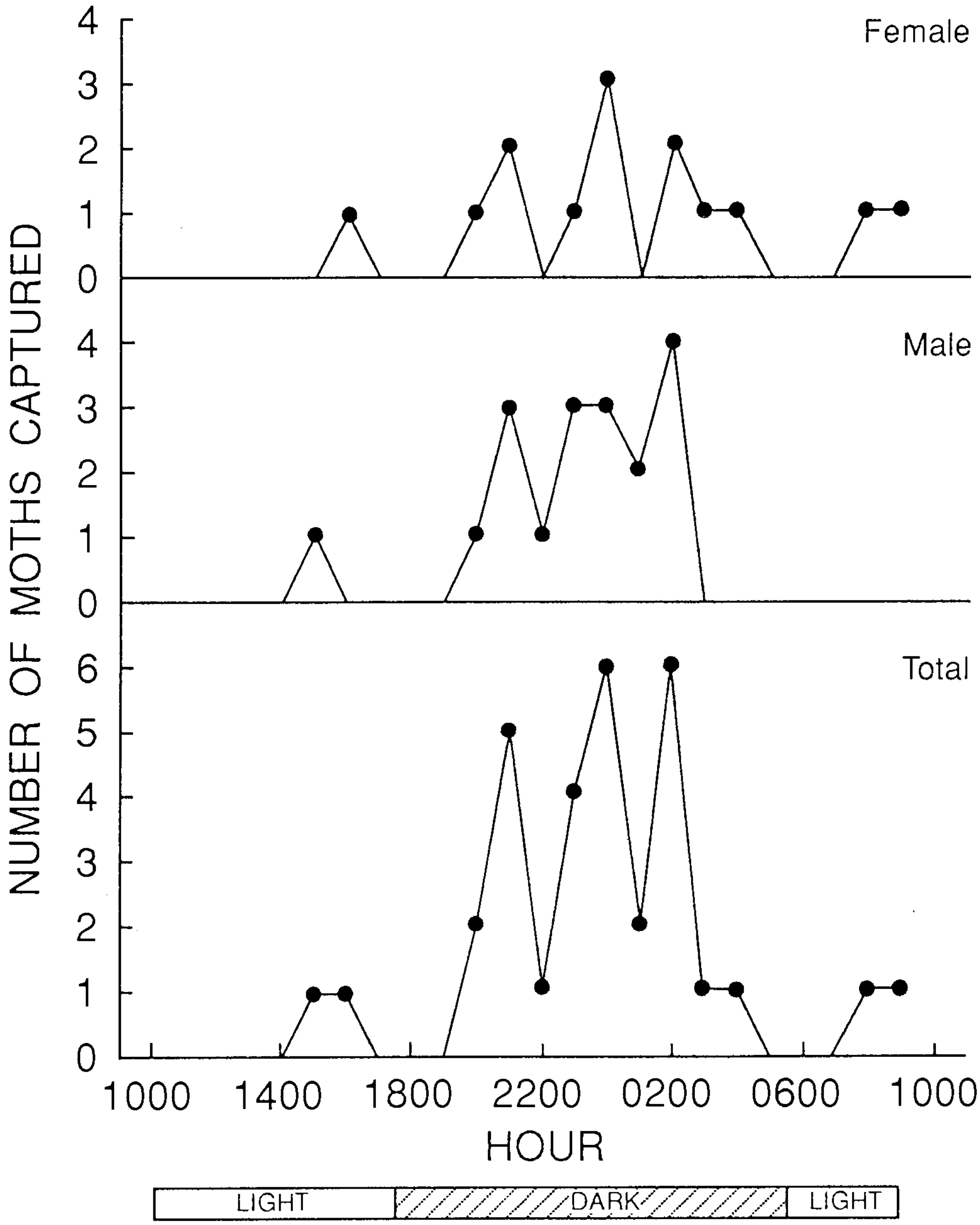
3. Evaluation of trap hue.

Non UV-reflecting white traps were significantly less attractive to both sexes of DBM than were yellow, green, blue or UV-reflecting white traps (Table 2). No significant differences between male and female moths were indicated by analysis of data for the proportion of moths caught that were female.

Within a linear replicate of traps, significantly more moths were caught on eastward than westward traps (ANOVA, $p = 0.043$). The position of a replicate within the field was also found to be a significant source of variation for males and total moths captured (ANOVA, $p = 0.035$ and $p = 0.015$, respectively).

As no significant differences were found between attractiveness of trap hues to females and males (ANOVA, $p > 0.05$), data for each sex were combined for analysis of the pooled data for hues from all tint and shade series experiments. In the pooled analysis, green traps were found

Figure 3. Hourly captures of diamondback moths on traps of the yellow reference hue for one 24 h period. (ANOVA, Females, not significant, $p > 0.05$; Males, $p = 0.02$; Total, $p < 0.001$).



NUMBER OF MOTHS CAPTURED
Female
Male
Total
0
1
2
3
4
5
6
1000
1400
1800
2200
0200
0600
1000
HOUR
LIGHT
DARK
LIGHT

Table 2. Numbers of diamondback moth adults captured on traps of 5 reference hues.

Trap type	N	Numbers of DBM captured (mean±SE)[a] Females	Males	Total	Proportion Female (mean±SE)[a]
Yellow 776	4	3.3±0.9a	2.3±1.4a	5.5±2.1a	0.7±0.2a
Blue 871	5	3.0±0.3a	4.0±1.5a	7.0±1.7a	0.5±0.1a
Green 785	5	2.8±0.7a	4.4±0.8a	7.2±1.3a	0.4±0.1a
UV White	5	2.8±0.7a	3.2±0.6a	6.0±0.3a	0.5±0.1a
Non UV White	5	0.4±0.3b	1.6±0.5a	2.0±0.6b	0.2±0.1a

[a]Means within a column followed by the same letter are not significantly different, Student-Newman-Kuels test, $p < 0.05$.

to be most attractive (Fig. 4). Non-UV white was least attractive.

4. Evaluation of degree of saturation of trap colour.

There were no significant differences in the proportion of captured moths that were female between treatments for any of 8 experiments on tint series of 3 hues and the achromatic series. No significant differences in attractiveness of traps to either males or females were found within any of the tint experiments except for the UV-grey series (ANOVA, $p = 0.014$). However, there was no consistent relationship between females caught and increased UV reflectance of the grey traps. The proportion of moths caught that were female was significantly affected by the position of a replicate within the field in the non-UV green series (Kruskal-Wallis test, $p = 0.017$).

5. Evaluation of trap intensity.

Significantly more males were caught on traps of intermediate reflectance (GRN5, peak of 40% at 500-550 nm) than on lighter (GRN 785, 60%), or darker shades (GRN15, 30%) (Table 3). This response caused a significant imbalance between the proportions of females and males captured in this experiment.

As for the tint series, there were no significant differences in the proportion female or in responses to different treatments in the yellow or blue shade

Figure 4. Numbers of diamondback moths captured per trap on traps of reference hues. Pooled data from the reference hue, and all tint and shade series experiments. Columns with same letter are not significantly different, Student-Newman-Kuels test, $p < 0.05$. For Non-UV White N=39, UV White N=40, Blue 871 N=25, Green 785 N=24, Yellow 776 N=78.

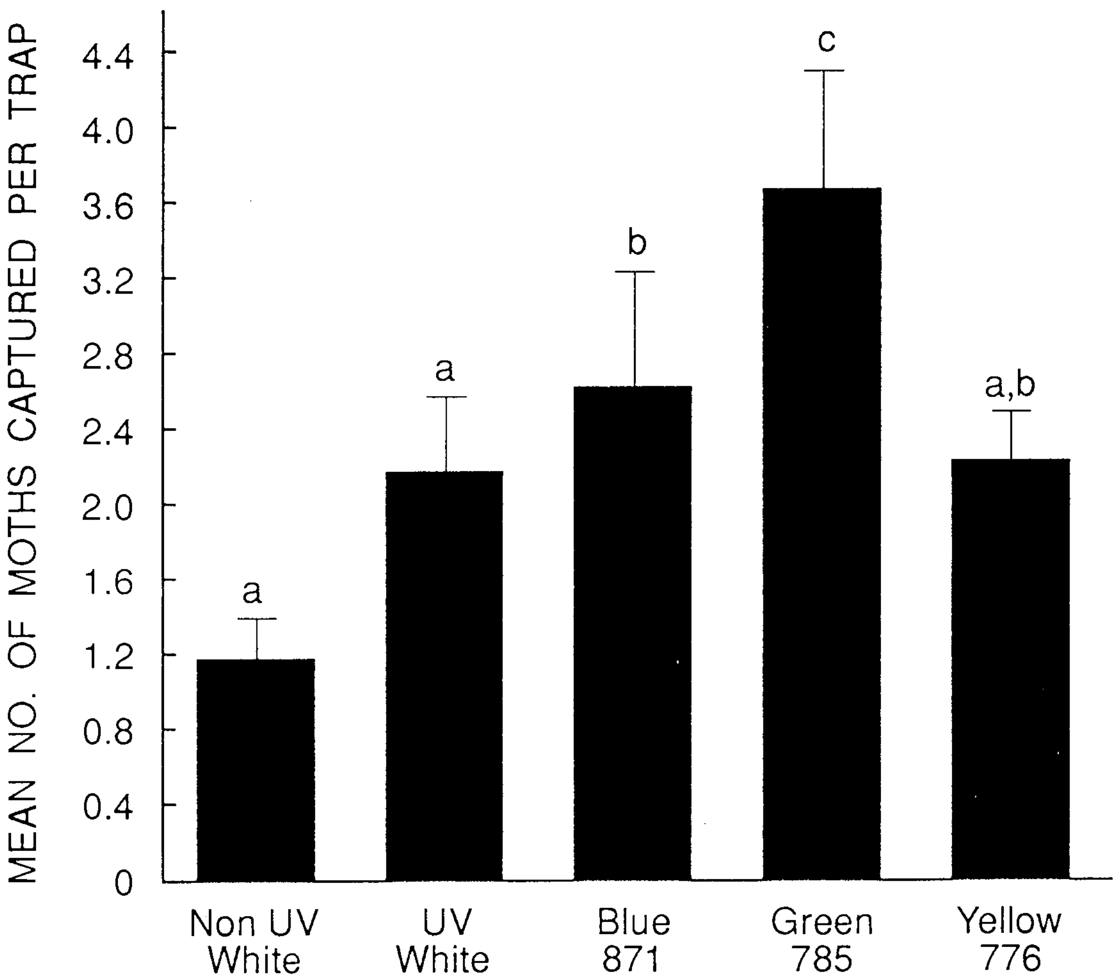

MEAN NO. OF MOTHS CAPTURED PER TRAP
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
a
a
b
c
a,b
Non UV White
UV White
Blue 871
Green 785
Yellow 776

Table 3. Numbers of diamondback moth adults captured on green shaded traps.

Trap type	N	Numbers of DBM captured (mean±SE)[a] Females	Males	Total	Proportion Female (mean±SE)[a]
Yellow 776	5	1.2±0.6a	0.8±0.4ab	2.0±0.7a	0.6±0.2a
Green 785	5	1.0±0.5a	0.0±0.0b	1.0±0.5a	1.0±0.0a
GRN5	5	0.4±0.4a	1.0±0.3a	1.4±0.5a	0.2±0.2b
GRN10	5	1.0±0.6a	0.2±0.2ab	1.2±0.7a	0.8±0.2a
GRN15	5	0.8±0.4a	0.0±0.0b	0.8±0.4a	1.0±0.0a

[a]Means in the same column followed by the same letter are not significantly different, Student-Newman-Kuels test, $p < 0.05$.

experiments. However, trap position within a replicate significantly affected the number of males caught in the blue shade series (Kruskal-Wallis tests, $p = 0.048$).

6. Population studies in farmers' fields.

Moth and larval populations were highest in Rurukan and lowest in Kumelembuai (Table 4). The moth population increased up to week 6 and then declined, while the larval population continued to increase (Fig. 5). A significant relationship was found between female and male DBM captured (FEMALE = 0.654 + 0.448 MALE, $r^2 = 25.4\%$, $p < 0.001$).

Moth catch was a significant predictor of larval populations during the same week or 1 or 2 weeks following for 4 of the 6 fields sampled (Table 5). When data for all fields were pooled, the strongest relationship was found between moth catch and larval population 2 weeks later (Table 5). Trap catches of females or males were also significant predictors of larval populations during same week or 1 or 2 weeks following for 4 (females) and 3 (males) of the 6 fields and for all fields combined.

Total moth catch and the distance between traps and sample plants were both significant predictors of larval populations per plant (Table 6), particularly for larval populations 2 weeks after moths were trapped (Fig. 5). Larval populations tended to increase as the distance of sample plants from traps increased (Fig. 6).

Table 4. Moth and larval populations by field and location. Data are pooled for the 8 week growing period.

		Moths		Larvae	
Village	Field	No. of samples	moths/trap (mean±SE)[a]	No. of samples	larvae/quadrat (mean±SE)[a]
Rurukan	1	32	7.8±1.5a	32	112.8±33.8a
	2	32	4.5±0.6b	32	49.5±8.8b
Temboan	3	27	4.2±0.8b	28	16.3±2.2b
	4[b]	28	2.3±0.6bc	28	12.8±2.7b
Kumelembuai	5	32	1.2±0.2c	32	15.2±3.0b
	6	32	2.7±0.7bc	32	54.8±12.9b

[a]Means in a column followed by the same letter are not significantly different, Student-Newman-Kuels test, $p < 0.05$.

[b]This field was located half-way between Temboan and Kumelembuai.

Figure 5. Moth (solid line) and larval (dashed line) populations in farmers' fields throughout the growing season. Data for all fields combined.

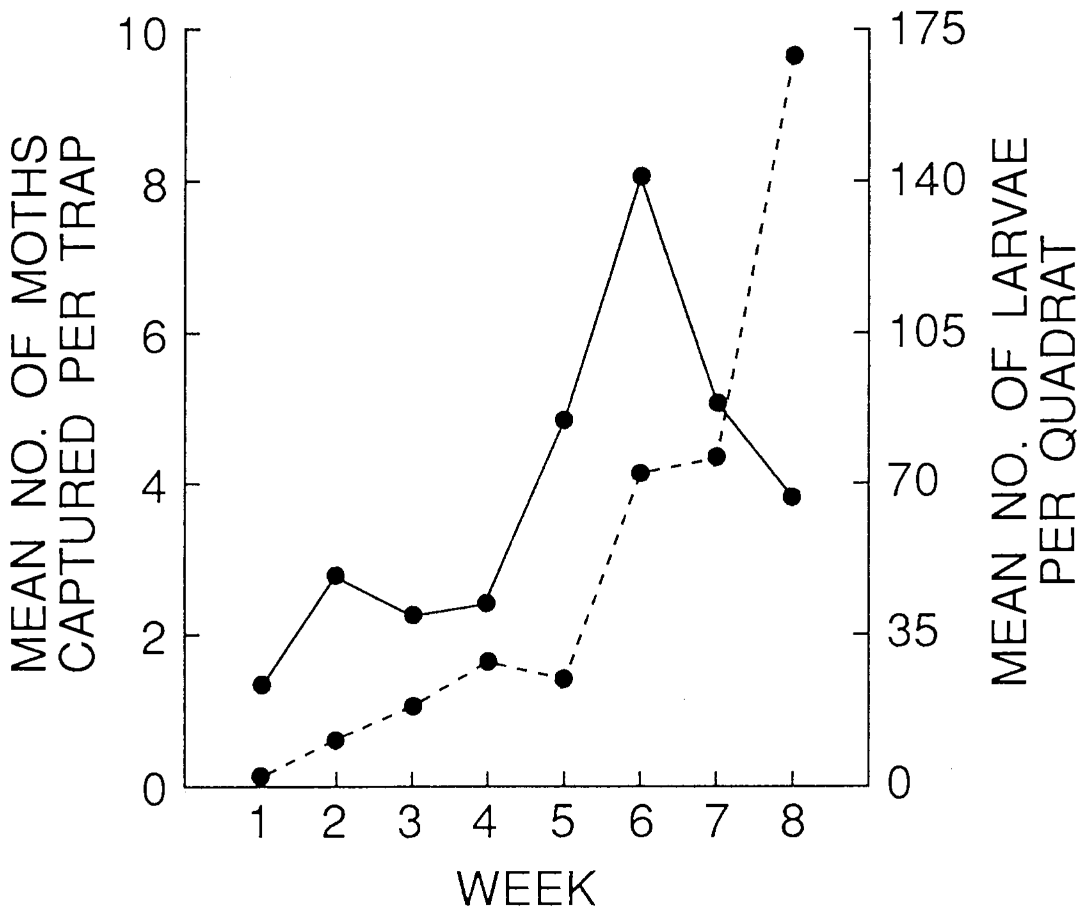

MEAN NO. OF MOTHS CAPTURED PER TRAP
MEAN NO. OF LARVAE PER QUADRAT
WEEK
0
2
4
6
8
10
0
35
70
105
140
175
1
2
3
4
5
6
7
8

Table 5. Regression equations for larval counts in the same week, 1 week and 2 weeks later regressed on total moths captured for individual fields and all fields together. For each field, data for 4 traps (moths) and 4 quadrats (larvae) were pooled.

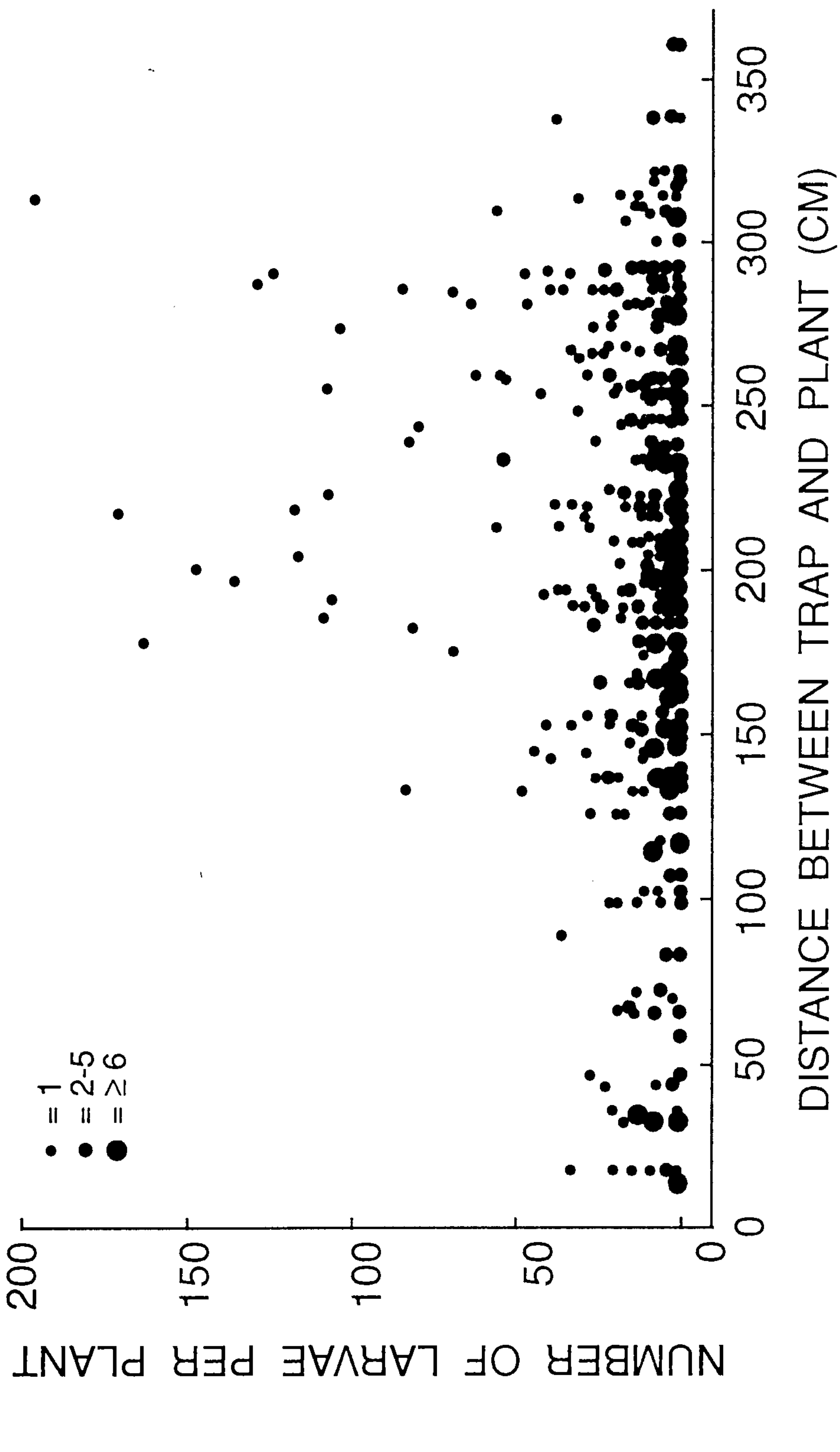
Field	Regression Equation	r^2	p^a
1	$Larvae_{same}$= 78.0 + 4.45 Moths	3.6	NS
	$Larvae_{1wk}$ = 83.0 + 6.0 Moths	6.8	NS
	$Larvae_{2wk}$ = 8.1 + 19.5 Moths	70.7	<0.001
2	$Larvae_{same}$= 48.4 + 0.24 Moths	0.0	NS
	$Larvae_{1wk}$ = 19.9 + 7.93 Moths	29.2	0.003
	$Larvae_{2wk}$ = 56.9 + 1.43 Moths	1.0	NS
3	$Larvae_{same}$= 16.7 - 0.24 Moths	0.8	NS
	$Larvae_{1wk}$ = 21.0 - 0.74 Moths	8.1	NS
	$Larvae_{2wk}$ = 14.8 + 0.60 Moths	5.2	NS
4	$Larvae_{same}$= 8.54 + 1.84 Moths	17.8	0.025
	$Larvae_{1wk}$ = 12.6 + 1.14 Moths	6.1	NS
	$Larvae_{2wk}$ = 18.0 - 1.57 Moths	1.7	NS
5	$Larvae_{same}$= 10.3 + 4.20 Moths	7.8	NS
	$Larvae_{1wk}$ = 19.1 - 1.53 Moths	1.1	NS
	$Larvae_{2wk}$ = 24.2 - 5.17 Moths	12.7	NS
6	$Larvae_{same}$= 18.1 + 13.6 Moths	52.8	<0.001
	$Larvae_{1wk}$ = 40.0 + 7.52 Moths	16.5	0.032
	$Larvae_{2wk}$ = 67.5 + 1.39 Moths	0.6	NS
ALL	$Larvae_{same}$= 45.6 + 8.83 Moths	15.4	0.007
	$Larvae_{1wk}$ = 56.8 + 9.93 Moths	18.8	0.005
	$Larvae_{2wk}$ = -22.5 + 18.1 Moths	59.2	<0.001

[a]NS= not significant at $p < 0.05$.

Table 6. Multiple regression equations for larval counts in the same week, 1 week and 2 weeks later regressed on total moths captured and distances between traps and plants for all fields combined.

Regression Equation	r^2	p
$Larvae_{same} = 1.01 + 0.018\ Distance + 0.99\ Moths$	7.8	<0.001
$Larvae_{1wk} = 1.15 + 0.020\ Distance + 1.14\ Moths$	9.8	<0.001
$Larvae_{2wk} = -2.34 + 0.023\ Distance + 2.29\ Moths$	33.8	<0.001

Figure 6. Relationship between larval population per sample plant and distance between trap and sample plant. Data for all fields and all weeks combined.



NUMBER OF LARVAE PER PLANT
0
50
100
150
200
DISTANCE BETWEEN TRAP AND PLANT (CM)
0
50
100
150
200
250
300
350
= 1
= 2-5
= ≥6

Discussion

Higher moth catches on traps within than above the crop canopy (Table 1) suggest that DBM does not prefer to fly above the crop canopy when scouting for suitable mates or oviposition sites. When observed in the field (personal observation), DBM made fairly short flights, <10 m, fairly close to the ground, and usually in a zigzag type path between adjacent raised cabbage beds. A moth would approach a plant near its base and then, in some cases, fly up the leaf until it alighted near the top of the plant.

The higher catches of both males and females on easterly than on westerly traps suggest that DBM orient their flight paths in an east-west direction. Some moths were observed taking up positions at the top of leaves and then orienting themselves to face in an easterly direction into the wind. Thus, DBM may use prevailing wind direction to guide it's flight paths.

The minor differences observed in diel activity patterns of females and males may arise because: (i) females may move actively about the field to locate suitable oviposition sites during the day while males rest on the host plants; or (ii) females may remain in the cabbage field during the day, while males move outside of the field to feed on cruciferous weeds, returning to the cabbage plants again at night when females are releasing pheromones.

The high response of DBM to traps of saturated green and blue hues (Fig. 2) is in contrast to Sivapragasam & Saito's (1986) study, in which yellow vinyl chloride traps caught more DBM than blue traps. The results of my experiments examining the influence of hue saturation indicate that DBM is not responsive to spectrum-wide increases in percent spectral reflectance of a given hue. However, DBM may respond to changes in percent spectral reflectance in certain wavelengths. Sivapragasam & Saito's (1986) blue had a peak of 20% reflectance in the 450-475 nm range, while my blue had a peak of 50% reflectance in this range. DBM appears, therefore, to respond to increased spectral reflectance in the blue range. My study indicates that the optimum range in terms of spectral reflectance, at least for males, is in the green range (500-550 nm). Although they did not test a green trap, Sivapragasam & Saito (1986) conjectured that higher intensity reflectance in the 550 nm region could be most attractive to DBM.

The combined results of this and Sivapragasam & Saito's (1986) studies suggest that yellow and white traps may be less attractive to DBM because of high spectral reflectance in wavelengths above 600 nm. DBM is also not attracted to hues with high spectral reflectance in the UV range (350-400 nm). It appears, therefore, that DBM is responsive to colours in only a narrow band of the insect visible spectrum.

A number of species of nocturnal moths have been found to have the ability to distinguish between different wavelengths of light (Eguchi et al. 1982). Nocturnal moths have several adaptations that enable them to see in low light conditions, such as corneal nipples (Bernhard et al. 1963; Bernhard et al. 1965), and pigment and/or retinula cell migration (Bernhard & Ottoson 1960b; Walcott 1975). Corneal nipples function as anti-reflectance coatings and thus increase the transmission of light through the cornea (Bernhard et al. 1963, 1965), while pigment and cell migration allow light from an oblique angle to reach the receptor within an ommatidium (Walcott 1975). Two phases of dark adaptation have been observed in nocturnal Lepidoptera which increase sensitivity to light by 4 log units (Bernhard & Ottoson 1960a,b). The spectral reflectance pattern of moonlight is similar to that of sunlight, but at mid-day total irradiance between 400 and 700 nm is 1.77×10^6 higher than that of moonlight (McFarland & Munz 1975). The visual adaptations of nocturnal Lepidoptera should, therefore, allow them to compensate for this difference and effectively reduce it to about 2 log units.

In general, the compound eyes of nocturnal moths have high sensitivities to light in the UV, blue (440-480 nm), and green (500-540 nm) regions of the spectrum (Eguchi et al. 1982). The results of my trap colour studies are not inconsistent with these findings, although for *Plutella* the greatest sensitivity was found in the green region. Ocelli of moths in a given species have been found to have the same spectral sensitivities as the compound eye of moths in the same species (Eaton 1976; Nordtug & Melo 1988). Visual input from the ocelli may effectively increase the ability of nocturnal insects to distinguish between colours and also contribute to increased acuity.

Although the intensity of light is reduced, spectral reflectance of traps and cabbage plants should be essentially the same at night as during the day. Prokopy et al. (1983) measured the spectral reflectance of young, intermediate and mature leaves of green cabbage. The spectral curve of young cabbage leaves peaked at about 25% between 525-575 nm; the waxy bloom on intermediate and mature leaves caused an overall increase in spectral reflectance, but reduced the distinctiveness of the peak green reflectance (Prokopy et al. 1983). The more distinct peak of the intermediate green shade (GRN 5), in comparison to the darker green shades used in this study, may account for the greater numbers of DBM captured. This is in keeping with Prokopy et al.'s (1983) finding that young cabbage leaves were more attractive to the cabbage root fly, *Delia radicum* (L.), than either of the older classes of leaves.

Eguchi et al. (1982) have suggested that nocturnal moths may have multiple pigment systems primarily for the purpose of maximizing the total capture of photons across a broad range of wavelengths, and that the colour vision function may be of secondary importance. If this were true for DBM, a high level of response to white traps would be expected because they have high levels of reflectance across the insect-visible spectrum. In addition, my data show a very narrow range of sensitivity in DBM, which suggests that the ability to distinguish between wavelengths is not simply a consequence of capturing photons across a broad spectral band. Thus, colour vision may play an important role in host- or mate-finding behaviours of nocturnal insects. It would appear that DBM uses pheromones at long distances and visual cues at close range to locate suitable host plants and potential mates. The fact that equal numbers of females and males were captured indicates that DBM use visual cues to locate both mating and ovipositional sites. Since both gravid and 'spent' females were caught (personal observation) it appears that female DBM oviposit on a number of host plants rather than remaining on one plant until all of their eggs have been laid.

The fact that DBM populations were found to increase in farmers' fields throughout the growing season (Fig. 3) indicates that cabbage growers are not completely successful in their attempts to control this pest. DBM populations may also increase by migration from nearby fields or wild host plants. A decision-making system that can follow trends in pest population levels and quantitatively assess when it is necessary to apply insecticides would probably improve the efficacy of insecticide applications by improving their timing, and reduce the need for repetitive pesticide applications. The strong relationship between larval population and trap catch when offset by 2 weeks, is presumably due to the emergence of second instar larvae from the mesophyll tissue of cabbage leaves 2 weeks after eggs are laid by adult females. Since first instar larvae, which are miners, are difficult to control with insecticide sprays, the optimum spray timing would be about 2 weeks after a high moth catch is observed. Thus farmers will know in advance that a spray is required, and this will enable them to prepare the time and resources required for a pesticide application.

The high DBM populations in Rurukan (Table 4) probably reflect the practice in this village of growing cabbage fairly continuously in both space and time, while there is a discontinuous distribution of cabbage fields between Rurukan-Temboan and Kumelembuai. Thus immigration of DBM into Kumelembuai, and the population size at any one time, may be kept low.

With the exception of a handful of cases in agricultural (Shelton & Wyman 1979; Tingle & Mitchell 1981; Judd et al. 1985; Lal 1989), forest (Sanders 1988), and orchard systems (Smith & Borden 1990), very few monitoring systems are based on a demonstrated relationship between adult and larval populations and/or damage levels. Trap catches of DBM on yellow sticky traps have been found to reflect the number of adult DBM accurately in a field in Japan (Sivapragasam & Saito 1986), and DBM catches on pheromone traps were significantly correlated with larval populations 11-21 days later in some fields in New York state (Baker et al. 1982). My results demonstrate that moth catches on coloured sticky traps can be used to predict larval populations on a regional basis (Table 5). Thus, there is real potential for the use of a sticky trap monitoring system for DBM. The greater predictive ability of a regional monitoring system over an individual field system, is probably due to several factors. Cabbage fields in the study region, which are small and close together, are affected by the migration of DBM from recently harvested fields to younger fields. In addition, local variations in climate, topography and surrounding crops and natural vegetation, likely contribute to variability in DBM catches.

The fact that there were significant relationships between total moths caught (as well as females and males) and larval populations (Table 5) means that it is not necessary to base a monitoring system on catches of only males or females. Further studies are necessary to establish the relationship between trap catch and damage levels and to validate sampling thresholds that would indicate the need for application of direct controls.

It appears that plants situated close to a trap may have lower larval populations than traps further away (Fig. 4), because females searching for ovipositing sites are captured on traps instead. This relationship should be examined further in order to assess the potential for using sticky traps as a mass trapping tool. The effectiveness of a sticky trap mass trapping system might be optimized if green traps were used instead of the yellow traps that I employed. Experiments should also be conducted to establish an optimum trap size. Moreno et al. (1984) demonstrated that trap size could be increased to an area at which the 'attractive colour point-source' was magnified, and beyond which trap catch was merely diffused over a larger point-source. Thus, optimum trap size is a factor which must be determined before a mass trapping system for DBM can be implemented.

When employed in the field, it will be necessary to validate the efficacy of the monitoring system by sampling larval populations on plants. However, since a relationship was found between larval populations, trap catches and the distance between traps and sampling plants, it will be necessary to sample larvae on plants which are beyond the influence of the trap. In fact, the predictive ability of the monitoring system in this study might have been found to be even greater, if the sample plants had been further away from the traps.

In June 1990, the first introductions of a DBM larval parasitoid, *Diadegma eucerophaga*, were made to North Sulawesi at BPP-Tomohon. One year later, parasitoid populations were very low and appeared to have been greatly reduced by the insecticide-based pest management practices of farmers in the surrounding area (D. Sembel, pers.

comm.).[2] With additional introductions of this parasitoid, it is possible that it may be able to successfully establish in the area. If the monitoring system is adopted and the frequency of insecticide use in the region is consequently reduced, then the survival and spread of the parasitoid should be increased. If *Diadegma* does become established, then it is likely that DBM populations will be reduced from present levels. If the parasitoid is able to keep the DBM population in this area in check, then the monitoring system could be used to verify the effectiveness of *Diadegma* in controlling DBM and to forecast sporadic outbreak situations, which may result if conditions became relatively more favourable for DBM than for its parasitoid. The attractiveness of traps to *Diadegma* should also be evaluated prior to implementation of a monitoring or mass trapping system, since the parasitoid may use host plant cues when searching for DBM larvae. If *Diadegma* is caught in low numbers, then the monitoring system could also be used to monitor population trends and range expansion of *Diadegma*. If a mass trapping system is found to be successful against DBM, it could be used to reduce DBM population levels prior to mass release of *Diadegma* into an area. This would enhance the parasitoids' ability to keep DBM populations at manageable levels.

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Chapter IV

An Examination of Gender Roles in Cabbage Production and Pest Management Decision-making, and Knowledge Levels Concerning DBM and Pest Management Practices

In order to obtain baseline data regarding current cabbage production and pest management practices, the level of pest management knowledge, and the roles of women and men in cabbage production in Kecamatan Tomohon, interviews were conducted with cabbage farmers in the villages of Rurukan, Temboan and Kumelembuai between February and May 1991. The interviews were designed and conducted with the following objectives in mind:

1. to document existing cabbage production and pest management practices in this region;
2. to determine whether differences exist in women's and men's roles and responsibilities in cabbage production;
3. to determine whether differences exist in women's and men's responsibilities in cabbage pest management;
4. to determine whether differences exist in women's and men's knowledge of pest management practices;
5. to determine whether differences exist in the quality of women's and men's pest management practices; and,
6. to determine whether there are differences in women's and men's access to pest management information.

Methodology and Analyses

Initial lists of cabbage growers were obtained from the Head of each village, and were intended to include all families that had recently planted cabbage (within the previous month) or who were about to transplant cabbage seedlings to the field. All interview participants were married, with the exception of two single men in Kumelembuai, who were included in order to increase the sample size from that village.

I conducted interviews in *Bahasa Indonesia*. All questions were read to the respondent and responses were recorded on prepared questionnaire sheets. In some cases wording of the questions was slightly altered or additional comments and questions were used in order to improve the respondents' comprehension of the question. My research assistant provided further clarifications to the respondents and translated into the widely understood language *Bahasa Manado* when required.

All interviews were conducted during the evening at participants' homes. My research assistant and I were generally accompanied on our visits to farmers' homes by a representative of the village Head (*Hukum Tua*). This was initially required for the practical purpose of introducing us to the participants and to the locations of their homes. It was also a matter of courtesy on the part of the village Head towards us, his guests, and towards the residents of his village. Our escort was usually a participating male grower or a male administrative assistant appointed by the village Head. When a grower accompanied us, he had been interviewed previously, before having a chance to hear other participants' responses.

The first two interviews were also intended to gain the respondent's trust and establish rapport needed for discussion with me of possibly sensitive topics in the final questionnaire.

All interview data were analyzed by Chi-square analysis for village and gender differences. Responses from women and men were pooled for village analyses. In gender analyses the 5 men in Kumelembuai, who were either single or whose wives did not work in the field, were excluded from the analyses.

1. Preliminary questionnaire.

The object of the preliminary questionnaire (Appendix 1) was to categorize farmers in terms of their usual frequency of insecticide use, the type of insecticides used, size of cabbage fields, and to collect background information on such items as educational history and other occupations. This information was also used in selecting fields in which to carry out sticky trap work. The questionnaire was conducted with both members of the couple together, except when one spouse was absent from the house at the time of the interview.

A total of 39 couples and 2 single respondents were interviewed: from Rurukan 23 couples (13-14 February), from Temboan 10 couples (19 February), and 5 couples plus 2 single men from Kumelembuai (15 February). Interviews took approximately 10-15 min per household.

2. Cabbage production questionnaire.

This questionnaire (Appendix 2) was designed to gather information regarding usual cultivation practices in cabbage production, land tenure patterns, labour patterns, the cost of insecticide applications, and factors influencing the marketing of cabbage. It was also conducted with both members of the couple together if possible, took 15-20 min/household, and involved 21 couples from Rurukan (5,7 March), 8 couples in Temboan (6 March) and 8 couples and 2 single men in Kumelembuai (8 March). Sample sizes were reduced from the preliminary interviews as some respondents were not available.

3. Questionnaire on pest management knowledge and gender roles in cabbage production and pest management decision-making.

This questionnaire (Appendix 3) was conducted with a smaller sample of cabbage growers in which both family heads worked actively in their cabbage field(s). Each spouse was interviewed individually in order to determine gender differences in knowledge and perception. The questionnaire was designed to assess levels of knowledge regarding cabbage pest problems, access to pest management information, safety practices used in applying pesticides, and the quality of the decision-making mechanisms used in determining pest management methods and the timing of pest control. In addition, it was determined who was responsible for monitoring the cabbage fields, selecting insecticides, and how decision-making responsibilities were divided between wives and husbands.

In the case of Kumelembuai, 5 men who were single or whose wives were not active in cabbage production were also included in order to increase the sample size. Thus, interviews were conducted with 13 women (3,9 April) and 13 men (13,15 April) in Rurukan, 6 women (10 April) and 6 men (11 April) in Temboan, and 2 women and 7 men in Kumelembuai (12 April). These interviews took approximately 30-40 min per respondent.

Due to a generally expressed belief in the study area that men are more knowledgeable than women regarding farm work, interviews with women were carried out first. Ideally it was possible to interview the woman in the absence of her husband. In cases where the husband joined us while his wife was being interviewed, he was engaged in conversation by my research assistant and our escort so that he could not directly influence his wife's responses nor be aware of the questions which were being asked. The husband's presence could have indirectly influenced his wife's responses, but social etiquette in the region prevented us from asking him to leave.

Results

1. General village population and agricultural characteristics.

There were no significant differences between villages in the age composition of respondents. Most were >30 years old, but 23% were 18-29 years old.

Significant differences were found between villages in the educational level of respondents (Table 7). In Temboan almost two-thirds of respondents had only attended primary school, while in Kumelembuai all had at least attended junior high school.

Between-village differences in the participation of respondents in field work were not significant (Table 7). However, more respondents from Kumelembuai did not work in their fields than in either of the other two villages. More respondents in Temboan worked full time in their fields than did respondents from the other villages. A significantly greater proportion of respondents from Kumelembuai were regular traders in the Tomohon market, or were employed as school teachers than respondents from either Rurukan or Temboan. However, a fifth of respondents in Rurukan worked occasionally in the market.

Table 7. General population and agricultural characteristics by village. (Kumelembuai= Kum, Rurukan= Rur, Temboan= Tem).

Criterion assessed	Sample size			Percent of growers				Probability of significant difference between villages[a]
	Kum	Rur	Tem	Kum	Rur	Tem	Total	
1. EDUCATION LEVEL	20	46	16					
Primary				0.0	39.1	62.5	34.2	
Junior High				50.0	39.1	25.0	39.1	
Senior High				45.0	21.7	12.5	25.6	
University				5.0	0.0	0.0	1.2	0.0004
2. ACTIVITY IN FIELD	19	46	16					
Never in field				26.3	8.7	12.5	12.6	
Occasionally				5.3	17.4	0.0	11.1	
Half day				26.3	17.4	6.3	17.3	
Full day				42.1	56.5	81.3	58.1	0.09
3. OTHER OCCUPATIONS	14	23	6					
Market occas'nally				0.0	21.7	0.0	11.6	
Market regularly				35.7	26.1	16.7	27.9	
Teacher				42.9	8.7	0.0	18.7	
Other				21.4	43.5	83.3	41.9	0.025
4. NO. FIELDS FARMED	10	21	8					
1				20.0	9.5	25.0	15.3	
2				20.0	14.3	25.0	17.9	
3				40.0	33.3	12.5	30.9	
4				10.0	23.8	0.0	15.4	
≥5				10.0	19.1	37.5	20.6	0.61

Table 7 continued.

Criterion assessed	Sample size Kum	Sample size Rur	Sample size Tem	Percent of growers Kum	Percent of growers Rur	Percent of growers Tem	Percent of growers Total	Probability of significant difference between villages[a]
5. NO. FIELDS RENTED	10	21	8					
0				100	57.1	75.0	71.8	
1				0.0	23.8	12.5	15.4	
2				0.0	9.5	0.0	5.1	
4				0.0	0.0	12.5	2.6	
≥5				0.0	9.5	0.0	5.1	0.23
6. NO. TIMES CABBAGE GROWN	11	23	8					
1				0.0	4.4	25.0	7.2	
2				45.5	43.5	12.5	38.1	
3				27.3	13.0	25.0	19.0	
4				27.3	8.7	12.5	24.3	
5				0.0	13.0	0.0	7.1	
6				0.0	17.4	25.0	14.3	0.20
7. AREA OF CABBAGE FIELD	11	23	8					
<0.25 ha				45.5	17.4	0.0	21.4	
0.26-0.35				27.3	39.1	25.0	33.3	
0.36-0.50				18.2	34.8	25.0	28.7	
>0.50				9.1	8.7	50.0	16.7	0.09
8. SEASONAL INSECTICIDE SPRAY FREQUENCY	11	23	8					
0-3x				9.1	8.7	37.5	14.3	
4-6				54.6	26.1	0.0	28.6	
8-12				27.3	47.8	62.5	45.2	
>12				9.1	17.4	0.0	11.9	0.08

Table 7 continued.

Criterion assessed	Sample size			Percent of growers				Probability of significant difference between villages[a]
	Kum	Rur	Tem	Kum	Rur	Tem	Total	
9. CABBAGE MARKETING	10	21	8					
Sell to Dealer				90.0	57.1	50.0	64.2	
Sell on own				10.0	28.6	25.0	23.1	
Either				0.0	14.3	25.0	12.8	0.34
10. SACKS OF CABBAGE NOT SOLD	10	21	8					
<1				40.0	52.4	37.5	46.2	
1-2				30.0	38.1	0.0	28.2	
>2				30.0	9.5	62.5	25.6	0.04

[a] Probability value determined by either Chi-square or Fisher's exact test.

In general, all participants farmed the same number of fields (of all crop types), but fewer respondents in Kumelembuai had >4 fields than did respondents from Rurukan or Temboan (Table 7). In addition, there were no significant differences in the other types of vegetable crops grown in addition to cabbage by farmers from these villages. Carrots and petsai were the two other vegetable crops most commonly grown.

Only 28% of respondents rented the field in which they were growing cabbage. Although there were no significant differences between villages, no respondents farmed rented fields in Kumelembuai (Table 7). The majority of renting growers paid rent to the owner, although some (9.1%) divided the yield with the owner instead. No respondents grew cabbage intercropped with another crop.

There were no significant differences in the number of times that respondents had grown cabbages previously, but no respondents in Kumelembuai had grown cabbage >4 times before (Table 7). The sizes of cabbage fields were generally smaller in Kumelembuai than in Rurukan or Temboan (Table 7). No cabbage fields were >1 ha.

Respondents from Kumelembuai reported the lowest seasonal insecticide spray frequencies (Table 7). There were many types of insecticide used (Table 8) and many farmers frequently switched insecticides. The most frequently used insecticides in Rurukan were Ambush, Sumicidin and Dharmasan. In Temboan they were Ambush, Curacron, Dessin,

Table 8. Insecticide usage by cabbage farmers in 3 villages in Tomohon. Number of growers sampled = 11 in Kumelembuai, 23 in Rurukan, 8 in Temboan.

Formulation	Active ingredient	Percent of growers			
		Kumelembuai	Rurukan	Temboan	Total
Ambush 2EC	Permethrin 20g/l	100	47.8	50.0	61.9
Basudin 60EC	Diazinon 600g/l	0.0	12.5	0.0	2.4
Curacron 500EC	Profenophos 500g/l	0.0	17.4	25.0	14.3
Dessin 5EC	Permethrin 4.6%	0.0	8.7	25.0	4.8
Dharmasan 600EC	Fenthoate 600g/l	9.1	21.7	0.0	14.3
Diazinon 60EC	Diazinon 600g/l	0.0	12.5	0.0	2.4
Lebaycid 550EC	Fenthion 550g/l	0.0	4.3	0.0	2.4
Mavrik 50EC	Fluvolinate 50g/l	0.0	4.3	0.0	2.4
Padan 50SP	Cartap hydrochloride 50%	90.9	0.0	12.5	26.2
Sumicidin 5EC	Fenvalerate 44.5g/l	0.0	34.8	25.0	23.8
Sumithion 50EC	Fenitrothion 555g/l	0.0	12.5	0.0	2.4
Supracide 40EC	Methidathion 420g/l	0.0	17.4	12.5	11.9
Tamaron 200LC	Methamidophos 205g/l	0.0	4.3	0.0	2.4

and Sumicidin. In Kumelembuai, almost all growers used a tank mixture of Padan and Ambush; one grower used Ambush alone and another had also used Dharmasan. Dharmasan, Lebaycid and Sumithion are not recommended for use on cabbage by their manufacturers.

Most farmers relied solely on conventional insecticidal control of cabbage pests (Table 9). The most frequently cited non-chemical method was handpicking of larvae. A few farmers avoided planting their crops during certain phases of the moon, or planted according to a Javanese or Chinese calendar system, so that losses due to pests would allegedly be low.

All respondents buried cabbage crop debris in the soil after harvest; one respondent also fed crop debris to livestock.

The majority of respondents sold their cabbage crop prior to harvest to a dealer who looked after harvesting (Table 7). In Kumelembuai almost all respondents sold to dealers from Rurukan, because of the difficulties in transporting the crop to the market, while more respondents in Temboan and Rurukan sold their crop in the market themselves.

Almost half of respondents kept 10-12 heads of cabbages to use at home or to give to friends (Table 7). Farmers in Rurukan kept the fewest cabbages for home use.

Table 9. Comparisons between use of conventional chemical insecticides and alternative insecticides or pest control methods by cabbage farmers in 3 villages in Tomohon. Number of growers sampled = 11 in Kumelembuai, 23 in Rurukan, 8 in Temboan.

	Percent of growers			
Method	Kumelembuai	Rurukan	Temboan	Total
Conventional chemical insecticides only	54.5	73.9	50.0	64.3
Astrology	18.2	0.0	12.5	7.1
Shake plants	0.0	4.3	0.0	2.4
Hand-picking	18.2	17.4	25.0	19.0
Soap	0.0	8.6	12.5	7.1
Kerosene	0.0	4.3	0.0	2.4
Repellent plant	0.0	4.3	0.0	2.4
Spray botanical	18.2[a]	4.3[a]	0.0	7.1[a]
Spray ashes	9.1[a]	0.0	0.0	2.4[a]

[a] Method suggested to, but not yet used by, the respondents.

2. Village comparisons of pest management practices and knowledge levels.

Due to the absence of an assigned extension officer from BPP-Tomohon to these three villages, farmers had no access to pest management or production information, precluding assessment as to whether village or gender differences existed.

The majority of farmers owned their own spray equipment (backpack sprayers), and the remainder borrowed from others (Table 10).

Cabbages with damage only to the outer leaves can be sold, but most farmers believed that cabbages with pest damage to the head itself could not be sold (Table 10). In times of high demand, however, even these cabbages were sold, by removing leaves until an undamaged saleable head (often called *kol buleh*, or albino cabbage) was obtained.

Most farmers believed that market prices for cabbage were based upon both the quality and abundance of cabbage, while the remainder believed that quality had no bearing on prices (Table 10).

Though not significantly different, 50% of growers in Kumelembuai spent more than Rp. 9000,- per ha on pesticides, while in Temboan no growers spent more than this (Table 10).

Time spent applying insecticides varied from 2-4 to ca. 24 h per ha for a single application (Table 10). These differences seemed to be due to the proximity of the nearest

Table 10. Village comparisons of pest management practices and knowledge levels. (Kumelembuai= Kum, Rurukan= Rur, Temboan= Tem).

Criterion assessed	Sample size			Percent of growers				Probability of significant difference between villages[a]
	Kum	Rur	Tem	Kum	Rur	Tem	Total	
1. OWNERSHIP OF SPRAY EQUIPMENT	10	21	8					
Borrow				30.0	38.1	12.5	30.8	
Own				70.0	61.9	87.5	69.3	0.52
2. CAN CABBAGES WITH PEST DAMAGE TO HEAD BE SOLD ?	10	16	7					
No				80.0	68.8	71.4	72.7	
Yes				20.0	31.3	28.6	27.2	0.88
3. FACTORS INFLUENCING CABBAGE PRICE	10	21	8					
Quality & abundance				50.0	61.9	62.5	58.9	
Abundance only				50.0	38.1	37.5	41.0	0.83
4. INSECTICIDE COST PER HA	10	20	8					
Rp 1000-3000				20.0	35.0	37.5	31.6	
3100-6000				20.0	30.0	50.0	31.6	
6100-9000				10.0	10.0	12.5	10.5	
9100-12000				30.0	5.0	0.0	10.5	
12100-15000				0.0	15.0	0.0	7.9	
≥15000				20.0	5.0	0.0	7.9	0.43

Table 10 continued.

Criterion assessed	Sample size			Percent of growers				Probability of significant difference between villages[a]
	Kum	Rur	Tem	Kum	Rur	Tem	Total	
5. SPRAY TIME PER HECTARE	10	21	8					
2-4 hours				10.0	19.1	12.5	15.5	
5-8				20.0	28.6	62.5	33.3	
9-12				40.0	14.3	25.0	23.1	
13-16				0.0	9.5	0.0	5.1	0.59
6. DETERMINATION OF SPRAY TIME	9	26	12					
By calendar				0.0	3.9	0.0	2.1	
By crop condition				100	96.2	100	97.9	1.00
7. FREQUENCY CROP CHECKED PER WEEK	9	24	12					
1-2x				44.4	41.7	33.3	40.0	
3-4				33.3	41.7	16.7	33.3	
5-6				22.2	16.7	50.0	26.6	0.32
8. METHOD OF DETERMINING NEED TO SPRAY INSECTICIDE	9	26	12					
Check for pests or damage				66.7	92.3	100	89.4	
Count pests or damage				33.3	7.7	0.0	10.7	0.06
9. CROP SPRAYED IMMEDIATELY IF PESTS PRESENT OR POPULATION MONITORED	9	26	12					
Spray immediately				66.7	84.6	91.7	83.0	
Monitor pest population				33.3	15.4	8.3	17.0	0.39

Table 10 continued.

Criterion assessed	Sample size			Percent of growers				Probability of significant difference between villages[a]
	Kum	Rur	Tem	Kum	Rur	Tem	Total	
10. FACTORS INFLUENCING DECISION-MAKING CONCERNING INSECTICIDE USE								
Neighbouring fields recently sprayed	8	26	12					
Spray				12.5	30.7	25.0	26.1	
Make own decision				87.5	69.2	75.0	73.9	0.67
Others advise that field be sprayed	9	26	12					
Spray				33.3	7.7	8.3	12.8	
Make own decision				66.7	92.3	91.7	87.3	0.15
Insecticide type used	9	26	12					
Recommended by other				11.1	15.4	33.3	19.1	
Make own choice				88.9	84.6	66.7	80.8	0.42
11. ABILITY TO AFFORD INSECTICIDES								
Ever not been able to afford insecticides	9	24	12					
Yes				88.9	50.0	75.0	64.5	
No				11.1	50.0	25.0	35.6	0.10
Means of coping with situation	8	12	10					
Wait				25.0	50.0	30.0	36.7	
Borrow				37.5	41.7	10.0	30.0	
Use soap				0.0	0.0	40.0	13.3	
Handpick larvae				37.5	8.3	20.0	20.0	0.07

Table 10 continued.

Criterion assessed	Sample size Kum	Sample size Rur	Sample size Tem	Percent of growers Kum	Percent of growers Rur	Percent of growers Tem	Percent of growers Total	Probability of significant difference between villages[a]
12. METHOD OF DETERMINING INSECTICIDE DOSAGE USED	9	26	12					
Make own decision				100	76.9	83.3	83.1	
Label instructions				0.0	23.1	16.7	17.1	0.43
13. FACTORS INFLUENCING INSECTICIDE DOSAGE USED								
Higher if cabbage plants large	9	26	12					
Yes				66.7	38.5	41.7	44.7	
No				33.3	61.5	58.3	55.3	0.41
Higher if pest population high	9	26	12					
Yes				55.6	30.8	41.7	38.2	
No				44.4	69.2	58.3	61.7	0.37
Depends upon types of pests present	9	26	12					
Yes				0.0	3.9	16.7	6.4	
No				100	96.2	83.3	93.7	0.25
Higher if rainy weather	9	21	10					
Yes				55.6	23.8	10.0	27.5	
No				44.4	76.2	90.0	72.5	0.10
Higher if previous spray ineffective	8	25	12					
Yes				50.0	28.0	25.0	31.2	
No				50.0	72.0	75.0	68.9	0.47

Table 10 continued.

Criterion assessed	Sample size Kum	Sample size Rur	Sample size Tem	Percent of growers Kum	Percent of growers Rur	Percent of growers Tem	Percent of growers Total	Probability of significant difference between villages[a]
14. PEST CONTROL PRACTICES AFTER AN INEFFECTIVE SPRAY	9	27	12					
No change				22.2	44.4	25.0	35.5	
Add soap				0.0	7.4	16.7	8.4	
Change dosage				33.3	14.8	33.3	22.9	
Change insecticide				22.2	22.2	25.0	23.0	
Change both				11.1	11.1	0.0	8.4	
Never encountered				11.1	0.0	0.0	2.1	0.46
15. INFLUENCE OF WEATHER ON SPRAY PRACTICES								
If it is raining	9	23	12					
Spray anyway				44.4	4.4	8.3	13.7	
Use soap				0.0	0.0	8.3	2.3	
Wait until stops				55.6	95.6	83.3	84.1	0.01
If it is windy	7	12	6					
Spray				100	100	100	100	
Don't spray				0.0	0.0	0.0	0.0	*
16. DANGER OF INSECTICIDES TO HUMANS	9	26	12					
Very dangerous				100	69.2	75.0	76.6	
Slightly dangerous				0.0	11.5	25.0	12.8	
Not dangerous				0.0	7.7	0.0	4.3	
Don't know				0.0	11.5	0.0	6.4	0.45

Table 10 continued.

Criterion assessed	Sample size Kum	Sample size Rur	Sample size Tem	Percent of growers Kum	Percent of growers Rur	Percent of growers Tem	Percent of growers Total	Probability of significant difference between villages[a]
17. PROTECTIVE EQUIPMENT WORN WHILE SPRAYING INSECTICIDES								
Dust mask	7	13	6					
No				71.4	53.9	100	69.2	
Yes				28.6	46.2	0.0	30.8	0.16
Cover mouth with cloth	7	13	6					
No				100	69.2	83.3	80.7	
Yes				0.0	30.8	16.7	19.3	0.38
Gloves	7	13	6					
No				100	76.9	100	88.5	
Yes				0.0	23.1	0.0	11.5	0.40
Shoes or boots	7	13	6					
No				100	84.6	83.3	88.4	
Yes				0.0	15.4	16.7	11.6	0.58
Goggles	7	13	6					
No				100	100	100	100	
Yes				0.0	0.0	0.0	0.0	*
18. MOST IMPORTANT PEST OF CABBAGE	8	23	11					
DBM				6.3	56.5	31.8	40.5	
Crocidolomia				18.8	23.9	31.8	25.0	
Cutworm				50.0	15.2	36.4	27.3	
Other				25.0	4.4	0.0	7.2	0.11

Table 10 continued.

Criterion assessed	Sample size			Percent of growers				Probability of significant difference between villages[a]
	Kum	Rur	Tem	Kum	Rur	Tem	Total	
19. KNOWLEDGE OF DBM & OTHER PESTS								
Able to name or describe cabbage pests	9	26	12					
No				11.1	7.7	0.0	6.4	
Yes				88.9	92.3	100	93.6	0.76
Aware that DBM undergoes metamorphosis	8	24	12					
No				0.0	8.3	8.3	6.9	
Yes				100	91.7	91.7	93.2	1.00
Know that DBM moths and larvae are the same insect	8	24	12					
No				0.0	25.0	8.3	15.9	
Yes				100	75.0	91.7	84.1	0.29
Life stage causing damage to cabbage	8	24	11					
Moth & Larvae				25.0	41.7	0.0	28.0	
Larvae				75.0	58.3	100	72.2	0.026
Life stage sprayed against	8	24	11					
Moth & Larvae				12.5	30.4	36.4	28.6	
Larvae only				87.5	69.6	63.6	71.4	0.59

Table 10 continued.

Criterion assessed	Sample size			Percent of growers				Probability of significant difference between villages[a]
	Kum	Rur	Tem	Kum	Rur	Tem	Total	
Able to name other DBM host plants	8	24	12					
No				0.0	12.5	0.0	6.8	
Wrong host named				6.3	14.6	33.3	18.2	
1 host named				31.3	39.6	29.2	35.3	
2 hosts named				37.5	27.1	33.3	30.7	
3 hosts named				25.0	6.3	4.2	9.1	0.69

[a]Probability value determined by either Chi-square or Fisher's exact test. Asterisk indicates that no statistics were computed because there was only one class of answer.

water supply. A third of growers spent from 5-8 h per ha applying insecticide sprays.

Almost all farmers used crop condition rather than a calendar system to determine whether or not to apply insecticides (Table 10). Most checked the condition of their cabbage crop 1-2 times per week (Table 10). Few growers used a quantitative system of assessing crop damage or pest population levels (Table 10). Most had difficulty explaining how they used their counts of damaged plants or pest populations to help them make pest management decisions. However, one farmer handpicked larvae from his plants, and if he had not finished after an hour, then he would spray the field with insecticides. The vast majority of farmers believed that it was necessary to make an insecticide application as soon as they saw pests in their crop, rather than wait to see if pest populations increased (Table 10).

Most farmers claimed to make their pest management decisions independently without influence of other factors. For example, about a quarter of farmers reported that it was necessary to spray their field if a neighbouring field had been sprayed, while the remainder said that they would only do so after assessing their own crop's condition (Table 10). Few farmers said that they would spray their field because another farmer or friend advised them to do so (Table 10), and most reported that they were solely responsible for deciding on what insecticide they would use (Table 10).

Most farmers had at some point been unable to afford to buy insecticides (Table 10). More farmers in Kumelembuai and Temboan had experienced this situation than in Rurukan. There were four strategies for coping with this situation: borrowing money or insecticide from a friend; spraying soap instead of conventional, chemical insecticides; handpicking larvae; and, simply waiting until insecticides could be purchased. No farmers in Kumelembuai or Rurukan sprayed soap, while 40% of farmers in Temboan did (Table 10). Handpicking was employed by 37.5% of farmers in Kumelembuai and 20% of farmers in Temboan, but by only 8.3% of Rurukan farmers. In Rurukan the preferred strategies were waiting or borrowing from others, but in Temboan only 10% of farmers coped with this situation by borrowing.

Most farmers determined the dosage of insecticide to be applied on their own, instead of reading the label on the package (Table 10). A number of factors were used to help determine the dosage used: size of cabbage plants; pest population levels; effectiveness of the previous spray; and weather conditions (Table 10). Very few believed that dosages should be altered according to the types of pests present.

Most farmers used spoons or insecticide bottle caps to measure the insecticide into the spray tank. The range of estimated dosage levels used by most farmers appear to be about 12-75% those recommended on insecticide labels. The dosages employed by a few farmers ranged from below to above recommended levels.

There were no village differences in approaches to pest management practices after an ineffective spray (Table 10). Most farmers would make some sort of change in the next spray, rather than repeat a previously ineffective spray, but over a third of farmers reported that they would repeat the same dosage and insecticide.

There were significant village differences in whether farmers sprayed while it was raining (Table 10). In Temboan and Rurukan the great majority of farmers waited until there was at least a short break in the rain before spraying their fields, but in Kumelembuai many respondents said that it was alright to spray even though it was raining. All farmers (only men were asked this particular question) believed that it was alright to spray insecticides when there was a wind blowing (Table 10), as long as the person spraying walked in the same direction as the wind.

There were no village differences in farmers' perceptions of the danger of insecticides (Table 10). The majority believed that insecticides were very dangerous to humans; very few thought that insecticides were not dangerous. Despite this, very little protective clothing was worn when applying insecticides. As will be discussed in a subsequent section, it was found that only males sprayed insecticides. Fifty percent of male respondents wore a dust mask or covered their mouths with cloth while spraying

(Table 10). Very few respondents used gloves, shoes or boots. No one reported using safety goggles to protect his eyes (Table 10). Almost a quarter of male farmers reported that they had at some point experienced headaches, nausea, or dizziness during or after applying insecticides. An additional 7.6% reported itchiness after spraying.

DBM was most frequently identified as the most important pest of cabbages (Table 10). Cutworms and *Crocidolomia binotalis* were also frequently mentioned. In Kumelembuai 50% of respondents identified cutworms as the major pest, while in Rurukan DBM was considered by 56.5% of respondents to be so (Table 10). Respondents in Temboan were fairly evenly divided on the importance of these three pests.

Levels of knowledge concerning the DBM were quite high; no significant differences were found between the villages. Almost all respondents were able to name or describe the cabbage pests in the area, were aware that DBM underwent metamorphosis during its life cycle, and knew that DBM larvae and adults were the same insect (Table 10). Almost all respondents in Kumelembuai and all in Temboan were aware that it is only the larvae of DBM that cause damage, while in Rurukan 41.7% thought that both adults and larvae caused damage (Table 10).

Most respondents said that they applied insecticide sprays to kill the larvae, while the remainder said that they were trying to kill both larvae and adults (Table 10).

Most respondents were able to identify 1-3 other crops that are alternative hosts for DBM, while the remainder wrongly identified hosts or did not know of any others (Table 10).

3. General population characteristics of respondents by gender.

Female respondents were slightly younger than the men. Almost a third of female respondents were <30 years old, while only 12.5% of men were under this age.

There were no significant differences between the educational backgrounds of women and men, but a greater proportion of women had attended high school than did men (Table 11).

There were highly significant gender differences in terms of occupation (Table 11). Twice as many men as women worked in their fields full-time and almost a quarter of women did not do field work. About half of the respondents had an additional occupation (Table 11). About half of the women worked regularly at the market as traders, while only 13.6% of men did so. More men were involved in other occupations (e.g. drivers, processors of palm sugar or palm wine) than were women.

Table 11. Population characteristics by gender.

Criterion assessed	Sample size		Percent of growers			Probability of significant difference between genders [a]
	Female	Male	Female	Male	Total	
1. EDUCATION LEVEL	40	40				
Primary			32.5	37.5	35.1	
Junior High			35.0	45.0	40.0	
Senior High			32.5	17.5	33.8	0.30
2. ACTIVITY IN FIELD	39	40				
Never in field			23.1	5.0	13.9	
Occasionally			15.4	7.5	11.4	
Half day			23.1	12.5	17.7	
Full day			38.5	75.0	57.0	0.008
3. OTHER OCCUPATIONS	21	22				
Market occas'nally			14.3	9.1	11.7	
Market regularly			42.9	13.6	27.9	
Teacher			23.8	13.6	18.6	
Other			19.1	63.6	41.9	0.021

[a]Probability value determined by either Chi-square or Fisher's exact test.

4. Gender comparisons of pest management practices and knowledge levels.

There were no significant gender differences between pest management practices or beliefs (Table 12). However, some differences in women's and men's approaches to coping with ineffective sprays did exist (Table 12). Fifty percent of women and about a quarter of men said that they would make no changes during their next spray. Men were about twice as likely as women to change the insecticide, the dosage or both. More men also suggested increasing dosage levels in response to factors such as plant size or pest population levels than women (Table 12).

Though the differences are not significant, women were less likely than men to report that they had been in a position where they could not afford to buy insecticides (Table 12). Women were also more likely to suggest borrowing money or insecticides than men, who more often suggested handpicking of larvae as a coping strategy.

Women and men had similar perceptions regarding the danger of insecticides to humans; however, no women believed that insecticides are not dangerous, in comparison to 9.5% of men.

More women than men believed DBM to be the most important pest in the region, while more men identified cutworms and *Crocidolomia* as most important.

Table 12. Gender comparisons of pest management practices and knowledge levels.

Criterion assessed	Sample size		Percent of growers			Probability of significant difference between genders[a]
	Female	Male	Female	Male	Total	
1. FREQUENCY CROP CHECKED PER WEEK	21	19				
1-2x			38.1	42.1	40.0	
3-4			38.1	26.3	32.5	
5-6			23.8	31.6	17.5	0.71
2. DETERMINATION OF SPRAY TIME	21	21				
By calendar			0.0	4.8	2.4	
By crop condition			100	95.2	97.6	1.00
3. METHOD OF DETERMINING NEED TO SPRAY INSECTICIDE	21	21				
Check for pests or damage			90.5	95.2	92.8	
Count pests or damage			9.5	4.8	7.2	1.00
4. CROP SPRAYED IMMEDIATELY IF PESTS PRESENT OR POPULATION MONITORED	21	21				
Spray immediately			81.0	90.5	85.7	
Monitor pest population			19.1	9.5	14.3	0.66

Table 12 continued.

Criterion assessed	Sample size		Percent of growers			Probability of significant difference between genders [a]
	Female	Male	Female	Male	Total	
5. FACTORS INFLUENCING DECISION-MAKING CONCERNING INSECTICIDE USE						
Neighbouring fields recently sprayed	21	21				
Spray			23.8	33.3	28.6	
Make own decision			76.2	66.7	71.4	0.50
Others advise that field be sprayed	21	21				
Spray			9.5	9.5	9.6	
Make own decision			90.5	90.5	90.4	1.00
Insecticide type used	21	21				
Recommended by other			19.1	23.8	21.4	
Make own choice			81.0	76.2	78.6	1.00
6. ABILITY TO AFFORD INSECTICIDES						
Ever not been able to afford insecticides	20	20				
Yes			50.0	75.0	62.5	
No			50.0	25.0	37.5	0.10

Table 12 continued.

Criterion assessed	Sample size Female	Sample size Male	Percent of growers Female	Percent of growers Male	Percent of growers Total	Probability of significant difference between genders [a]
Means of coping with situation	10	15				
Wait			40.0	40.0	40.0	
Borrow			40.0	23.3	30.0	
Use soap			20.0	13.3	16.0	
Handpick larvae			0.0	23.3	14.0	0.45
7. METHOD OF DETERMINING INSECTICIDE DOSAGE USED	21	21				
Make own decision			85.7	76.2	81.0	
Label instructions			14.3	23.8	19.0	0.70
8. FACTORS INFLUENCING INSECTICIDE DOSAGE USED						
Higher if plants large	21	21				
Yes			38.1	47.6	42.9	
No			61.9	53.4	57.2	0.53
Higher if pest population high	21	21				
Yes			23.8	47.6	35.7	
No			76.2	52.4	64.3	0.11

Table 12 continued.

Criterion assessed	Sample size		Percent of growers			Probability of significant difference between genders[a]
	Female	Male	Female	Male	Total	
Depends upon types of pests present	21	21				
Yes			85.7	100	92.9	
No			14.3	0.0	7.1	0.23
Higher if rainy weather	17	18				
Yes			17.7	33.3	25.7	
No			82.4	66.7	74.3	0.44
Higher if previous spray ineffective	19	21				
Yes			21.1	38.1	30.0	
No			79.0	61.9	70.0	0.24
9. PEST CONTROL PRACTICES AFTER AN INEFFECTIVE SPRAY	22	21				
No change			50.0	23.8	37.2	
Add soap			13.6	4.8	9.3	
Change dosage			13.6	28.6	21.0	
Change insecticide			13.6	28.6	21.0	
Change both			4.6	14.3	9.3	
Never encountered			4.6	0.0	2.3	0.21

Table 12 continued.

Criterion assessed	Sample size Female	Sample size Male	Percent of growers Female	Percent of growers Male	Percent of growers Total	Probability of significant difference between genders [a]
10. INFLUENCE OF WEATHER ON SPRAY PRACTICES						
If it is raining	19	20				
Spray anyway			10.5	5.0	7.7	
Use soap			0.0	5.0	2.6	
Wait until stops			89.5	90.0	89.8	1.00
11. DANGER OF INSECT-ICIDES TO HUMANS	21	21				
Very dangerous			71.4	76.2	73.8	
Slightly dangerous			14.3	14.3	14.3	
Not dangerous			0.0	9.5	4.8	
Don't know			14.3	0.0	7.1	0.21
12. MOST IMPORTANT PEST OF CABBAGE	16	21				
DBM			65.6	28.6	44.6	
Crocidolomia			9.4	35.7	24.4	
Cutworm			18.8	31.0	25.7	
Other			6.3	4.8	5.4	0.11
13. KNOWLEDGE OF DBM & OTHER PESTS						
Able to name or describe cabbage pests	21	21				
No			14.3	0.0	7.1	
Yes			85.7	100	92.9	0.23

Table 12 continued.

Criterion assessed	Sample size Female	Sample size Male	Percent of growers Female	Percent of growers Male	Percent of growers Total	Probability of significant difference between genders [a]
Aware that DBM undergoes metamorphosis	18	21				
No			16.7	0.0	7.7	
Yes			83.3	100	92.4	0.09
Know that DBM moths and larvae are the same insect	18	21				
No			27.8	9.5	17.9	
Yes			72.2	90.5	82.0	0.22
Life stage causing damage to cabbage	17	21				
Moth & Larvae			35.3	23.8	29.0	
Larvae			64.7	76.2	71.1	0.49
Life stage sprayed against	17	20				
Moth & Larvae			41.2	20.0	29.7	
Larvae only			58.8	80.0	70.2	0.16
Able to name other DBM host plants	18	21				
No			5.6	9.5	7.7	
Wrong host named			33.3	9.5	20.5	
1 host named			36.1	33.3	34.6	
2 hosts named			13.9	42.9	29.5	
3 hosts named			11.1	4.8	7.7	0.15

[a] Probability value determined by either Chi-square or Fisher's exact test.

No significant differences were found between women's and men's knowledge levels concerning pests of cabbage (Table 12). However, consistently fewer women than men answered correctly.

5. Labour patterns in cabbage production.

In all three villages, about 75% of respondents hired paid labourers for some tasks in cabbage production (Table 13). Few growers hired no labourers, or had tasks performed free of charge by members of farmer self-help groups (*mapalus*) to which they belonged.

The majority of respondents hired labourers for field preparation, weeding and harvesting (Table 13). No respondents hired other people to sell their cabbages at market for them.

Significant differences were found between villages in the gender of labourers hired to work in cabbage fields (Table 13). In Kumelembuai, no respondents hired female labourers. In the other villages a significant proportion of women were hired for all jobs, except spraying insecticides and harvesting (Table 13). The greatest proportions of women labourers were hired for planting seeds, weeding, transplanting seedlings, and applying fertilizer.

Farm couples in Rurukan or Temboan hired both female and male labourers (Table 13), but a sizeable proportion of respondents hired only women for planting, weeding, transplanting, and fertilizing. In Temboan no couples hired

Table 13. Labour patterns in cabbage production by village. (Kumelembuai= Kum, Rurukan= Rur, Temboan= Tem).

Criterion assessed	Sample size			Percent of growers				Probability of significant difference between villages[a]
	Kum	Rur	Tem	Kum	Rur	Tem	Total	
1. FORM OF LABOUR HIRING	10	22	8					
Paid labour				70.0	77.3	75.0	75.0	
Cooperative labour				10.0	13.6	12.5	12.5	
Hire no workers				20.0	9.1	12.5	12.5	0.97
2. TASKS FOR WHICH LABOURERS ARE HIRED								
Land preparation	10	21	8					
No				20.0	14.3	25.0	17.9	
Yes				80.0	85.7	75.0	82.1	0.86
Planting seeds	10	21	8					
No				70.0	71.4	62.5	69.2	
Yes				30.0	28.6	37.5	30.8	0.90
Transplanting	7	18	6					
No				42.9	61.1	50.0	54.9	
Yes				57.1	38.9	50.0	45.2	0.70
Applying fertilizer	10	21	8					
No				60.0	66.7	62.5	64.1	
Yes				40.0	33.3	37.5	36.0	1.00
Spraying insecticides	10	21	8					
No				40.0	57.1	87.5	59.1	
Yes				60.0	42.9	12.5	41.1	0.14
Weeding	10	21	8					
No				30.0	38.1	50.0	38.5	
Yes				70.0	61.9	50.0	61.6	0.76

Table 13 continued.

Criterion assessed	Sample size Kum	Sample size Rur	Sample size Tem	Percent of growers Kum	Percent of growers Rur	Percent of growers Tem	Percent of growers Total	Probability of significant difference between villages[a]
Harvesting	1	8	4					
No				0.0	25.0	25.0	23.1	
Yes				100	75.0	75.0	77.0	1.00
Marketing	1	8	4					
No				100	100	100	100	
Yes				0.0	0.0	0.0	0.0	*
3. NO. OF WORKERS HIRED BY GENDER & TASK[b]								
Land preparation	44	127	35					
Male				100	70.5	91.4	80.4	
Female				0.0	29.5	8.6	19.7	<0.001
Planting seeds	8	14	5					
Male				100	25.0	40.0	50.0	
Female				0.0	75.0	60.0	50.0	0.002
Transplanting seedlings	14	23	6					
Male				100	56.5	33.3	67.5	
Female				0.0	43.5	66.7	32.6	0.002
Applying fertilizer	13	18	6					
Male				100	61.1	50.0	72.9	
Female				0.0	38.9	50.0	27.0	0.014
Spraying insecticides	8	9	1					
Male				100	100	100	100	
Female				0.0	0.0	0.0	0.0	*
Weeding	24	44.5	13					
Male				100	30.3	46.2	53.5	
Female				0.0	69.7	53.9	46.6	<0.001

Table 13 continued.

Criterion assessed	Sample size Kum	Sample size Rur	Sample size Tem	Percent of growers Kum	Percent of growers Rur	Percent of growers Tem	Percent of growers Total	Probability of significant difference between villages [a]
Harvesting	10	11	3					
Male				100	90.9	100	95.9	
Female				0.0	9.1	0.0	4.2	1.00
4. NO. OF COUPLES HIRING LABOURERS BY GENDER								
Land preparation	8	18	6					
Male				100	66.7	50.0	71.9	
Female				0.0	11.1	0.0	6.3	
Both				0.0	22.2	50.0	21.9	0.15
Planting seeds	4	6	3					
Male				100	33.3	0.0	46.2	
Female				0.0	33.3	33.3	23.1	
Both				0.0	33.3	66.7	30.8	0.11
Transplanting seedlings	4	7	3					
Male				100	57.1	33.3	64.3	
Female				0.0	14.3	33.3	14.2	
Both				0.0	28.6	33.3	21.4	0.51
Applying fertilizer	4	7	3					
Male				100	42.9	0.0	50.0	
Female				0.0	14.3	33.3	14.2	
Both				0.0	42.9	66.7	35.7	0.12
Spraying insecticides	6	9	1					
Male				100	100	100	100	
Female				0.0	0.0	0.0	0.0	
Both				0.0	0.0	0.0	0.0	*

Table 13 continued.

Criterion assessed	Sample size Kum	Sample size Rur	Sample size Tem	Percent of growers Kum	Percent of growers Rur	Percent of growers Tem	Percent of growers Total	Probability of significant difference between villages[a]
Weeding	7	13	4					
Male				100	46.2	0.0	54.2	
Female				0.0	30.8	25.0	20.9	
Both				0.0	23.1	75.0	25.0	0.008
Harvesting	1	6	3					
Male				100	83.3	100	100	
Female				0.0	0.0	0.0	0.0	
Both				0.0	16.7	0.0	0.0	1.00
5. TASKS PERFORMED BY COUPLE								
Land preparation	8	21	8					
Husband				50.0	23.8	50.0	35.1	
Wife				0.0	0.0	0.0	0.0	
Both				0.0	23.8	0.0	13.5	
Neither				50.0	52.4	50.0	51.3	0.31
Planting seeds	8	21	8					
Husband				62.5	23.8	12.5	29.7	
Wife				0.0	4.8	25.0	8.1	
Both				0.0	14.3	12.5	10.8	
Neither				37.5	57.1	50.0	51.3	0.23
Transplanting seedlings	7	18	6					
Husband				42.9	22.2	50.0	32.3	
Wife				0.0	5.6	0.0	3.2	
Both				14.3	50.0	33.3	38.7	
Neither				42.9	22.2	16.7	25.8	0.54

Table 13 continued.

Criterion assessed	Sample size Kum	Sample size Rur	Sample size Tem	Percent of growers Kum	Percent of growers Rur	Percent of growers Tem	Percent of growers Total	Probability of significant difference between villages[a]
Applying fertilizer	8	21	8					
Husband				50.0	33.3	50.0	40.5	
Wife				12.5	14.3	25.0	16.2	
Both				0.0	28.6	12.5	18.9	
Neither				37.5	23.8	12.5	24.3	0.63
Spraying insecticides	8	21	8					
Husband				62.5	71.4	87.5	72.9	
Wife				0.0	0.0	0.0	0.0	
Both				0.0	0.0	0.0	0.0	
Neither				37.5	28.6	12.5	27.0	0.55
Weeding	8	21	8					
Husband				12.5	19.2	25.0	18.9	
Wife				0.0	14.3	0.0	8.1	
Both				0.0	42.9	37.5	32.4	
Neither				87.5	23.8	37.5	40.5	0.06
Harvesting	8	20	8					
Husband				12.5	10.0	37.5	16.7	
Wife				0.0	0.0	0.0	0.0	
Both				0.0	10.0	0.0	5.6	
Neither				87.5	80.0	62.5	77.7	0.46
6. DECISION-MAKING RESPONSIBILITIES BY GENDER								
Checking crop condition	7	26	12					
Husband				57.1	80.8	50.0	68.9	
Wife				28.6	7.7	0.0	8.8	
Both				14.3	11.5	50.0	22.2	0.03

Table 13 continued.

Criterion assessed	Sample size Kum	Sample size Rur	Sample size Tem	Percent of growers Kum	Percent of growers Rur	Percent of growers Tem	Percent of growers Total	Probability of significant difference between villages[a]
Selecting insecticide	7	26	12					
Husband				85.7	76.9	100	84.4	
Wife				0.0	7.7	0.0	4.4	
Both				14.3	15.4	0.0	11.1	0.51
Buying insecticide	7	24	12					
Husband				57.1	58.3	50.0	55.9	
Wife				14.3	33.3	0.0	20.9	
Both				28.6	8.3	50.0	23.4	0.02
Deciding on crops to plant	7	26	12					
Husband				14.3	26.9	8.3	20.0	
Wife				0.0	3.9	8.3	4.4	
Both				85.7	69.2	83.3	75.5	0.64
Timing of planting seeds	7	26	12					
Husband				42.9	57.7	33.3	48.9	
Wife				0.0	3.9	8.3	4.4	
Both				57.1	38.5	58.3	46.7	0.55
Timing of transplanting seedlings	6	25	12					
Husband				50.0	60.0	33.3	51.2	
Wife				0.0	12.0	16.7	11.6	
Both				50.0	28.0	50.0	37.2	0.50
Timing of fertilizer applications	7	26	12					
Husband				71.4	61.5	25.0	53.4	
Wife				0.0	7.7	16.7	8.8	
Both				28.6	30.8	58.3	37.8	0.18

Table 13 continued.

Criterion assessed	Sample size Kum	Sample size Rur	Sample size Tem	Percent of growers Kum	Percent of growers Rur	Percent of growers Tem	Percent of growers Total	Probability of significant difference between villages[a]
Timing of insecticide sprays	7	26	12					
Husband				57.1	46.2	41.7	46.7	
Wife				0.0	3.9	8.3	4.4	
Both				42.9	50.0	50.0	48.9	0.97
Timing of weeding	7	26	12					
Husband				28.6	50.0	25.0	40.0	
Wife				28.6	7.7	16.7	13.2	
Both				42.9	42.3	58.3	46.7	0.39
Timing of harvest	7	26	12					
Husband				42.9	53.9	25.0	44.5	
Wife				0.0	11.5	0.0	6.7	
Both				57.1	34.6	75.0	48.9	0.19

[a] Probability value determined by either Chi-square or Fisher's exact test. Asterisks indicate that no statistics were computed because there was only one class of answer.

[b] In this case N = total number of labourers hired for each task.

only men for weeding in comparison to almost half of couples in Rurukan (Table 13).

Very few women had sole responsibility for certain tasks, and instead tasks were performed by both spouses together (Table 13). However, 16% of women applied fertilizer without their husbands, and 8% planted seeds alone (Table 13). In Rurukan more women weeded on their own or were responsible for selling the cabbage crop at the market than for other tasks.

Differences regarding decision-making responsibilities of women and their husbands occurred only in the tasks of checking crop condition and buying insecticides (Table 13). In Kumelembuai, more women checked the condition of the cabbage crop on their own, than women in Temboan and Rurukan. In Temboan, no women purchased insecticides for cabbages on their own while a third of women in Rurukan did. Other tasks and decisions were usually carried out by both spouses together, but a greater proportion of women had sole responsibility for timing the transplanting of seedlings to the field, for timing fertilizer applications, and for timing weeding of the field, than for other tasks.

6. Comparisons of gender perceptions concerning labour patterns and roles.

While there were generally no significant differences between women's and men's perceptions of the division of decision-making responsibilities, there appeared to be a general trend for women to perceive more sharing of decision-making than did men (Table 14). For example, the same proportions of women and men cite women as solely responsible for checking crop condition; however, more women than men perceived that the responsibility for checking the crop was shared (Table 14). The same trend can be seen for selecting insecticides; the same proportion of women and men said that women were solely responsible for selecting insecticides. However, four times more women than men believed that the responsibility was shared. There were no differences between women's and men's perceptions of who is responsible for buying insecticides or who determines when planting of seeds will occur (Table 14). Almost all women believed that they jointly decided on which crops to plant, whereas less than two-thirds of men perceived this responsibility as shared (Table 13). Similar differences occurred in perceptions regarding decisions on the timing of fertilizer applications, transplanting seedlings to the field, or deciding when to weed and when to harvest (Table 14). An exception was in the timing of insecticide applications, for which significantly more men than women reported that this was a shared decision.

Table 14. Gender perceptions of the division of decision-making responsibilities and gender roles in cabbage production.

Criterion assessed	Sample size		Percent of growers			Probability of significant difference between genders[a]
	Female	Male	Female	Male	Total	
1. CHECKING CROP CONDITION	21	21				
Husband alone			61.9	71.4	66.7	
Wife alone			9.5	9.5	9.6	
Both			28.6	19.1	23.8	0.89
2. SELECTING INSECTICIDE	21	21				
Husband alone			76.2	90.5	83.3	
Wife alone			4.8	4.8	4.8	
Both			19.1	4.8	11.9	0.49
3. BUYING INSECTICIDE	20	20				
Husband alone			55.0	60.0	57.5	
Wife alone			25.0	15.0	20.0	
Both			20.0	25.0	22.5	0.83
4. DECIDING ON CROPS TO PLANT	21	21				
Husband alone			9.5	28.6	19.1	
Wife alone			0.0	9.5	4.8	
Both			90.5	61.9	76.2	0.08

Table 14 continued.

Criterion assessed	Sample size		Percent of growers			Probability of significant difference between genders [a]
	Female	Male	Female	Male	Total	
5. DETERMINING TIMING OF PLANTING SEEDS	21	21				
Husband alone			47.6	47.6	47.6	
Wife alone			4.8	4.8	4.8	
Both			47.6	47.6	47.6	1.00
6. DETERMINING TIMING OF TRANSPLANTING SEEDLINGS	21	20				
Husband alone			38.1	65.0	51.2	
Wife alone			19.1	5.0	12.2	
Both			42.9	30.0	36.6	0.16
7. DETERMINING TIMING OF FERTILIZER APPLICATIONS	21	21				
Husband alone			33.3	66.7	50.0	
Wife alone			14.3	4.8	9.5	
Both			52.4	28.6	40.5	0.13
8. DETERMINING TIMING OF INSECTICIDE SPRAYS	21	21				
Husband alone			66.7	19.1	42.8	
Wife alone			4.8	4.8	4.8	
Both			28.6	76.2	52.4	0.002

Table 14 continued.

Criterion assessed	Sample size Female	Male	Percent of growers Female	Male	Total	Probability of significant difference between genders[a]
9. DETERMINING TIMING OF WEEDING	21	21				
Husband alone			23.8	57.1	40.5	
Wife alone			14.3	14.3	14.3	
Both			61.9	28.6	45.3	0.07
10. DETERMINING TIMING OF HARVEST	21	21				
Husband alone			33.3	52.4	42.9	
Wife alone			4.8	9.5	7.2	
Both			61.9	38.1	50.1	0.39

[a]Probability value determined by either Chi-square or Fisher's exact test.

Discussion

There are a number of particularly pertinent points that arise from this study.

1. While village differences are absent in other comparisons, differences did exist in the gender of labourers hired.

2. Levels of knowledge concerning the biology of DBM were quite high, but the quality of pest management practices was low.

3. There were no gender-based differences in pest and pest management knowledge.

4. Farmers did use crop condition to help determine if insecticides should be applied, but quantitative assessments were not utilized.

5. No tasks in cabbage production were considered to be solely women's work, although the application of insecticides was considered to be men's work.

The absence of significant differences between villages in pest management practices in most cases indicates that there are common practices employed in the area and that these three villages are presumably representative of the region. There is a longer history of vegetable production in general, and cabbage production specifically, in Rurukan than in Kumelembuai. It would be expected, therefore, that growers in Rurukan would have a greater knowledge and experience base on which to draw than growers in

Kumelembuai. However, less than 60% of farmers in Rurukan knew that only the larval stage of DBM causes damage to plants.

The differences in gender composition of labourers hired in each of the villages may be due to the longer history of commercial cabbage production in Rurukan than Kumelembuai. Farmers in Rurukan rent fields to grow cabbages, there are a greater number of cabbage growers, and there are dealers who both grow their own crops and buy those of other farmers wholesale. Therefore, there may be both more positions available and a greater demand for labourers. In such a situation, more positions are likely to be available to women, than if the demand for hired labourers is lower. Because cabbage production is fairly recent in Kumelembuai, the number of growers is still low, there is a low demand for labourers, and available positions are more likely to go to men than to women. There is one other possible explanation for this situation. New technologies or processes are often initially dominated by men, and as they become less novel, women's participation relative to men's increases (World Bank 1985). Thus, the 'newness' of cabbage production in Kumelembuai may also preclude women's participation as agricultural labourers at this time. The preference for male labourers in Kumelembuai is not due to economic considerations, as female farm workers in this region receive Rp. 2.500 per day, while men are paid Rp. 3.500 per day (about Cdn$ 2.00).

The different periods over which cabbage has been grown could also affect other practices, such as spray frequency. The somewhat higher reported spray frequencies among growers in Rurukan and Temboan than in Kumelembuai (Table 7) could result from several factors: effectiveness of the control measures used; pest population levels; insecticide resistant pest populations; and growers' experience and perceptions concerning the need to employ pest control measures. Almost all growers in Kumelembuai used a tank mixture of Padan and Ambush against cabbage pests, while no growers in either Rurukan or Temboan used such mixtures, and most sprayed Ambush. It is possible, therefore, that the combination of insecticides is much more effective in controlling cabbage pests and that growers in Kumelembuai do not have to spray as frequently as those in Rurukan. As indicated previously, the primary reason for lower DBM populations in Kumelembuai than either Temboan or Rurukan is probably that large populations of DBM have not yet been able to establish in the relatively short period that cabbage has been grown, but could also be due in part to the effectiveness of control measures employed.

Another pertinent factor could arise from the aforementioned 'experience base' in Rurukan. There are three 'rules' of cabbage production that are often expressed by farmers in this area. 1. Cabbage seeds must be purchased; it is not possible to produce one's own seeds. 2. Chemical fertilizer must be applied to cabbage fields in order to get good-sized heads. 3. It is always necessary to apply insecticides to the cabbage crop because pest problems are severe. It is possible that due to the longer history of cabbage production in Rurukan that the third belief is firmly embedded in farmers' minds, and farmers thus are predisposed to spraying whenever pests are present. Farmers in Kumelembuai may not be constrained by this belief and thus may not be as quick to decide that it is necessary to apply insecticides. Adherence to these three beliefs necessitates large expenditures for seeds, fertilizers and pesticides. Cabbage growers are thus very vulnerable to fluctuations in the market price of cabbage.

Farmers' perceptions of what is the most important cabbage pest in the region would also influence their approach to pest management. In Kumelembuai, cutworms are considered to be more important than DBM. Thus, a farmer in this village might not be as sensitive to seeing DBM adults flying in the field as a farmer from Rurukan, where DBM is considered by the majority to be the most important pest, and where many respondents believe that DBM adults also cause damage. Farmers in Kumelembuai could also be less apt to decide to spray because a tank mixture of two chemicals is more expensive than using a single insecticide.

It is interesting to note that farmers tend to claim greater personal responsibility for choosing insecticides than is supported by fact. Farmers claimed that they alone decided on what insecticides to spray, and yet almost all growers in Kumelembuai used the same combination of chemicals.

On the whole, cabbage growers in this region use no 'traditional' pest control practices, presumably because cabbage is an introduced crop. Farmers in Kakaskasen II did mention that certain ants could be used as biological control agents against larval pests damaging cabbage, but I did not see this intentionally practiced nor did any farmers in the study villages cite it as an alternative pest control method.

Since most farmers do not utilize quantitative assessments of crop condition or pest populations in determining whether it is necessary to spray, they are likely to experience either financial or crop losses due to the excessive or insufficient use of pesticides, or poor timing of pesticide applications.

Due to the nature of the insecticide formulations available, some phytotoxicity may occur when applications are made to small cabbage plants, and farmers may thus have good reason to reduce dosage levels on young plants. However, dosage levels should not be altered due to either weather or the abundance of pests in the field. It is recommended by the manufacturer that the doses of certain pesticides (e.g. Dessin 5EC) be altered depending on whether DBM or *Crocidolomia* is present, but very few farmers believe that dosage levels should be changed for this reason. By not using recommended doses, cabbage growers may be contributing to the development of insecticide resistance in DBM and other cabbage pests. The development of resistance in a susceptible population can be slowed down by using the lowest possible dose in order to conserve the susceptible gene pool (Brattsten et al. 1986). However, if low dosages are used against a population that has incipient resistance, the spread of resistant genotypes through the population will be accelerated. This occurs because susceptible homozygotes are killed by low doses, but resistant heterozygotes are not. Heterozygotes are therefore able to reproduce, and the resistant allele is spread through the population (Brattsten et al. 1986). On the other hand, frequent switching of insecticide types by some farmers could offset the development of resistance, if the insecticides are unrelated or have different modes of action. Varying degrees of cross resistance in DBM to synthetic pyrethroids have been documented in strains resistant to DDT (Kadir 1987), and to some organophosphate (Liu et al. 1981; Cheng et al. 1985) and carbamate compounds (Liu et al. 1981; Chou & Cheng 1983).

Due to the practice in this area of referring to insecticides as *racun* (poison), farmers are well aware of the dangers of oral poisoning by pesticides. However, as reflected by the few farmers who cover their skin when spraying, they are not really aware of the dangers of dermal uptake. Many did express the necessity of washing one's hands after spraying or before eating, however. Since most farmers do not wear shoes when working in their fields or spraying insecticides, the possibility of farmers absorbing a high dose of pesticide through their feet is very high.

With the exception of spraying insecticides, tasks in cabbage production in this area are not strictly divided along gender lines. There are no tasks in cabbage production that are considered to be solely women's work, but women tend to participate mostly in planting, weeding, transplanting, and fertilizing. Although this pattern is fairly typical of women's involvement in agriculture in developing countries (Stevens & Date-Bah 1984), women are involved in a broader range of tasks than has been found elsewhere. Women's greater role in markets than men's explains why a high proportion of women are responsible for the purchase of insecticides. This participation does not seem to give them greater responsibility in actual selection of the insecticide, however.

In a study examining the perceptions of women and men regarding decision-making in Java, Wahyuni et al. (1985) found that women's participation in decision-making as reported by their husbands was much lower than that reported by the women themselves. Since there is agreement regarding the role of women as the sole decision-maker in my study, the discrepancies in gender perception presumably arise in situations in which there is consultation between husband and wife. For example, a husband may ask his wife for her opinion on a certain matter. If the women confirms her husband's view, or even if the woman disagrees but the final decision is in agreement with the husband's stance, then the man may perceive that he was the primary decision-maker, whereas the woman may perceive that the decision was made jointly. The fact that men perceived more joint decision-making regarding timing of pesticide applications than women did may be explained by the need for consultation between spouses before expensive applications of insecticides are made.

Both female and male cabbage growers in this region have very high knowledge levels concerning the life cycle of DBM. This knowledge is presumably gained from field observations rather than from formal training. Women's knowledge levels are slightly lower than those of men, but not to the extent suggested by the comments of farmers (mostly male) concerning the relative superiority of men's knowledge and experience. It is interesting to note that in general, women's formal period of education is longer than that of men. This is in contrast to national educational trends reported by the Government of Indonesia & UNICEF (1989), and may be due to the historical emphasis placed on education in Minahasa (Mai & Buchholt 1987), and also to the relatively liberated status of women in Minahasa in comparison to other areas of Indonesia. In addition, men may leave school at an earlier age than women due to their role as primary agricultural labourers. Women may not participate in farm work until after they graduate (if their family can afford to pay their school fees for this long), or until they are married and become jointly responsible for agricultural production with their husband. Women's understanding of pests and pest management is not limited in comparison to men's and presumably results from both high levels of formal education and participation in crop management. Women farmers' understanding of agricultural techniques and technologies, such as a monitoring system, should, therefore, not be limited by their level of education, although it may be limited in the future by unequal access to training. Both female and male farmers are in need of training to help them determine which of their pest management practices are appropriate.

Chapter V

Assessing the Potential for and Impacts of the Introduction of a Sticky Trap Monitoring System for DBM to Cabbage Growers in Kecamatan Tomohon

The trapping studies indicate that a regional monitoring system might be the most appropriate for management of DBM in this area. In general, pest monitoring systems reduce pesticide use, and, as a result, expenses, but evaluation of a technology in terms of economics only is unlikely to be a very accurate indicator of its potential acceptance (Anderson 1985). Other factors that also influence the adoption of a technology include the availability of materials, proper training, time required to use the technology properly, and the sociocultural appropriateness of the technology. Using these criteria, a regional monitoring system, carried out by agricultural extension agents or by farmers' groups, seems to have several advantages over a system of individual field monitoring.

Most farmers have quite limited means with which to fund their pest management efforts. Thus, for a technology to be considered low cost, it would have to rely on materials that farmers can find and prepare themselves, that are very cheap to buy, or that are reusable or subsidized by the government. At this time no type of insect glue is commercially available in North Sulawesi. In addition, bristol board card is either very difficult to find or prohibitively expensive for use by farmers. Alternative trap materials such as acrylic plastic or sheet metal are probably more appropriate materials to use in this situation as once they are painted with the appropriate colour they could be reused, thus reducing long term costs. Although this option may be affordable for some farmers, marginal farmers are still unlikely to be able to accumulate the economic resources initially required. This system is not likely to be prohibitively expensive for the provincial or federal departments of agriculture, however. Once the initial purchase of materials is made and the traps are prepared, few additional expenditures would be required. It is also probable that the departments of agriculture could arrange for a supply of insect glue to be brought to the area.

In addition to lower costs over the long term, traps of acrylic or sheet metal have the advantage over bristol board traps that they would not be susceptible to the vagaries of weather, and would thus require little maintenance. These field experiments were conducted using weekly monitoring of the traps; if there was a lot of rain during this period the card traps would often curl up or the layers of card would separate, necessitating frequent trap replacement. More permanent types of trap would require only that insects captured were removed each week and that a new coat of insect glue be periodically applied, if the trap became too dirty or too much glue was washed off by rain.

Although there was no agricultural extension agent assigned to the three study villages during the time that this study was carried out, Indonesia has a well established infrastructure for conducting training programs for farmers and field extension agents (*Penyuluh Pertanian Lapangan*, PPLs), and for disseminating agricultural information. Each PPL is supposed to visit her or his assigned villages at least once a week to conduct extension activities. There is also one pest and disease observer (*Pengamat Hama dan Penyakit*, PHP) per Kecamatan, but often they concentrate on the pests of food or cash crops due to the overwhelming size of their task. The beauty of this monitoring system is that traps need to be checked only once a week, and damage-causing larval populations occurring two weeks later can be predicted. This trap monitoring schedule would fit perfectly with the PPLs required schedule of field visits and would give them 1-2 weeks to inform all farmers of an upcoming outbreak of DBM. This would give farmers the time to gather the necessary resources to purchase insecticides if necessary and would greatly help to improve the timing of their insecticide sprays. PPLs could inform growers about the need to spray through the village heads and ward heads in each village, by announcement over the village loudspeaker or through church meetings.

The monitoring system could also be expanded to include other hosts of DBM such as *petsai* (chinese cabbage), cauliflower and *cai sin* (mustard greens).

Due to the apparently independent nature of farmers in this area, it is unlikely that farmers would completely trust the PPL's advice. Agricultural extension services have been found to be most successful when supporting low risk or risk-free technology, when key inputs are available on time, and when farmers have ready access to markets for their additional production (Donovan 1987). In order for this system to work effectively, therefore, it is necessary that farmers be included in training sessions regarding the importance and principles of monitoring so that they are convinced of the advantages and low risk nature of the system. In this way farmers could appreciate the objectives and methods of the regional monitoring system and could learn to fine tune the advice of the PPLs by monitoring their own fields. Farmers in this region are already using crop condition as a means of determining the necessity of applying insecticides. This needs to be developed however, so that they are actually monitoring damage or pest population levels. The weekly predictive monitoring system would work very well in conjunction with mass trapping of DBM with sticky traps in problem fields, which farmers could be trained to operate or that could be maintained by the PPL.

The program could be promoted on the basis of its economic merits, predictive ability, and health benefits. The perception of insecticides as poison (*racun*) in this region should facilitate education regarding the importance of reducing reliance upon insecticides for DBM control. Since women play an active role in all aspects of cabbage production, it is essential that female farmers be included in training sessions on the underlying principles and use of the monitoring system. This would ensure that women could make informed pest management decisions, have an understanding of the nature of the regional monitoring system and the use of a mass trapping system.

If the monitoring system is carried out on a regional basis, it is unlikely to alter gender roles directly. However, there is the potential for women to be removed from pest management decision making, if consultations regarding pest problems are made only between the PPL and the male farmer. This would depend upon several factors, however, including the gender of the assigned PPL. There are several female PPLs employed through Tomohon's agricultural extension center (BPP), so this situation need not arise.

The implementation of a regional monitoring system could save farmers some time by reducing time spent on the task of checking crop condition. Often labour-saving technologies have the undesired effect of displacing small farmers and farm labourers (Mollett 1984). Labourers are not likely to be displaced by the implementation of this system, however, as no farmers hired labourers to check the condition of their crop. Workers hired to apply insecticides may be affected by reduced need of their services. This could be framed in a positive light, however, if they were made aware of the dangers of dermal contamination by pesticides.

If farmers are trained to operate the mass trapping system in their own fields, there would be greater demands upon their time. It is unclear which gender would be most affected. I suggest that both female and male farmers would remain active in checking crop condition, and that checking the trap would become a part of this task. Alternately, farmers may end up hiring workers to keep the traps free of insects.

A regional monitoring system could be implemented more quickly than an individual field system, as only the PPLs involved would need to receive training initially. A regional system also seems to have the potential of avoiding many of the classic problems of introduced technologies, such as disrupting gender roles and labour patterns. It is very important to the successful implementation of this program, however, that both female and male farmers, be included in and receive training on this system. Training is also required in this area on issues such as the health and environmental dangers of pesticides, and proper pest management practices that help to reduce or manage insecticide resistance.

Chapter VI

Recommendations

A number of recommendations arise from this research, which address the need for further research prior to implementation of the monitoring system, strategies that might help to ensure the successful implementation of a monitoring system, and related research projects. Ideally these further studies would be undertaken by Faculty members and students in the Faculty of Agriculture, Universitas Sam Ratulangi, in conjunction with staff of the provincial department of agriculture.

Research required prior to implementation of the monitoring system:

1. determine the relationship between trap catch and damage to the host plant;

2. establish sampling (i.e. trap catch) thresholds that can be used as a decision-making criteria;

3. determine optimum trap size;

4. determine number of traps required per unit area and total number for region;

5. determine cost of establishing and operating the monitoring system, and savings to growers.

Strategies to enhance the successful implementation of the monitoring system:

6. Obtain financing from appropriate sources, including aid agencies, and the provincial and central departments of agriculture.

7. Until such a time as the monitoring system can be implemented, the use of alternative insecticides (e.g. soap) and control methods, should be promoted among cabbage growers, and training should be provided on the dangers of pesticide exposure and resistance management. Such training could be given by PPLs or by university students as part of their mandatory term of community service, and would serve to sensitize farmers to the importance of reduced reliance upon conventional insecticides and the utility of a monitoring system.

8. After all practices concerning the use of the monitoring system have been finalized, PPLs should be given training in order that they fully understand its implementation and intentions.

9. Prior to implementation of a monitoring system, all growers in the involved villages should be given training courses by the PPLs both to explain the program to them and to help establish trust between the PPLs and farmers.

10. Equal access of female and male farmers to training sessions should be ensured.

11. PPLs should avoid transferring information regarding outbreaks of DBM to male farmers only. This could be done by making announcements of the need to spray at village churches, or over village loudspeaker systems. Involving the ward heads in each village could also help to ensure that all farmers were informed, but might exclude women farmers.

Related research projects:

12. Examine further the potential for using a sticky trap mass trapping system against the diamondback moth.

13. Examine the attractiveness of sticky traps to *Diadegma*, and determine the potential of using the DBM monitoring or mass trapping system to also monitor *Diadegma* populations and range expansion.

14. Examine the potential for using a sticky trap mass trapping system in conjunction with a pheromone-based trapping or mating disruption program.

APPENDIX 1

PRELIMINARY QUESTIONNAIRE

VILLAGE: HAMLET: COUPLE CODE:

1. WOMAN'S NAME: Age:
   Grade level completed:
   Nat'l or religious school?
   Field of study:
   Member of Women Farmers' Group ?
   Member of Vegetable Farmers'Group ?

2. MAN'S NAME: Age:
   Grade level completed:
   Nat'l or religious school?
   Field of study:
   Member of Vegetable Farmers'Group ?

3. Children's names Age Grade level Subject Area

Children's names	Age	Grade level	Subject Area

4. Do you (Mrs or Mr) work:

	WOMAN	MAN
	(Hours per day ?)	
At home		
In your own fields		
In someone else's fields		
In the market		
Other work		
What?		

5. How many times have you grown cabbage ?

6. Are seeds planted in the nursery first or directly in the field ?

7. a. *[If in nursery first]* Have the seedlings been transplanted to the field ?
   When were/will they be transplanted ?

   b. *[If directly to field]* When were the seeds planted ?

8. In how many fields do you grow cabbage ?
   What is their area ?
   Age of cabbage ?

9. Do you usually use insecticides in your cabbage fields ?

10. Normally how many times are your cabbage fields sprayed per season ?

11. Normally what type of insecticide do you use ?
Name Liquid or powder formulation ?

________________________ _______________________________

12. Are there any non-chemical pest control methods that you use ?

APPENDIX 2

CABBAGE PRODUCTION QUESTIONNAIRE

VILLAGE: HAMLET: COUPLE CODE:

1. How many fields do you farm ?
   What crops do you grow ?
   Do you own the fields or rent them ?

2. *[If there is a rented cabbage field]* Is rent paid or is the yield divided with the owner ?)
   How is the yield divided ?

3. Do you always grow cabbage in the same field ?

4. Is cabbage grown alone or intercropped with other crops ?
   With what other crops ?

5. If cabbage is harvested, how many days pass before the next crop is planted ?

6. Do you hire other people to work in your cabbage field ?

   a. Usually workers are hired for what jobs ? and
   b. What jobs do the two of you do ?

JOB	NO. WORKERS (Gender)	NO. HOURS	PAID/ COOP'VE
Prepare bedding	________	________	________
Plant seeds	________	________	________
Apply Fertilizer	________	________	________
Transplant seedlings	________	________	________
Spray insecticides	________	________	________
Weed field	________	________	________
Harvest cabbage	________	________	________
Sell cabbage	________	________	________
Other	________	________	________

7. Do you own or borrow spray equipment ?

8. If the cabbage field is sprayed once, what is the cost ? (Insecticide and/or workers ?)

9. If the field is rented, does the owner provide insecticides or fertilizer ?

   Does the owner say when it is necessary to spray ?

10. If there is pest damage does the price of cabbage fall or is it dependent on the amount of cabbage in the market ?

The price falls how much if the cabbage is damaged ?

11. Are damaged leaves removed before the cabbage are put in sacks ?

Therefore, if the cabbage is damaged more heads can fit into one sack ?

12. How much damage is acceptable ? or

Can the cabbage still be sold if there is damage...

a. to the outer leaves only
b. to the outer leaves and head

13. After cabbage is harvested, are the debris removed from the field ?

burned ? given to livestock ?
buried in the soil ?

14. Normally do you sell the cabbage yourself or to a dealer/wholesaler ?

15. Normally how many sacks do you sell and how many are used at home or given to friends and relations ?

APPENDIX 3

QUESTIONNAIRE ON KNOWLEDGE LEVELS & GENDER ROLES IN CABBAGE PRODUCTION AND PEST MANAGEMENT

VILLAGE: COUPLE CODE:
RESPONDENT:

1. What types of pest damage cabbage in this area ?
What types of damage are caused ?

[If respondent is unable to answer, go to # 6]

2. What pest causes the most damage to cabbage in this region ? or
what pest do you tihink is the most important/ destructive in this region ?

3. *[If respondent listed DBM larva in # 1 or 2, ask about larva and go to (a); if DBM adult listed, ask about moth and go to (b)]*

What damage does the 'hanging worm' or small brown moth[1] cause ?

(a) The larvae comes from an egg, what lays the egg ?
If the larvae gets big enough does it change its form ?
The larvae becomes what type of insect ?

(b) Does the moth eat the cabbage ?
If the moth lays an egg, what kind of insect emerges from it ?

4. If you spray, is it the moth or the larvae that you want to kill ?

5. The 'hanging worm' also damages what other plants ?

6. How many times do you go to your cabbage field each week?

7. If you spray insecticides, do you spray at a regularly determined interval of days or according to the condition of the field ?

8. If you look at the field first, what do you look for ?
- Damaged plants ?
- Pests - Moths or Larvae ?

9. Do you count the number of larvae or damaged plants ? or just see if there are any ?
[If counts] After how many damaged plants or how many larvae per plant are found do you decide to spray ?

10. If there are pests or damaged plants, but only a few, can you wait to see if the pest population increases or must you spray quickly ?

11. After the cabbage has been sprayed, is the field checked again for pests or damage ?
After how many days ?
Normally after spraying, is there a change in the condition of the cabbage ?
If there is no change, do you: spray again ?
change insecticides ?
change the dosage used ?

12. If neighbouring fields have been sprayed recently, is it necessary to spray your field ?

13. If friends or other farmers say that your cabbage should be sprayed do you follow their advice ?

14. Have you ever felt that it was necessary to spray your cabbage field, but not had any insecticides or the money to buy them ?
Does this occur often or rarely ?
What do you do if you have no money ?
Wait until you can afford to buy insecticides?
Borrow money or insecticide ?
Use another method ?

15. How do you decide which insecticide to use ?
Recommended by another
Make own decision
Why did you choose that insecticide over another ?

16. Normally who selects the insecticide ? (Woman or man ?)
Who buys it ?

17. How do you decide on the dosage to use ?
According to the label ?
Other method ? (e.g. bottle cap or spoon)
If you look at the label, it does not say how many caps or spoons to use, so how do you know that that is the right dosage ?

18. Does the dosage used differ:
If the cabbage is young or old ?
If there are few or a lot of pests ?
If there are 'hanging worms' or other types of pest ?

19. Cabbage can be sprayed with insecticides until how many days before harvest ?

20. What type of weather is best if you want to spray ?
What do you do if there are pests in your field and you had planned to spray but it is raining ?
Does the dosage used differ if it is sunny or raining ?

21. *[Asked of male respondents only]* Is it alright to spray if it is windy ?

22. *[Asked of male respondents only]* If cabbage is going to be sprayed,
a. What clothes are worn ?
b. Do you wear: Mask Gloves Shoes Goggles

23. *[For female respondents ask about husband instead]*[2]

Have you (or your husband) ever felt sick, dizzy or not well after spraying ?

Are insecticides dangerous to people ?
No
A little
Very

24. ACTIVITY	WOMAN ALONE	WOMAN & MAN	MAN ALONE
Usually who determines:			
what kinds of crops will be grown	______	______	______
when cabbage beds will be prepared	______	______	______
when seeds will be planted	______	______	______
when seedlings will be transplanted to the field	______	______	______
when fertilizer will be applied	______	______	______
when cabbage will be sprayed with insecticides	______	______	______
when cabbage field will be weeded	______	______	______
when cabbage will be harvested	______	______	______

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1. The larvae of DBM are called *ulat gantung* or the hanging worm, adults are often described as *kupu-kupu yang coklat dan kecil* or the small brown moth.
2. It was learned from a previous questionnaire that women do not spray insecticides.

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