

EFFICACY OF THE DIAMONDBACK
MOTH PARASITOID
COTESIA PLUTELLAE AND FARMERS'
PERCEPTIONS ABOUT THE PEST



University of Fort Hare
Together in Excellence

BY

LEUTLE M.F.

**UNIVERSITY OF FORT HARE
FACULTY OF SCIENCE
DEPARTMENT OF ZOOLOGY (ENTOMOLOGY)
ALICE**

**EFFICACY OF THE DIAMONDBACK MOTH
PARASITOID
COTESIA PLUTELLAE AND FARMERS'
PERCEPTIONS ABOUT THE PEST**

by



LEUTLE MAMOGOTO FRANS

Submitted in partial fulfilment of the requirement for the degree

University of Fort Hare
Together in Excellence

MASTER OF AGRICULTURE

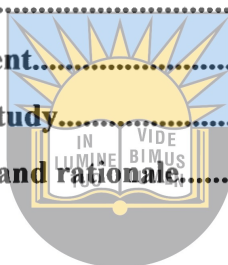
in the

**Department of Agricultural Extension and Economics
Faculty of Agriculture
University of Fort Hare
Alice**

December, 1999

CONTENTS

CHAPTER	PAGE
ABSTRACT	(i)
DECLARATION.....	(iii)
ACKNOWLEDGEMENTS	(iv)
1 INTRODUCTION	
1.1 Introduction.....	1
1.2 Background statement.....	4
1.3 Motivation for the study.....	4
1.4 Research objective and rationale.....	5
2 LITERATURE REVIEW	
2.1 Description of the pest.....	6
2.2 Distribution of the pest.....	9
2.3 Common host plant(s).....	9
2.4 Plant damage.....	10
2.5 Management of the pest	
2.5.1 Chemical control.....	10
2.5.2 Cultural.....	12
2.5.3 Organic/Biological control.....	15
2.5.4 Integrated pest management.....	17
3 METHODOLOGY	
3.1 FIELD OBSERVATIONS.....	22
3.1.1 Study sites.....	22
3.1.2 <i>P. xylostella</i> infestation (population density).....	22



University of Fort Hare
Together in Excellence

3.1.3	<i>Cotesia plutellae</i> parasitism.....	22
3.2	LABORATORY OBSERVATIONS	
3.2.1	<i>Cotesia plutellae</i> parasitism.....	23
3.2.1.1	Rearing of <i>P. xylostella</i> and <i>C. plutellae</i>	23
3.3.2.2	Susceptibility of <i>P. xylostella</i> larvae to <i>C. plutellae</i>	24
3.3	SURVEY ON FARMERS' SOCIO-ECONOMIC CHARACTERISTICS AND CONCEPTS ABOUT THE PEST	
3.4.1	Questionnaire to contact farmers.....	25
3.4.2	Questionnaire design.....	25
3.4.3	Sampling procedure.....	26
3.4.4	Interviewing procedure.....	26
3.4.5	Qualitative reliability.....	26
3.4.6	Coding and analysis.....	27
4.	RESULTS AND DISCUSSION	
4.1	FIELD OBSERVATIONS.....	28
4.1.1	Field <i>P. xylostella</i> infestation and parasitization.....	28
4.1.1.1	<i>P. xylostella</i> density on cabbage plants.....	28
4.1.1.2	The performance of parasitoids in the field.....	33
4.2	LABORATORY OBSERVATIONS	
4.2.1	Susceptibility of <i>P. xylostella</i> to <i>C. plutellae</i> parasitoids.....	36
4.3	SURVEY ON FARMERS' SOCIO-ECONOMIC CHARACTERISTICS AND CONCEPTS ABOUT THE PEST	



4.3.1	Demographic and socio-economic characteristics of the farmer.....	42
4.3.1.1	Gender and age.....	42
4.3.1.2	Education.....	44
4.3.1.3	Land tenure system.....	46
4.3.1.4	Experience of the contact farmer in vegetables production (Cabbage).....	49
4.3.1.5	Inputs, labour and marketing.....	49
4.3.1.6	Estimated average annual production of cabbage.....	50
4.3.1.7	The use of pesticides.....	52
4.3.1.8	Economic importance of the target crop (Cabbage).....	54
4.3.1.9	Pest control practices.....	55
4.3.1.10	Previous livestock farming experience.....	57

University of Port Hare
Together in Excellence

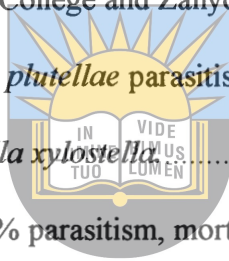
5.	DISCUSSION AND CONCLUSIONS	
5.1	Field observations.....	59
5.2	Laboratory observations.....	60
5.3	Socio-economic condition and required resources	61

LITERATURE CITED

APPENDICES

LIST OF TABLES

Table 2.1	Characteristics of the life stages of the diamondback moth.....	8
Table 2.2	Influence of intercropping on the marketable yield of cabbage, in relation to infestation by DBM.....	13
Table 4.3	An outline of the IPM program for <i>P. xylostella</i> in Malaysia.....	19
Table 4.4	Levels of parasitization of <i>P. xylostella</i> by <i>C. plutellae</i> and <i>D. collaris</i> observed at Fort Cox College and Zanyokwe Irrigation Scheme.....	34
Table 4.5	Mean percent <i>Cotesia plutellae</i> parasitism on different larval instars of <i>Plutella xylostella</i>	35
Table 4.6	Comparison of mean % parasitism, mortality, <i>P. xylostella</i> adults obtained and mean longevity per female <i>C. plutellae</i> (days) on different larval instars of <i>P. xylostella</i>	39
Table 4.7	Mean percentage host larval mortality parasitism by <i>C. plutellae</i> in the four instars of <i>P. xylostella</i>	65
Table 4.8	Average DBM parasitism by <i>C. plutellae</i> at 2 nd instar based on the first 8 days of the female parasitoid.....	65
Table 4.9	Average DBM parasitism by <i>C. plutellae</i> at 3 rd instar based on the first 5 days of the female parasitoid.....	66
Table 4.10	Average DBM parasitism by <i>C. plutellae</i> at 4 th instar based on the first 7 days of the female parasitoid.....	66



University of Fort Hare
Together in Excellence

LIST OF FIGURES

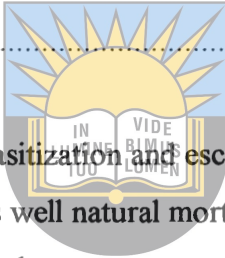
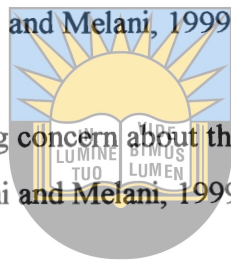
Fig.4.1	Mean <i>P. xylostella</i> larvae infestation per cabbage at Fort Cox, Zanyokwe, Kama furrow, Alice and Fort Beaufort area from June 1997 to September 1999.....	29
Fig.4.2	The average temperature and rainfall at Fort Cox, Zanyokwe and Kama furrow area in 1996 and 1997.....	30
Fig.4.3	The average temperature and rainfall at Alice in 1997 and 1998.....	31
Fig.4.4	<div style="text-align: center;">  <p>University of Fort Hare Together in Excellence</p> </div> <i>Plutella xylostella</i> parasitization and escaping of parasitization by <i>Cotesia plutellae</i> as well natural mortality when different larval instars were tested.....	38
Fig. 4.5	Mean daily of parasitism realized by a single female <i>C. plutellae</i> on the 2 nd , 3 rd and 4 th instar larvae of <i>P. xylostella</i> during its period oviposition.....	41
Fig 4.6	Gender distribution of the contact farmers (Alice District, Roxeni and Melani, 1999).....	43
Fig 4. 7	Age distribution of the contact farmers (Alice District, Roxeni and Melani, 1999).....	43
Fig 4.8	Distribution of farmers according to number of years spent in school (Alice District, Roxeni and Melani, 1999).....	45

Fig 4.9	Area of land occupied by each respondent (Alice District, Roxeni and Melani, 1999).....	45
Fig 4.10	Number of different crops grown by each farmer (Alice District, Roxeni and Melani, 1999).....	48
Fig 4.11	Farmers` experience in cabbage production (Alice District, Roxeni and Melani, 1999).....	48
Fig 4.12	Distribution of respondents according to cabbage yield category (Alice District, Roxeni and Melani, 1999).....	51
Fig 4.13	Respondents indicating concern about the use of pesticides (Alice District, Roxeni and Melani, 1999).....	51
Fig 4.14	Number of respondents indicating that they are aware of the benefits of integrated pest management (IPM) (Alice District, Roxeni and Melani, 1999).....	53
Fig 4.15	The pesticides used by the contact farmers at Roxeni and Melani to control vegetable pests (Alice District, Roxeni and Melani, 1999).....	56
Fig 4.16	Number of years in livestock production by respondents (Alice District, Roxeni and Melani, 1999).....	58



University of Fort Hare
Together in Excellence

ABSTRACT

The diamondback moth (DBM), *Plutella xylostella* (L), is the most destructive pest of cabbage and other cruciferous crop's world wide (Mitchel, Tingle, Navasero-Warde & Kehat, 1997). It is a holometabolous pest which survive as long as 50 days at low temperatures and as short as 15 days at high temperature (Hutchison, Bolin, & Hines, 1997). The main method of control practised by farmers has been the use of synthetic insecticides. Due to over- dependence on chemicals, several pesticide related problems such as resistance development, hazards to non-target organism, environmental pollution, poisoning and residues in crops have surfaced and become serious (Lim, Loke, Chan & Syed, 1988). The alternative strategy to manage this pest would have to involve biological control as major component of the integrated pest management. The latter approach requires the study of this pest and its natural enemies.

University of Fort Hare

Together in Excellence

Field observations were carried out at Fort Cox College and Zanyokwe irrigation scheme to document the level of parasitism on *P. xylostella* in the farmers fields. Among the parasitoids active in the field was *Cotesia plutellae* which performed better than *Diadromus collaris* in the study areas. Other parasitoids found in the areas included *Diadegma sp*, *Diadromus sp* and *Cotesia sp*. *Plutella xylostella* infestation rate varied considerably from August to September but in all cases showed an increase in the numbers of larvae per cabbage plant from June to September 1997. The mean number of *P. xylostella* larvae per cabbage was 4 in June , 5 in July, 9 in August and over 20 from September to December. Seasonal changes have an impact on population density of *P. xylostella* larvae per cabbage plant.

The aim of the field survey was to establish the socio-economic characteristics of the farming group in the community, strategies used by farmers to control the pest and their concepts about the pest and its parasitoids. The results showed that a considerable amount of

pesticides are used by the farmers to manage this pest. The group of pesticides used by farmers included Methamidophos which is a very harmful to beneficial organisms.

Kao & Tzeng (1986) reported *C. plutellae* mortality of 99% in case of exposure to Methamidophos. The susceptibility of the *Plutella xylostella* larval instars to *Cotesia plutellae*, was investigated under laboratory conditions from 22 May 1997 - 20 December 1998. In the laboratory (22 ± 2 °C, 40 - 45 % RH, 16 : 8 (L:D)) results showed that the 2nd and 3rd instars of *P. xylostella* larvae were relatively more susceptible to *C. plutellae* attack than the 4th instar.



University of Fort Hare
Together in Excellence

DECLARATION

I hereby certify that the research work reported in this dissertation is the result of my own investigation, except where acknowledged.



University of Fort Hare
Together in Excellence

ACKNOWLEDGMENTS

The author would like to thank his supervisor Dr S. M. Waladde for his support and guidance in the course of this work.

I would like to thank the National Research Foundation (NRF) formerly the Foundation for Research Development (FRD) for sponsoring this research project.



Thanks also to:

University of Fort Hare
Together in Excellence

Mr J L H Williams for technical assistance and advice.

Mr T Vanda for having assisted as an interpreter.

The extension officers in Department of Agriculture at Alice District for having co-operated very well and assisted in many ways.

Mr E Sampungwe for having assisted in the analysis of the data.

I would like to express my sincere and deepest gratitude and thanks to my parents. Without your support and encouragement this would never have been possible.

CHAPTER 1

1.1 INTRODUCTION

The diamondback Moth (DBM), *Plutella xylostella* (L) (Lepidoptera: Yponomeutidae) is the most destructive pest of all economically important crucifers worldwide (Idris & Graffill, 1997; Kmec & Weiss 1997; Talekar & Yang 1991; Kao & Tzeng, 1992) and the annual cost for controlling this pest was estimated to be U.S \$ 1 billion (Talekar, 1998). Members of the plant family Cruciferae occur in temperate and tropical climates and represent a diverse and widespread plant group that includes cabbage, broccoli, cauliflower, collards, rape seed, mustard, and chinese cabbage (Li, 1981). Most of these crucifers are used as vegetables and produce oil seeds (Yang, Chu & Talekar, 1994).

Plutella xylostella is believed to have originated in the Mediterranean area (Harcourt, 1954), the source of some of our most important crucifers (Tsunoda, 1980) but now it occurs wherever crucifers are grown and as a result this insect is the most universally distributed of all Lepidoptera (Meyrick, 1928). It is a cosmopolitan pest which thrives under varied climatic conditions (Paramonov, 1953) but a temperature range of 17 - 25°C is considered optimum for the pest (Atwal, 1995). The larvae of *P. xylostella* attacks and feeds on the leaves and growing points of cabbage plants, resulting in the proliferation of small, useless heads from stunted cabbage plants (Annecke & Nurain, 1982). The greatest damage occurs when infestation takes place on young plants. In older plants the larvae develop mainly on the outer leaves. Such damage is of little economic significance (Mustata, 1992). On the whole the feeding habits of this pest reduces both yield and quality of the produce (Yang, Chu & Talekar, 1994).

Farmers rely mainly on chemical pesticides to control *P. xylostella*. Prior to the introduction of synthetic insecticides in the late 1940s, *P. xylostella* was not reported as major pests of crucifer. However, with widespread use of synthetic insecticides on crucifers beginning in the mid 1950s, important natural enemies were eliminated. This event, in turn, led to

continued use of synthetic insecticides and eventual insecticide resistance and control failures (Talekar & Shelton, 1993). This pest is notorious for its ability to develop resistance against a wide range of insecticides (Sastrosiswojo & Sastradihardjo, 1986). *Plutella xylostella* became the first crop pest in the world to develop resistance to dichlorodiphenyl trichloroethane (DDT) (Ankersmit, 1953 ; Johnson, 1953). In addition, *P. xylostella* has the distinction of being the first insects to develop resistance in the field to the biopesticide *Bacillus thuringiensis* (Hama, 1992; Kirsch & Schmutterer, 1998; Shelton & Heyman, 1992; Tabashni, Cushing, Finson & Johnson, 1990). In South Africa, *P. xylostella* resistance to pesticide has been reported in various areas where cabbages are grown intensively. This phenomenon has been reported in many parts of the world (Marallo - Rejesus & Sayaboc, 1992) and represents a serious threat to the effective management of this important crucifer defoliator (Soares & Quick, 1992). The main drawbacks in using insecticidal control are: development of insecticidal resistance, resurgence of the insect after applications of the insecticides and non-selective killing of harmless and beneficial insect species (Nemota, Yano & Kiritani, 1992). As noted by Kardir (1992), the use of increasing dosages of chemicals insecticides which become less effective can lead to poisoning residues in the vegetable crop produced for human consumption.

It is therefore important to adopt an integrated pest management approach with biological control as a major tactic. Biological control of *P. xylostella* is an appropriate major tactic in an integrated pest management package, which may involve other measures such as selection of sprays that are harmless to parasitoids, planting cultivars that are resistant to *P. xylostella*, provision of flowering plants to supply nectar to boost parasitoid reproduction, and overhead water sprays to increase small larval mortality (SLM) (Waterhouse, 1992). The above mentioned mortality is due to the fact that *P. xylostella* are susceptible to drowning during heavy rainfalls (Harcourt, 1986) and overhead water sprays. Small larvae are readily disturbed and are washed into leaf axils or baloon to the ground where they perish in water puddle.

The significance of the biological control of *P. xylostella* and other brassicas insect pests lies in the fact that this approach reduces environmental damage and can provide a more

sustainable control measure. Therefore, identification of the most active and locally available parasitoids should be encouraged. Moreover, an approximation of the potential biological control agents and the extent to which they can be exploited is essential for the pest management program aiming to optimize utilisation of such agent (Lim, 1986). Absence of effective natural enemies, especially parasitoids, is believed to be a major cause of *P. xylostella*'s pest status in most parts of the world (Lim, 1986). Lack of parasitoids in a particular area may occur because *P. xylostella* is better established in newly planted crucifers than are the parasitoid. Reports on the ability of *P. xylostella* to migrate long distance are numerous (Bretherton, 1982; French, 1967; Gray, 1915; Miles, 1924), but there is no record of migration of any of its parasitoids. Another reason for the lack of effective biological control in a given area may be destruction of natural enemies by the use of broad-spectrum insecticides.

The South African Plant Protection Research Institute collaborated with the Council of Agriculture in Taiwan and carried out field survey of *P. xylostella* parasitoids at Brits Rietondale and Roodeplaat. Result from this survey showed that at least seventeen parasitoids were active in that part of South Africa. Though numerous *P. xylostella* parasitoids species (*Cotesia sp.*, *Diadromus sp.*, *Diadegma sp.* etc.) exists in the Eastern Cape region, not all are found to be equally active all year around and the impact of each of these parasitoids is not yet well researched. Since the pest status of *P. xylostella* and its parasitoids in the other parts of South Africa are not documented, it is essential to undertake studies on *P. xylostella*, especially in areas where cabbage and other cruciferous vegetables are grown. It is also important to investigate the efficiency of the most common *P. xylostella* parasitoids. In this project we report on studies conducted at the University of Fort Hare in the Eastern Cape. *Phutellae xylostella* parasitoids found in this area included *Cotesia sp.*, *Diadromous sp.* and *Diadegma sp.* *Cotesia phutellae* was the predominant parasitoid (Waladde & Villet, 1997). In this particular study we investigated the efficacy of *C. phutellae* in parasitizing different instars of *P. xylostella* larvae. Since this investigation is part of an agricultural extension study, attempts were made to conduct a field survey on farmers' socio-economic characteristics and concepts about pest and also to find out whether farmers are aware of about the natural enemies of *P. xylostella*. The survey was undertaken with the cooperation of small scale vegetable farmers in the Alice District especially Roxeni and Melani localities.

1.2 Background Statement

Cultivation of vegetables on both small and large scale is an important agricultural activity in the Eastern Cape. Different types of vegetables are grown in this region, comprising both tropical and temperate species. Leafy brassica vegetables in particular cabbage (*Brassica oleracea*) is the most popular leaf vegetable grown by the small scale farmers in the Eastern Cape, in spite of the fact that this crop is susceptible to insect pests and diseases. In terms of pest ranking *P. xylostella*, the diamondback moth (DBM) is the most important insect pest of the Cruciferae (Corbett & Pagden, 1941) and it has been regarded as a pest in South Africa since 1746 (Harcourt, 1962).

Larvae damage cabbage plants by feeding on the leaves and growing points. In order to control this pest, brassica and cruciferous vegetables are drenched with ever-increasing amounts and varieties of pesticides. This has led to the development of *P. xylostella* strains resistant to various categories of chemical insecticides (Sun, 1992; Sun et al. 1986) and in some cases microbial pesticides such as the endotoxins of *Bacillus thuringiensis* (Soare & Quick, 1992).



University of Fort Hare
Together in Excellence

1.3 Motivation for the study

Although *D. semiclausum* was introduced in South Africa long ago (Evans, 1939) to combat the DBM menace, general use of this and other parasitoids to control DBM as an alternative to the use chemicals, was not developed to a state where this biocontrol agent could be established. Furthermore there is no comprehensive country- wide or regional data on DBM and its parasitoids.

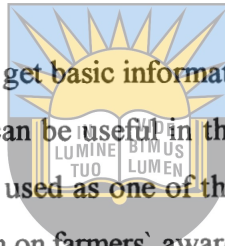
Since chemical insecticides are used intensively to control the diamondback moth in South Africa, it is essential to conduct investigations which can generate data likely to facilitate the adoption of sustainable and environmentally friendly diamondback moth control strategies.

1.4 Research objectives and rationale.

The objectives were threefold namely :

- i Gather basic data on *P. xylostella* infestation and parasitism in the vicinity of Alice.
- ii Assess the efficacy of the most common parasitoid *C. plutellae* in parasitizing different instars of *P. xylostella*.
- iii Gather information on the small-scale farmers' socio-economic characteristics and concepts about the pest and its natural enemies.

The rationale behind this work was to get basic information about DBM in the area and at the same time get information that can be useful in the mass rearing of *C. plutellae*. If biological control is eventually to be used as one of the tactics in the management of the DBM, it is essential to have information on farmers' awareness about the pest and its natural enemies.



University of Fort Hare
Together in Excellence

CHAPTER 2

2 LITERATURE REVIEW

This section deals with all aspects of the pest and its control. These included description of the pest, life cycle, distribution, movement, common host plants and plant damage. Methods used to reduce pest damage included chemical, cultural, biological control and the integrated pest management strategies are also considered.

2.1 Description of the pest

The adult of *P. xylostella* is about 9 mm long and greyish with a characteristic cream-coloured and row of diamond-shaped markings along the mid-line of the folded wings. Adults are grey moths with a wing expanse of 14 mm. This gives them their common name - the diamondback moth. The tips of the wings are fringed with long grey hairs (Hely, Pasfield & Gellatley, 1982).

University of Fort Hare
Together in Excellence

The larvae are small (about 10 mm when full grown) compared to other caterpillars in cole crops. They are usually found on the undersurfaces of leaves. The incubation period ranges from three to six days (Abramham & Padmanabhan, 1968). Patil & Pokharkar (1971) reported an incubation period of four to six days under laboratory conditions. Jayarathnam (1977) records an incubation period of three to four days under both laboratory and field conditions. The larval body is wider in the middle and tapering at both ends with two prolegs on the last segment forming a distinctive V-shape at the rear end (Chaney, Toscano, Bentley & Natwick, 1998). This species undergoes complete metamorphosis. Its eggs are oval and cream coloured. The larvae are minute when they hatch. There are four larval stages or instars which can be distinguished by the width of the head capsule (Hely et al, 1982). Jayarathnam (1977) observed that the 1st instar occupied three days in the hot season, 3 to 4 days in the rainy season and 4 to 5 days in the cold season. The 1st instar generally stay in the mines for about two days. The 2nd instar stage lasts two days in the hot and rainy seasons and 2 to 3 days in the cold season. The 3rd instar larvae generally feed on mature leaves for two days in the hot and rainy seasons and for two to three days in the cold season. The 4th

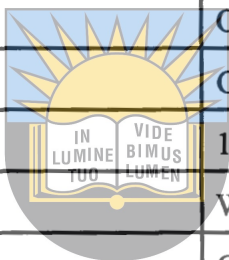
instar larvae, excluding the prepupal period, consume the largest quantity of leaf tissue and last for two days in the hot season, two to three days in the rainy, and three to four days in cold season. The pre-pupal period lasts for one day in all three seasons. The total larval and prepupal period are estimated as 10 days in the hot and rainy seasons and 12 to 15 days in the cold season.

When disturbed the larvae wiggle frantically or rapidly attach a silken line to a leaf and balloons over the edge. They feed mostly on the growing points of young plants chewing out holes as they feed. They will also feed on floral stalks and flower buds. Larvae mature in 10 to 14 days and spin a loose cocoon on leaves or stems for pupation. The mature pupae are 6 mm long and of light brown colour. The pupal stages ranges from 7 to 11 days (Abraham & Padmanabhan, 1968). Jayarathnam (1977) found adults to survive for three to six days without food and for 11 to 16 days when provided with food.

Jayarathnam (1977) observed that DBM completed 13 to 14 generations per year in Bangalore, India. He also postulated that if the eggs were to be laid by the adults of each generation on the same day as emergence, up to 16 generations per year could be completed. Although they may occur all year round, especially in coastal areas, diamondback moths are abundant in spring and early summer and in the temperate regions, populations may rise again in fall annually (Chaney, Toscano, Bentley & Natwick, 1998).

Table: 2.1 Characteristics of the life stages of the diamondback moth

Common Name	Diamondback moth
Scientific Name	<i>Plutella xylostella</i>
Order	Lepidoptera
Family	Plutellidae
Adult type	Moth
Adult colour	Greyish
Wings marks	Cream diamonds
Egg shape	Round, tiny
Egg shape	Cream coloured
Larva colour	Green /Gray
Larva size	10 mm mature
Larval behaviour	Wiggles and balloons
Pupation site	On leaf
Pupa type	loose mesh cocoon
Pupa size	6 mm



University of Fort Hare
Together in Excellence

2.2 Distribution and movement

Few agricultural insect pests are as cosmopolitan as the DBM, *P. xylostella*. Besides the potential to colonize under varying conditions, their strong dispersal or migrating capacity is contributory to the increase of their distribution range. It is obvious that the migration of the insect is one of the important factors in the extension of its distribution. Both immigration and emigration result in big changes in the population size in the area concerned (Chu, 1992). The migrating distance of the moth is generally considered to be over 3000 km (Thygesen, 1968; Bretherton, 1982) .

This insect has been recorded beyond latitude 60°N in Iceland, in the temperate zone (Ooi, 1992). *Plutella xylostella* is prevalent in tropics and subtropics where crucifers can be grown year-round and where favourable temperatures facilitate proliferation of several generations of this pest per year (Yang, Chu & Talekar, 1994). It thus has an ability to survive a wide range of temperatures. According to Hardy (1938) , *P. xylostella* prefers a warmer environment for its development, and he suggested the Mediterranean region as its most probable original habitat. The complex of natural enemies present in the European continent and the effective natural control reported lends support to the case.

2.3 Common host plants

The diamondback moth is an oligophagous insect and will feed on plants that contain mustard glucosides. An important economic group of plants with mustard glucosides are members of family Cruciferae, which are essentially temperate climate crops. *Plutella xylostella* infests important crucifers viz: cabbage, broccoli, cauliflower, brussels sprouts, collards greens, turnip greens, and kale. Non-cruciferous crop like *Amaranthus viridis* L has also been reported to be the host of this species (Thorsteinson, 1953).

Studies on the food plant preference of *P. xylostella* have revealed that among several crucifers, the pest exhibits a marked preference for cauliflower and cabbage. This is probably due to the fact that both plants possess fleshy and succulent leaves compared to the rest of the crucifers tested, and this probably provides olfactory and gustatory stimuli for successful

host selection and development (Dube & Chand, 1977; Singh & Singh, 1982). However, the crucifers, in particular the genus *Brassica*, have been spread from their original home to other regions. It is likely that *P.xylostella* spread along with the spread of the crucifers (Ooi, 1992).

2.4 Plant damage

Initial damage results in small incomplete holes caused by young larvae and larger complete holes caused by mature larvae. The *P.xylostella* larvae feed by scraping the epidermis of the crucifer plants, and in cases of a large number of larvae feeding on the leaves these quickly become skeletonised (Ooi,1992). The entire plant may become riddled with holes under moderate to heavy populations. Young plants would not survive such defoliation. Larvae also feed in the developing heads of cabbage, causing deformed heads and encouraging soft rots. However, because of their small size, relative to cabbage looper (CL) *Trichoplusia ni* (Hubner) and imported cabbageworm (ICW) *Pieris rapae* (L), it takes approximately 20 DBM larvae to defoliate as much cabbage as 1 looper, or about 2 ICW larvae (Hutchison, Bolin & Hines, 1997). The most serious damage occurs when larvae feed directly on the growing parts of the plant (Road, 1991).

2.5 Management of the pest

2.5.1 Chemical control

General use patterns of insecticides vary widely over geographic locations and decades. The most dramatic patterns of pesticide usage have been reported in South Asia where diamondback moth pesticide resistance is most abundant. A dominant product like mevinphos provide excellent control in 1965, fair control in 1974, and poor control in 1984. In 1976, permethrin was introduced and provided excellent control in the central region, but provided only fair control two year later. In the early 1980s, insect growth regulators (IGRs) were introduced. . IGRs, like triflumuron, provided good control in 1982 but poor control by 1984. Other biologicals like *B. thuringiensis* (Bt) were introduced in the early 1970s and provided fair to good (but never excellent) control when they were first introduced. Because

of the lack of excellent control when used alone, *B.thuringiensis* has been used primarily in IPM programs and conserve natural enemies (Talekar & Shelton , 1993).

Diamondback moths have a long history of eventually becoming resistant to every insecticide used intensively against them. Factors that influence the development of resistance in diamondback moths include high fecundity and reproductive potential, rapid turnover of generations, a long growing season, extensive acreage of crucifers, and frequent insecticides applications (Sun, Chi & Feng, 1978; Yamada & Koshihara, 1978). In 1953, Ankersmit (1953) reported the development of resistance to DDT in Lembang, Indonesia. Subsequently, the diamondback moth has become resistant to most of the other major classes of insecticides used in Indonesia. In the Philippines, Barroga (1974) first reported the development of resistance by diamondback moths in 1974 when she confirmed field failures with EPN and mevinphos. In Malaysia, diamondback moths have become resistant to all groups of conventional insecticides (Sarnthoy, Keinmeesuke, Sinchairsri, and Nakasuiji, 1989). Additional reports from Tiawan (Chen, Kao & Chiu, 1992), Japan (Hama, 1992) and Australia (Altmann, 1988) have documented resistance to a variety of insecticides.



University of Fort Hare
Together in Excellence

Insect-growth regulator and pathogens offer promise as alternatives to broad-spectrum insecticides, which often disrupt the control exerted by natural enemies. Products such as benzoylphenyl urea (BPU) that interfere with chitin synthesis provide an alternative to the more common classes of insecticides and may help in resistance management. Additional studies indicated that insects collected from Thailand in 1988 showed resistance to several IGRs including chlorfluazuro, diflubenzuron, hexaflumron, and several experimental IGRs.

2.5.2 Cultural control

Since *P. xylostella* is widely becoming resistant to various pesticides, interest is growing in cultural controls in commercial crucifer production. Cultural practices can contribute to the suppression of populations in integrated pest management programs (Brader, 1979). Some of the classical control measures that have been tried with some success are inter-cropping, use of sprinkler irrigation, trap cropping, rotation, and clean cultivation.

Inter-cropping

Inter-cropping, the practice of growing two or more crop species together, is a normal cultivation practice in the tropics where farms are small and land is used intensively. However, in these areas inter-cropping is not presently used for management of diamondback moths, but rather for horticultural and economic reasons. For some crop-insect situations, inter-cropping has reduced pest populations because the plants act as physical barriers to the movement of pest insects, because natural enemies are more abundant, and/or because the chemical or visual communication between pest insects and their host plants is disrupted (Risch, 1981; Root, 1973; Sheehan, 1986). Inter-cropping with *Salvia officinalis*, *Thymus vulgaris*, and *Trifolium repens* consistently reduced damage to Brussels sprouts from diamondback moth (Dover, 1986; Dover, 1985), but these crops would not be economically suitable for most small farmers.

Tomato, when inter-cropped with cabbage, has been reported to inhibit or reduce *P. xylostella* egg-laying (Vostrikov, 1915; Buranday & Raros, 1973, Sivapragasam et al 1982). The reduction in oviposition and subsequent development of the pest is essentially due to emission of volatile compounds by the tomato plants. Srinivasan (1984) conducted experiments involving different combinations of cabbage-tomato inter-cropping at Bangalore. He reported that there was no reduction in the incidence of *P. xylostella* larvae when different combinations of cabbage and tomato were planted at the same time (Table 2. 2 P 13). According to his study, however, a planting pattern of one row of cabbage and one row of tomato (the cabbage planted 30 days later than the tomato), afforded greater reduction of *P. xylostella* larvae on cabbage. The reduction in larval incidence was attributed to the release of volatile substance from the late growth stages of tomato which inhibited DBM oviposition (Srinivasan, 1984).

Table 2. 2. Influence of intercropping on the marketable yield of cabbage in relation to infestation by DBM^a (Srinivasan, 1984).

Crop combination t/ha	Cabbage yield (t/ha) ^b			Mean Yield
	Planting time			
	C and T ^c planted	C planted 15 days	C planted 30 days	
	Together	later than T	later than T	
1 row C and 1 row T	0.578a	2.878a	5.333a	2.930a
2 rows C and 2 rows T	0.611a	2.817a	4.300b	2.576a
3 rows C and 2 rows T	0.583a	2.844a	4.322b	2.583a
4 rows C and 1 row T	0.604a	2.773a	1.178c	1.519b
C alone	0.608	0.650b	0.800c	0.685c
Mean	.596	2.397	3.187	--

^a Source : Srinivasan 1984. ^b Means in each vertical column followed by the same letter are not significantly different at 5% level according to Duncan's Multiple Range Test. ^c C=cabbage, T=tomato

The spreading foliage of full-grown tomato plants also hid the cabbage leaves from the female moths and thus reduced oviposition. Srinivasan as cited by Chelliah & Srinivasan (1982) further indicated, however, that this reduction in larval incidence was not manifested in any significant increase in the marketable yield of cabbage compared to the yield recorded from sprayed plots.

Sprinkler irrigation.

All but the first-instar larvae of the diamondback moth are exposed on the leaf surface and influenced by various abiotic factors. Several reports indicate that rainfall is an important mortality factor for the diamondback moth larvae (Chang, 1961; Chin, 1974, Gunn, 1917; Harcourt, 1954; Karnervo, 1936; Talekar & Lee, 1985), and thus, it is only a serious pest during the dry season. Overhead irrigation has been shown to reduce cabbage crop injury caused by the diamondback moth (Talekar, Lee & Huang, 1986) and watercress (Tabashnik & Mau, 1986). The sprinkler drops are believed to drown or physically dislodge the insect from the plant surface, which causes this reduction. However, leaving the sprinkler system on from dusk through the early evening hours is believed to disrupt the mating and oviposition activities of the diamondback moth adults. According to Harcourt (1957), mating begins at dusk on the day of emergence. Oviposition begins shortly after dusk, reaching a peak two hours later. Using sprinkler irrigation to control diamondback moth in crops, is not practical on a commercial farm because of the high cost and probable increase of diseases such as black rot and downy mildew.

Trap-cropping.

Before the advent of modern organic insecticides, a common practice was to plant strips of an economically less important plant highly preferred by the diamondback moth within a commercial crucifer field. The preferred crops, primarily white mustard (*Brassica hirta*) or rape (*B. juncea*), attracted diamondback moths, thus sparing the commercial crop, such as cabbage, brussels sprout, and others, from its attack (Kanervo, 1936). Now that the same modern insecticides that made past trap-cropping practices obsolete are made obsolete by insecticides resistance, trap cropping is becoming a more realistic alternative, especially in developing countries. In India when mustard was alternated with every 15 to 20 rows of cabbage, diamondback moths colonised the mustard and spared the main cabbage crop

(Srinivasan & Moorthy, 1992) . In order to trap most immigrating diamondback moth adults in a field, mustard must be available throughout the cabbage growing period. Effective trap cropping can increase parasitism because diamondback moth larvae are retained in the trap crop and become heavily parasitized. Presence of high numbers of parasitoids can reduce the need to use insecticides altogether.

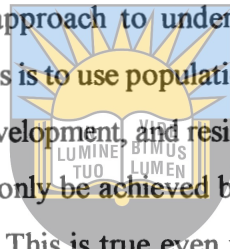
Rotation and clean cultivation.

Crop rotation is rarely practised for control of diamondback moth populations in intensive vegetable growing areas of the tropics and subtropics because of the high prices that crucifers fetch. However, because continuous planting of crucifers allows continuous generations of diamondback moth, which leads to frequent use of insecticides and the development of resistance, crop rotation may become a necessity. Clean cultivation can be an important factor in the management of diamondback moth. Planting seedbeds away from production fields, and ploughing down crop residues in seedbeds and production fields is an efficient and easy management practice. Where transplants are grown in the greenhouse, prevention of infestations by immigrating adults can be accomplished through the use of screening. Frequent insecticide spraying is common for control of greenhouse infestations, but this may lead to insecticide resistance (Hama, 1992; Shelton & Wyman, 1992).

2.5.3 Organic/Biological control

All larval stages of diamondback moth are attacked by numerous parasitoids and predators with parasitoids being the most widely studied. Larval parasitoids are the most predominant and effective. Many of the effective larval parasitoids belong to two major genera, *Diadegma*, *Cotesia* and *Apanteles sp*, a few *Diadromus spp.*, most of which are pupal parasitoids, also exert significant control. The majority of these species came from Europe where the diamondback moth is believed to have originated. In Moldavia in Romania, 25 species of parasitoids occur and parasitize 80-90% of diamondback moths (Mustata ,1992). Southeast Asia, the Pacific islands, Central America, the Caribbean, and most of sub-Saharan Africa are most intensively plagued by diamondback moths because these areas lack effective larval parasitoids. This contrasts with countries in continental Europe which are endowed with many *Diadegma*, *Cotesia*, and *Diadromus sp* (Talekar & Shelton, 1993).

Biological control of insect pests with natural enemies has achieved considerable success (Huffaker, 1974, Beddington, Free & Lawton, 1978, Barclay, 1982). However, widespread use of parasitoids in pest control depends on their integration with other control measures such as pesticides (Croft, 1990). Biological and chemical controls are often incompatible because pesticides severely reduce natural enemy populations, especially when pest species develop resistance while their associated natural enemies do not (DeBach, 1974). Because of the nonselectivity of conventional pesticides toward natural enemies, there has been an increase in the use of microbial organisms as selective biopesticides, especially the bacterial pathogen *Bacillus thuringiensis* (Croft, 1990). Microbial pesticides such as *B. thuringiensis* are generally harmless to adult parasitoids, but may harm larval parasitoids by killing the hosts in which they are developing (Flexner, Lighthard & Croft, 1986; Idris & Grafius 1993; Chilcut & Tabashnik, 1997). One approach to understanding complicated interactions between different pest control strategies is to use population models that simulate the effects of pesticides, parasitoids, resistance development, and resistance management strategies. The decreased reliance on pesticides can only be achieved by implementing alternative control measures such as biological control. This is true even for environmentally safe pesticides such as *B. thuringiensis*, because pests such as diamondback moth have developed resistance to these pesticides, thus decreasing their usefulness (Chilcutt & Tabashnick , 1999).



University of Fort Hare
Together in Excellence

2.5.4 Integrated pest management (IPM)

IPM program is the integration of available techniques to reduce pest populations and maintain them below the levels causing economic injury in a way which avoids harmful side effects. An example of IPM program is shown in table 2.3 P 19 which outlines a successful IPM program for *P. xylostella* in Malaysia (Williamson, 1999). For the past 36 years, as noted by Talekar & Shelton (1993), farmers have depended exclusively on insecticides to control the diamondback moth, but resistance to presently available insecticides and lack of new insecticides has stimulated research on alternative control methods which are essentially the same ones that were discarded in favour of synthetic insecticides. Since parasitoids play such an important role in checking diamondback moth population growth, introduction and conservation of parasitoids will be basic to any sustainable IPM program. To implement IPM, growers must coordinate their efforts because practices of one grower influence those of his neighbour. This applies to the development of insecticide resistance or introduction and conservation of natural enemies. Such coordination will be most needed in small-scale agriculture where farms are often less than 1 ha and where many farms in an area are owned by different growers.



University of Fort Hare
Together in Excellence

In the low lowland areas of the tropics and subtropics where temperatures are high, *C. plutellae* is the major larval parasitoid that can survive. Although this parasitoid has been established in several crucifer-growing areas in the tropics and subtropics (Talekar & Lee, 1985), this parasitoid alone is not effective in controlling the diamondback moth. Supplemental measures are required. One of the most successful IPM programs was developed in Malaysia (Williamson, 1999). This program was initiated in 1987 after a complete control failure of diamondback moth with the applications of synthetic insecticides (Table 2.3, P 19). The marketable yields obtained were 5-60% higher and up to 6-fold increases in profits were obtained in IPM trail plots. The number of insecticide applications was also significantly reduced from 7 to 9 times per 0.1 ha in prophylactic plots to a maximum of only three applications per 0.1 ha in IPM plots.

Because of the magnitude of control failures of the diamondback moth, as well as the pressure to reduce insecticide input in small-and large-scale agriculture, both systems must be open to alternatives to broad-spectrum insecticides. Traditionally, such ideas as trap cropping, adult trapping, and pheromones disruption were considered more amenable to small scale-scale agriculture, but this is no longer true. Researchers in India have demonstrated the benefits of using a mustard (*B. juncea*) trap crop to attract diamondback moths away from the principal crops (Srinivasan et al, 1992), thus reducing the need for insecticides to a maximum of two sprays compared with 10 or more per season for conventional control methods.

A team of Thai and Japanese scientists has demonstrated the utility of yellow sticky traps to capture diamondback moth adults, thereby reducing their oviposition and subsequent damage by larvaev . In fields with such traps, three sprays of *B.thuringiensis* achieved better control and twice as much crop yield as five sprays of *B.thuringiensis* mixed with mevinphos in a check field. Combining mustard trap cropping and yellow sticky traps may reduce the need for insecticides even more. In Japanese field tests of mating disruption by pheromones, populations of diamondback moth have been reduced by 95% compared with control fields (Ohno, Asayama & Ichikawa, 1992).

Table 2.3 An outline of the IPM program for *P.xylostella* in Malaysia (Williamson, 1999)

These main steps are designed to help achieve the following objectives :

1. Make a decision on whether to spray or not
2. Manage applied pesticides judiciously
3. Encourage build-up and enhance action of biological control agents
4. Encourage adoption of good agricultural practices

Spray decision

The decision to spray or not to spray is based on :

1. Economic Threshold level (ETL) of DBM
2. Level of parasitization by parasitoids



Sampling of DBM and Natural Enemies

To obtain the necessary data for spray, weekly sampling is carried out.

The procedure is as follows :

1. Counting of DBM larvae on 60 plant/0.1 ha plot using alternating U-shaped sampling system
2. Counting of parasitoid cocoons and pupae from 60 plants
3. Dissection of 60 or available number of 3rd/4th instar DBM larvae for determination of level of parasitization.

Thresholds adopted

1. No spray - if number of DBM larvae < 4 / plant
2. No spray - if number is > 4 but < 7 and level of parasitization is $> 40\%$
3. Spray - Use *B.thuringiensis* if number is >4 but < 7 and level of parasitization is 40% .

Example: Bactospiene at the rate of 1.14 kg/ha

4. Spray - Use synthetic insecticides if number is >7

The concept of sampling populations and treating when thresholds are exceeded is fundamental to IPM and has been promoted in developed countries (Beck, 1992) and in many developing countries of the tropics (Chen & Su, 1986). Adoption of this strategy is hindered because it requires regular scouting by trained personnel who may not be available. In underdeveloped countries, adoption of IPM is also hindered because many farmers cannot differentiate pests from beneficials, some farmers have difficulty in counting because of their illiteracy, and resistance to multiple insecticides makes most insecticide applications useless. Thus, in the tropics and subtropics, community-wide management will most likely rely primarily on the release and establishment of as many parasitoids as possible and the use of cultural practice.

Many IPM systems, especially in north America and Europe and those used in large-scale commercial farms in South Africa, have focussed on interventions with pesticides or biologically-based technologies (e.g. releases of beneficial insects or the use of biological pesticides) to keep pest populations below the level where they cause net economic loss to the farmer (Waage, 1998). Williamson (1999) reported that in contrast to this technological mode of IPM, recent IPM successes in developing countries stress the importance of maintaining and encouraging the existing natural enemies of pests, diseases and weeds which generally keep these under natural control. This ecological mode of IPM, which emphasizes cultural, biological, physical and interference methods and host plant resistance, has developed as a direct response to pest outbreaks generated by misuse of pesticides and subsequent human health and production crises, especially in cotton, vegetable, beverage and fruit crops.

Many of these crops are grown increasingly by small-scale farmers and their lack of understanding of biological processes such as pesticide resistance, beneficial insects and crop compensation has fuelled the pesticide treadmill observed today in many developing countries. IPM knowledge to tackle these problems remains at an academic level, and not at the farm level where it is of real value. The failure to create this channel of information flow between researcher and farmer has also allowed research to become isolated from the real needs of framers.

For successful pest and crop management in the crop systems, farmers need to become agroecological experts in their own fields. The success of the farmer field school (FFS) approach lies in its focus on the farmer as the key decision-maker in pest management and on facilitation of a discovery-learning process using non-formal education methods in a group context. The field is the primary classroom and the four major principles of the farmers' training are :

1. Grow a healthy crop
2. Observe fields weekly
3. Conserve natural enemies
4. Farmers understand ecology and become experts in their own fields



University of Fort Hare
Together in Excellence

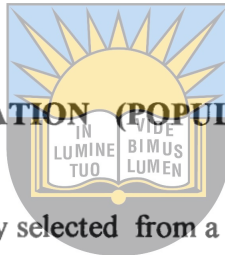
CHAPTER 3

3. METHODOLOGY

3.1 ESTABLISHMENT OF PEST AND PARASITOID DENSITY IN THE FARMERS FIELDS

3.1.1 STUDY SITES

From 22nd May to 20th December 1997 field sampling was done at five different farms: Zanyokwe irrigation scheme, Kama furrow plots, Alice, Fort Beaufort area and Fort Cox College.



3.1.2 *P. XYLOSTELLA* INFESTATION (POPULATION DENSITY)

Twenty cabbage plants were randomly selected from a 0.5 ha cabbage plot. The cabbage plants were brought into the laboratory and all the insects on the plants were collected and placed in rearing cages made of nylon netting on an aluminium frame (100 long x 100 width x 100 high cm). This sampling was done on farmers' fields which were routinely sprayed with insecticides such as Dithane, Tamaron (Methamidophos), Bulldock, Metasystox and Cypermethrin, Malathion. A total of 204 cabbage plants were sampled and the *P. xylostella* larvae collected were recorded and were reared on rape seedlings until they became either *P. xylostella* pupae or parasitoid larvae emerged from the parasitized larvae.

3.1.3 *COTESIA PLUTELLA* PARASITISM

The collected insects were brought in the laboratory and kept in the cages made out of nylon netting on an aluminium frame (100 long x 100 width x 100 high cm). The cages were kept in the laboratory maintained at a relative humidity of 40 - 45%, temperature of

$\pm 22^{\circ}\text{C}$ and a photoperiod of 16:8 (L:D) regime. Emerging parasitoids and adult *P. xylostella* were recorded and the data were used to calculate parasitism using the method of Polking (1992) in his formula.

$$\% \text{ parasitism} = \frac{\text{Cotesia cocoons}}{\text{Diadegma cocoons} + \text{Cotesia cocoons} + \text{P. xylostella pupae}} \times 100$$

3.2 LABORATORY OBSERVATIONS

3.2.1 COTESIA PLUTELLAE PARASITISM

3.2.1.1 Rearing of *P. xylostella* and *C. plutellae*

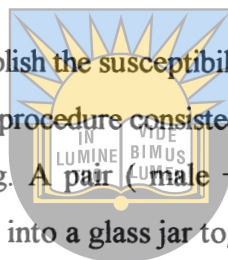


A colony of *P. xylostella* was established from field-collected larval specimen kept in the laboratory maintained at conditions described above. The larvae were fed on rape seedlings (*Brassica juncea*) (Koshihara & Yamada, 1976) germinated on vermiculite contained in plastic vials. Light which facilitated rape seedling growth was produced by grow-lux fluorescent tubes. The seedling served both as oviposition substrates for the adults and as food for the larval stage of *P. xylostella*. When a vial bearing seedlings infested with feeding larvae was slanted and tapped gently, the *P. xylostella* larvae which ballooned from the seedling could be collected and transferred to fresh seedling or used in experiments as required. Some larvae were allowed to develop into adults in order to sustain the pest colony. As explained earlier *Plutella xylostella* is an oligophagous holometabolous pest that lay eggs on the foliage of crucifer crop plants which then hatch and develop into larvae. And the larvae of this pest undergo four stages of development 1st, 2nd, 3rd and 4th instar. The 4th instar will metamorphoses and form a pupa which eventually emerges into an adult *P. xylostella*.

The laboratory colony of *C. plutellae* was started from *C. plutellae* specimens collected from the field as cocoons (pupae) or parasitized *P. xylostella* larvae. The colony was maintained under the same laboratory conditions as described above for *P. xylostella* colony. The female parasitoids after mating, oviposited into the *P. xylostella* larvae and the resultant endoparasitoid larva colonised the host larva. A fully developed *C. Plutellae* larva normally chews its way out of the host larvae and pupates beside the dying *P. xylostella* larvae. Newly emerged parasitoids were fed with diluted 10% honey or 15% glucose soaked in cotton wool.

3.3.2.2 Susceptibility of *P. xylostella* larvae to *C. plutellae* parasitism

The aim of this experiment was to establish the susceptibility of 2nd, 3rd and 4th *P. xylostella* larval instar to *C. plutellae* attack. The procedure consisted of a 3.5 litre glass jar, with nylon sleeves wrapped around the opening. A pair (male + female) of newly emerged and unmated *C. plutellae* were introduced into a glass jar together with a cotton pad soaked in 10 % honey solution to provide the pair of parasitoids with a source of food. A pair of plastic vials bearing rape seedlings was then introduced into a glass jar. The rape seedlings were then infested with ten *P. xylostella* larvae of a known instar. The rape seedlings and the larvae introduced in the jar were changed daily. In this case, the host larvae of *C. plutellae* introduced into the experimental jar were removed every 24 hours and replaced with a fresh batch. Care was taken to ensure that the pair of parasitoid kept in the jar remained there until they died. The daily batch of rape seedling bearing the exposed larvae was transferred to a fresh experimental jar and the larvae were reared till adults of either *C. plutellae* or *P. xylostella* emerged. For each instar (2nd, 3rd and 4th) experiments were replicated 4 times. Parasitism of *C. plutellae* on different larval instars of *P. xylostella* was determined by noting the number of larvae parasitized by a single female parasitoid.



University of Fort Hare
Pursuing the Frontiers of Knowledge

4.4 FIELD SURVEY ON FARMERS' SOCIO-ECONOMIC CHARACTERISTICS AND CONCEPTS ABOUT THE PEST

3.4.1 Questionnaire to contact farmers

Since this investigation was part of an agricultural extension study, a survey involving vegetable farmers in particular small scale was undertaken in the study area. The survey attempted to get information about farmers' awareness about *P. xylostella* problem and how they go about controlling this pest. Since this kind of information is essential for the design of adequate management strategies a questionnaire was designed to assess the following:

- i Pest problem limiting cabbage production by the small scale farmers.
- ii The extent of economic damage caused by cabbage pests especially the diamondback moth (*P. xylostella*) which is a world-wide cabbage pest.
- iii Educational strategies or methods that can be effective in facilitating adoption of *P. xylostella* control approaches that will improve the performance of parasitoids.
- iv Information that can be used to facilitate use of parasitoids in the integrated pest management of cabbage.

3.4.2 Questionnaire design

The questionnaire was used to obtain as much accurate information as possible from the vegetables commodity groups. A commodity group refers to a discrete group of farmers involved in a similar enterprise (i.e vegetable production) sharing common interest and common problems. All farmers were subjected to similar set of questions set out in the questionnaire because they belonged to the similar commodity group. Some of the questions were open ended, giving the contact farmer a chance to express his opinion without necessarily being restricted. They were structured in a simple manner understandable to the contact farmers but aimed at extracting as much valuable information as possible. Details on the questionnaire are shown in appendix 1

3.4.3 Sampling procedure

Prior to the survey, the Department of Agriculture at Alice district was approach to provide the correct records of the numbers of small scale farmer specialising in vegetables production in the district. A total of 60 vegetable small scale farmers were identified as a single commodity group base in two major localities. Seventy three per cent of the farmers were from Roxeni and twenty seven per cent were from Melani locality. Because the farmer`s population was small, it was not necessary to sample, but rather to cover the whole population .

3.4.4 Interviewing procedure

The interviews were undertaken at farmers` field , where normal farm activities were underway. Personal interviews were conducted with the help of the interpreter, a local person who was known to both the Department of Agriculture Extension Officers and the farmers and was familiar with the two localities of Roxeni and Melani . The average amount of time spent per farmer was one hour. The farmers were unavailable on Thursdays as they usually have weekly meetings with the local extension officers. The time spent to complete this survey was roughly five weeks.

3.4.5 Qualitative reliability

Ideally, the data should be accurate and objective to reflect the situation as it is, so as to give the researcher a proper picture of the situation for better analysis, but unfortunately chances are that they will always be an element of bias and errors. The translation of questions for instance from the questionnaire by the interpreter may not always be accurate and as a result errors may occur. However, all the farmers co-operated and participated freely.

5.4.6 Coding and analysis

The coding of the question was done by the researcher. A preliminary and exploratory analysis of the data was performed using a PC Lotus 1-2-3- computer programme. When two samples are obtained from a population, the two samples could score different results or the same results. When different results are obtained, the obtained difference could be as a result of a sampling error or indeed it could be a genuine difference.

The procedure by which the obtained difference is tested to see whether it is real or just as a result of sampling error is referred to as a test of significance or t-test. In this procedure, a question asked is “ is the obtained difference large enough (or significant) to justify the null hypothesis?”. The answer is given in the form of probability i.e. what is the probability that a difference as large as the one observed would occur by chance alone?

Acceptable levels of probability, referred to as levels of confidence have traditionally been set at $P=$ or less than either .05 or .01. The lower the P value, the more real the difference is , i.e. confirming the significance of the difference thus allowing for the rejection of the null hypothesis.



University of Fort Hare
Together in Excellence

The t-tests were calculated using PC Lotus 1-2-3- computer programme @function formula:
@T-TEST(range1;range2;[type];[tails])

4. RESULTS AND DISCUSSION

4.1 FIELD OBSERVATIONS

4.1.1 FIELD LARVAL POPULATION AND PARASITISM

4.1.1.1 *P. xylostella* density on cabbage plants

Data collected from Fort Cox , Zanyokwe, Kama furrow, Alice and Fort Beaufort area showed that the average *P. xylostella* larval infestation was variable. The mean *P. xylostella* larvae per cabbage was 4 in June , 5 in July, 9 in August and over 20 in September (Figure 4.1, P 29). The change in the season from winter to spring had limiting effects on the larval population density in the field. As shown by Figure 4.1, infestation rates in the early and mid winter were relatively low. During the cold season infestation rates showed standard variation (S.D.) of 7.32 which is relatively high. This high variation is possibly due to the fact that the data was collected from five localities. The low infestation rate in winter was probably due to lower temperatures (Figure 4.2, P 30 and Figure 4.3, P 31) .

Wakisaka, Tsukuda & Nakasuji (1992) reported that *P. xylostella* which does not have diapause can develop slowly in the winter season. The delayed developmental period in winter causes high mortality, and population density does not increase. In early spring, development becomes faster, and cultivation area of cruciferous crops increases considerably. The major parasitoids are still not very active therefore the number of larvae developing into adults is high. All these facts contribute to the population density increasing rapidly in spring. Talekar & Lee (1985) reported that heavy summer rainfall and high temperature are the major decimating factors accounting for the reduction in population density. Heavy rainfall not only washes off young larvae from the plant, but also hinders flight and egg-laying activity of the adults.

Fig.4.1

Mean *P.xylostella* larvae infestation per cabbage at Fort Cox , Zanyokwe, Kama furrow , Alice and Fort Beaufort area from June to September 1997.

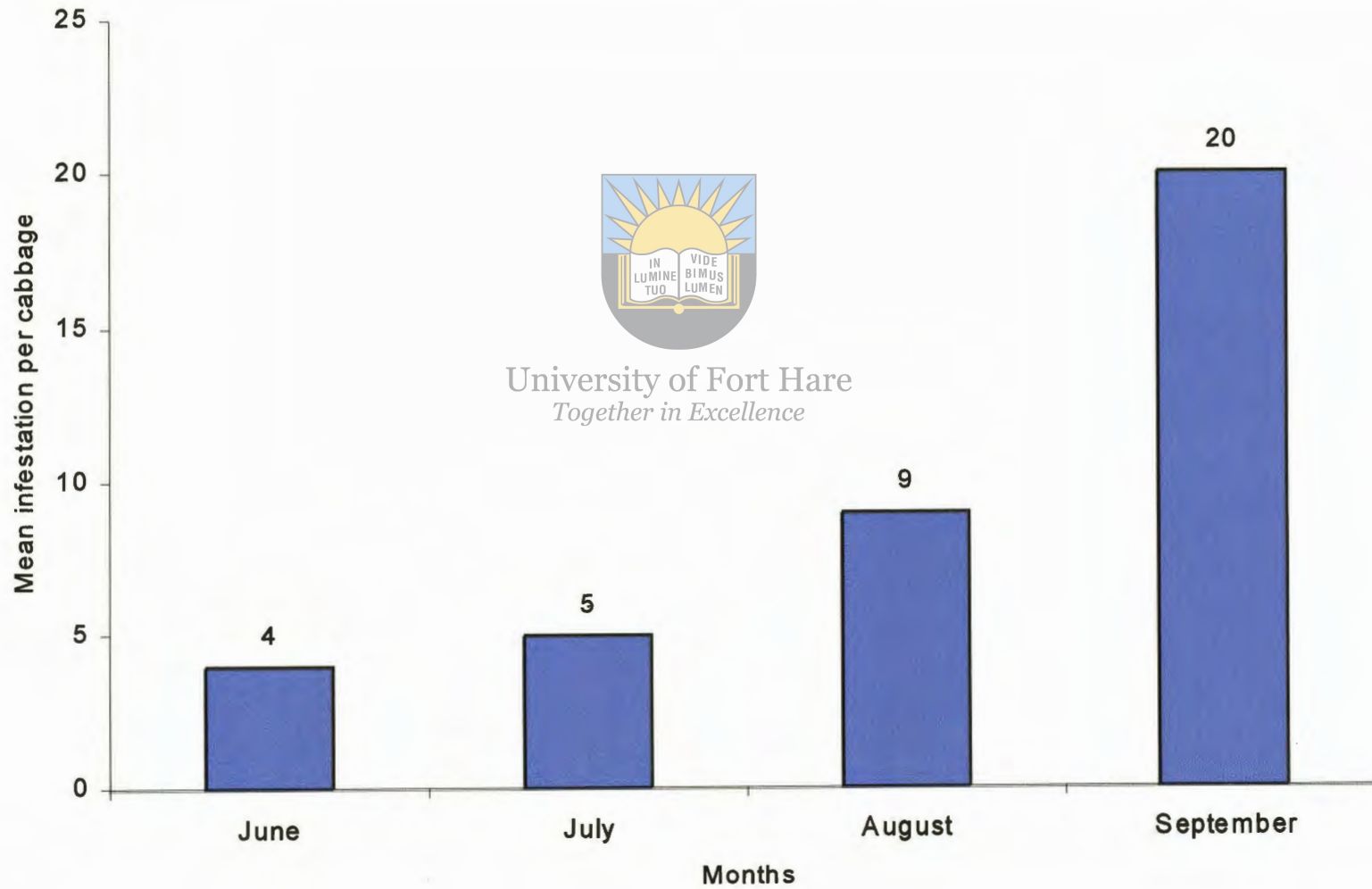


Fig.4.2 The average temperature and rainfall at Fort Cox , Zanyokwe and Kama furrow in 1996 and 1997.

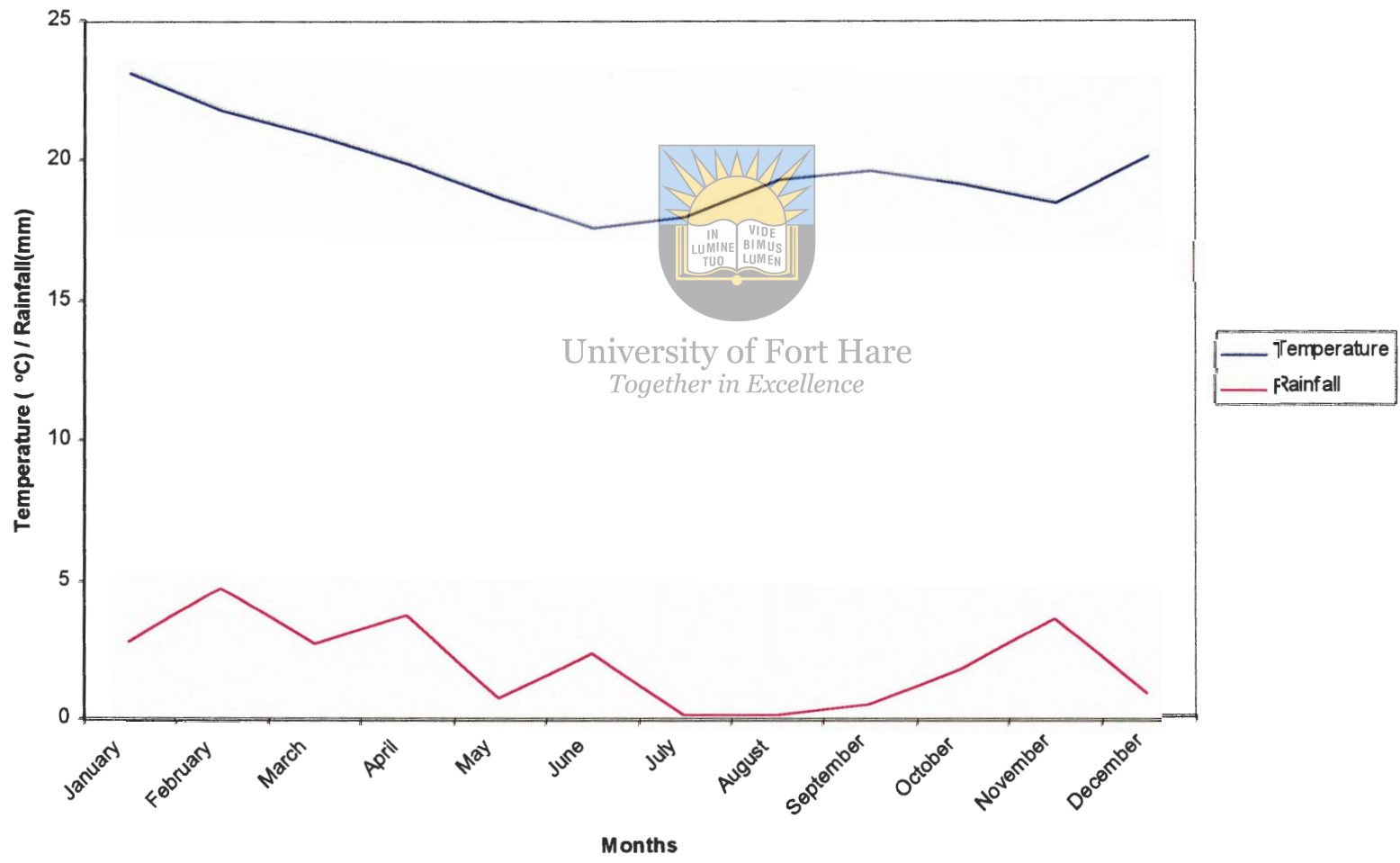
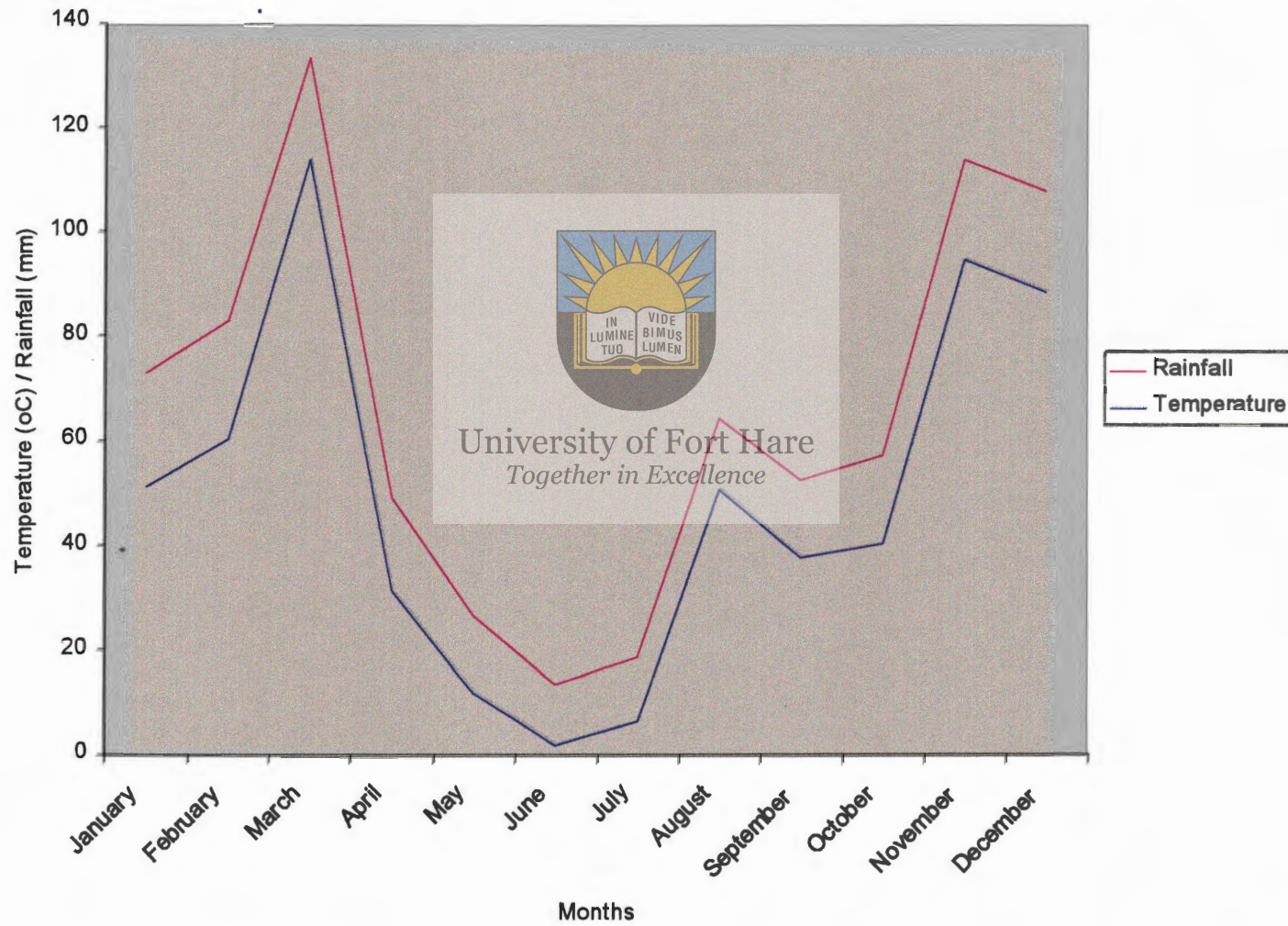


Fig.4.3 The average temperature and rainfall at Alice 1997 and 1998.



Further more the study undertaken by Salinas (1986) in Venezuela indicated that increase in temperature in spring results in a decrease in the developmental time of all the different larval stages from egg to adult. The most probable reason for this decrease is an increase of the metabolic rate which in turn accelerate the life processes. The use of energy to cope with the increased metabolic functions probably explains the differences in fecundity as expressed by the number of eggs per female. In summer because of abundance of food, the pest is able to cope with the energy demand for both growth and egg production while in winter most of the energy is used for growth and development and less is left for egg production. The more the energy used in going from one stage to the next as in winter, for example from egg to larvae or from pupa to adult, the less of it is left to develop all the potential eggs in the female. The latter explains the reasons why there was a drastic build up of the larval population per cabbage in September than it was in June to August 1997(Fig.4.1, P 29).

The age of cabbage and rate of infestation by *Pteroxystella* larvae determined amount of damage to the crop caused per cabbage plant. As indicated by Mustata (1992) the greatest damage occurs when the infestation takes place in young plants. In older cabbage plants the larvae develop mainly on the outer leaves. Such damage is of little economic importance.

University of Fort Hare
Together in Excellence

4.1.2 The performance of parasitoids in the field.

At Fort Cox College, 554 host of *P. xylostella* larvae were collected. From that collection 230 moths and 324 parasitoids (192 *C. Plutellae* and 132 *D. Collaris*) emerged and this amounted to 58.4% parasitism. At Zanyokwe irrigation scheme 2079 hosts *P. xylostella* larvae were collected . In this case, 1184 moths and 895 parasitoids (682 *C. plutella* and 213 *D. collaris*) emerged and this amounted to 43.0% parasitism (Table 4.4, P 34). *Cotesia Plutellae* parasitism was 34.6% at Fort Cox and 32.8% at Zanyokwe irrigation scheme while *D. collaris* parasitism was 23.8% at Fort Cox and 10.2% at Zanyokwe irrigation scheme. The level of parasitism by *C. Plutellae* was relatively similar in these two areas but not very effective in controlling *P. xylostella*. *Cotesia plutellae* performed relatively better than *D. collaris* in these two areas. Generally the field parasitism of *D. collaris* was erratic and very low i.e. Fort Cox College 23.8% and Zanyokwe irrigation scheme 10.2%. The relationship between the parasitoid species may vary from sample to sample in the same locality.

The combined parasitism of these two parasitoids (*C. plutella* and *D. collaris*) appeared to have played an important role in combatting the *P. xylostella* at Fort Cox College than at Zanyokwe irrigation scheme (Table 4.4, P 34). The relatively poor performance of these two parasitoids at the later site could be attributed to the intensive application of pesticides by the farmers against *P. xylostella* infestation . Pesticide applications impact negatively on parasitoid populations. Such negative effects depend on the pesticide used. Kao & Tzeng (1986) reported that methamidpphos can cause mortalities of 99% in *C. plutellae*. Although *C. plutellae* mortalities of 99% are possible, at Fort Cox College 34,6% parasitism was obtained and at Zanyokwe irrigation scheme 32,8 % was obtained (Table 4.4, P 34). *Cotesia plutellae* resistance to Tamaron could be possible, it is unfortunate that no organised study on parasitoid resistance to pesticides has been done.

Table 4.4. *Cotesia plutellae* and *Diadromus Collaris* parasitism on *Plutella xylostella* observed at Fort Cox College and Zanyakwe Irrigation Scheme.

Location	Larvae collected	Moth and parasitoids that emerged			Total % Parasitism
		Moth	<i>C.plutellae</i>	<i>D.collaris</i>	
Fort Cox College (a)	554	230	192	132	58.4
Zanyokwe Irrigation scheme (b)	2079	1184	682	213	43.0

(a) Data collected on 23/10/97

(b) Data collected on 29/10/97

Table 4.5 *Cotesia Plutellae* % parasitism on different host larval instars of *Plutella xylostella*

larval instars 4 reps each	Longevity of ovipositing Parasitoid tested (days)	Mean longevity (days)	Host-larvae presented daily	Total host-larvae exposed	% host-larvae dead or unaccounted for	% non parasitized host-larvae producing adult moths	% host-larvae parasitized by <i>C. plutellae</i>	mean Parasitism
2 nd	9	9.5	10	85	11.76	20.00	68.23	75.92
	9		10	85	9.41	9.41	81.17	
	8		10	80	8.75	10.00	81.17	
	12		10	115	18.26	8.69	73.04	
3 rd	6	6.5	10	50	6.66	28.33	65.00	56.92
	5		10	50	14.00	46.00	40.00	
	5		10	50	6.00	22.00	72.00	
	10		10	100	30.00	21.00	49.00	
4 th	2	7.2	10	20	5.00	85.00	10.00	16.27
	9		10	90	11.11	74.44	14.44	
	11		10	110	33.63	60.00	6.36	
	7		10	70	1.42	64.28	34.28	

4.2 LABORATORY OBSERVATIONS

4.2.1 Susceptibility of *P. xylostella* to *C. plutellae* parasitoids

Analysis of variance between the three means of parasitism for the 2nd, 3rd and 4th instars was undertaken to determine whether significant differences exist between the three stages of larval development samples. A One-way Between-Subjects ANOVA was used because the experiment had only one independent variable, which is the *C. plutellae* % parasitism, and we assume that the population represented by the scores in each condition forms a normal distribution and the mean is the appropriate measure of the central tendency. Since the experiment meets these assumptions, we set alpha at 0.05 and proceeded with our statistical null hypothesis that there are no differences in the parasitism of *C. plutellae* in three instars.

To perform ANOVA we calculated the *F* statistic which simultaneously compares all the sample means in a factor to determine whether two or more sample means represent different populations. We calculated the F_{obt} and compared it to the F_{crit} . Based on our degrees of freedom between groups (2) and within groups (9) and our alpha at .05, the statistical tables indicated that our F_{crit} was 4.26. Our obtained *F* statistic was 6.02 which confirms that indeed our means for 2nd, 3rd and 4th instars are significantly different from each other.

Post hoc comparisons were made to determine the absolute differences between means. First the Honestly Significant Difference (HSD) was calculated and was found to be 18.59. Thus if the differences between the individual means are above the HSD, there is a significant difference between them. The lowest difference between any two means is 19 (between the means of the 2nd and 3rd instars). This confirms that indeed all the means are significantly different from each other.

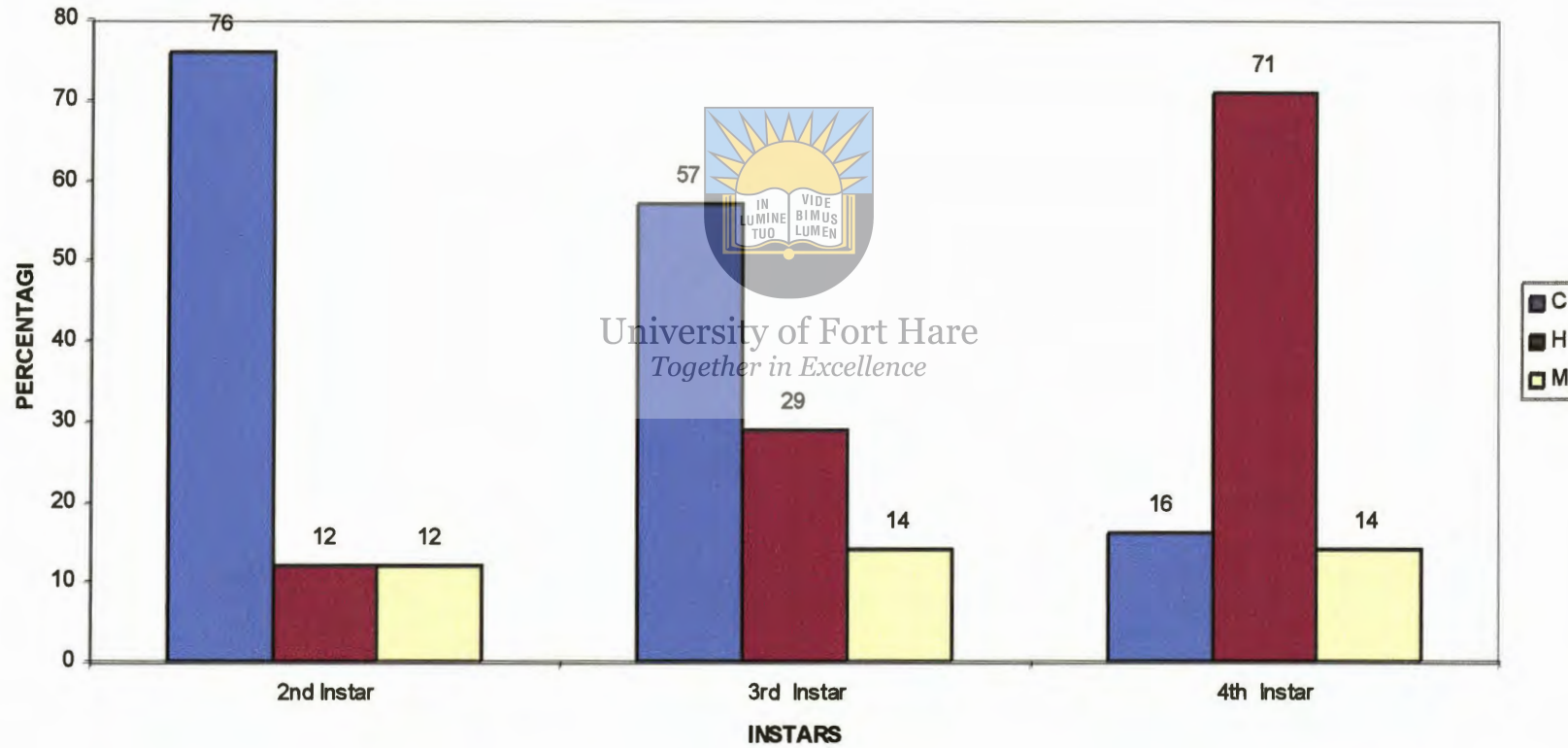
Cotesia plutellae average parasitism obtained varied between 16.27% on the 4th instar, 75.92% on the 2nd instar and 56.5% on the 3rd instar. This parasitoid seems to be effective in parasitizing the 2nd and 3rd instars (table 4.5, P 35 and Figure 4.4, P 38) and this observation may have important practical significance. The 2nd and 3rd instars are relatively

more susceptible to *C. plutellae* attack while the 4th instar is less susceptible to attack as the larvae at this stage is old enough to fight back and minimize parasitoid attack. The feeding activity of the host larvae attract the attention of the parasitoid, which utilises host-produced kairomones from a variety of sources, such as frass, hemolymph, and salivary secretion. This parasitoid locates the host's habitat through the use of the kairomones. The high feeding activities of the 2nd and 3rd instar coupled with the fact that they lack a strong defence mechanism make them easy targets susceptible to *C. plutellae* attack. The 4th instar is already getting into the resting stage with low feeding activity, which means less attraction of parasitoid. These attributes coupled with a very strong defence mechanism tend to minimize *C. plutellae* parasitism.

A relationship between longevity and parasitism was described using correlation analysis. A correlation coefficient was calculated. This is a number that summarises and describes the important characteristics of the relationship which are the type and strength of the relationship. The absolute value of the correlation coefficient (the size of the number) indicates the strength of the relationship while whether it is a positive or negative number explains the type of relationship. The largest absolute value that can be obtained is 1.0 and the smallest is 0.0. The larger the absolute value, whether positive or negative, the stronger the relationship meaning that there is perfect correlation between the scores of longevity and parasitism. With a strong correlation, we can predict the extent of parasitism by knowing the extent of longevity. The longevity and parasitism scores reflect the behaviors of living organisms, and living organisms do not show a great deal of consistency. Therefore a correlation coefficient in the neighborhood of ± 0.5 are said to be impressive (Heiman, 1992).

In the case of our experiment, it is only in the 2nd Instar which shows a correlation coefficient of -0.42, that we can conclude that there is a relationship between longevity and parasitism. Which means that there is an impact of longevity of the female parasitoids in parasitizing the *P. xylostella* larvae (Table 4.5, P 35). Correlation coefficients for the 3rd and 4th instars were -0.28 and -0.08 respectively which means that there is a very weak relationship between the impact of longevity of *C. plutella* in parasitising those two larval instars of *P. xylostella*.

Fig.4.4 *Plutella xylostella* mortality, parasitization and escape of parasitization by *C.xylostellae* when different larval instars were tested.



C, & H represent % larvae parasitized and escaping parasitization respectively while M represents % larval mortality due to unknown causes

Table 4.6. Comparison of the three larval instars in terms of parasitoid longevity, larval mortality, escaping the parasitoid and parasitization.

Instars	Mean longevity female parasitoid	Mean % host-larvae mortality	Mean % <i>P.xylostella</i> adults obtained	Mean % <i>C.plutellae</i>
2 nd	9.12a	12.13 a	31.61a	75.92a
3 rd	6.50a	14.16a	29.33a	56.50b
4 th	7.25a	13.54a	70.93b	16.27c

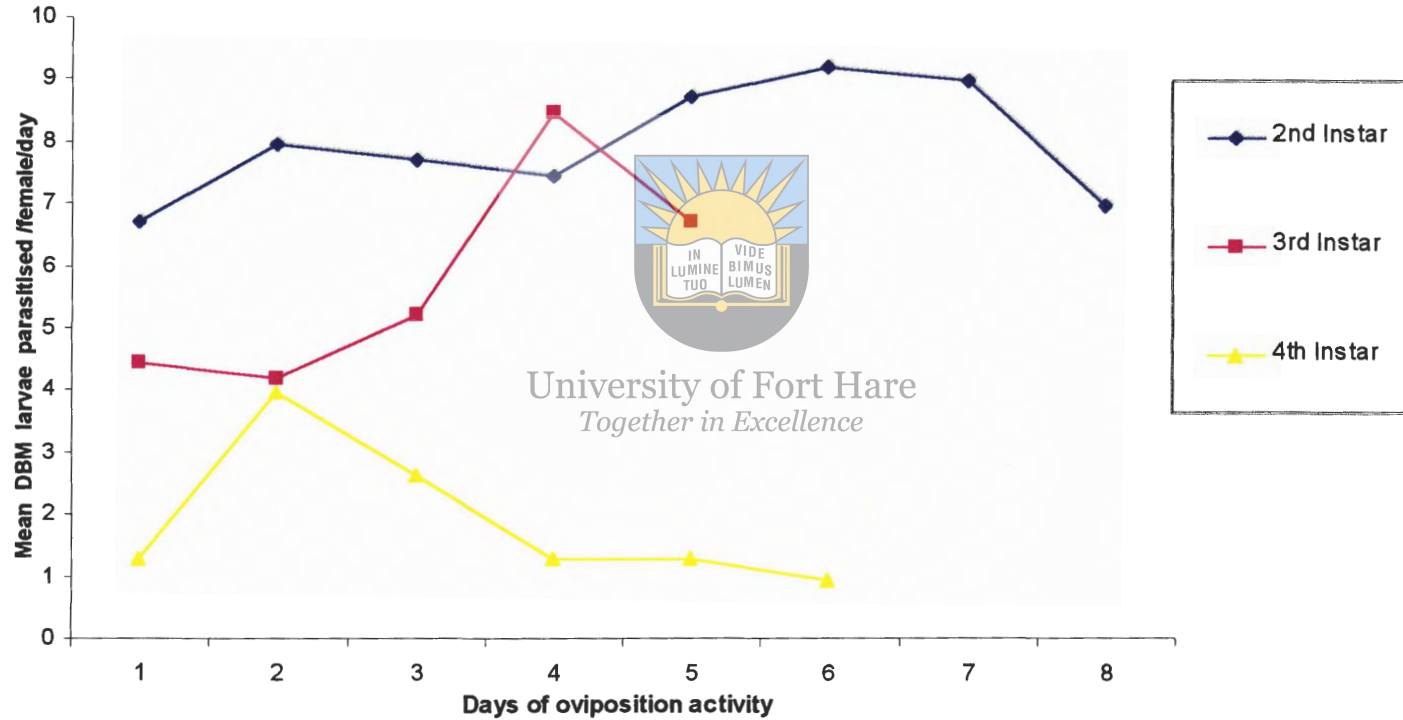
A number accompanied by the same letter are not statistically different at 0.05.

Results presented in Table 4. 6 (P 39) using Anova showed that there was significant difference in proportion parasitism between 2nd ; 3rd and 4th instar but there was no significant difference in mean mortality of *P. xylostella* in all the instars. The proportion of larvae that survived until pupation did not differ significantly in the 2nd and 3rd instar, but differed significantly with the 4th instar. There was no significant difference in mean longevity in all the instars of the *P. xylostella* exposed to *C. plutellae*.

The results as shown in Figure 4.5 (P 41) that the average *C. plutellae* parasitism for the 2nd instar was based on the first 8 days of parasitism while the 3rd and 4th instars were based on 5th and 7th days parasitism respectively. The parasitizing behaviour of *C. plutellae* varied with the stages of the host larval development (Figure 4.5, P 41). On the 2nd instar, parasitism peaked when the parasitoid was five days old while at the 4th instar parasitism peaked when it was two days old. The 3rd instar parasitism peaked when the parasitoids were four days old. The peak parasitism of *C. plutellae* at any instar can be explained within the context kairomone used by parasitoids to locate the host larvae. The parasitizing behaviour of the parasitoid is changed by a kairomone released by the host during feeding. The parasitoid become attracted to a potential host community by the plant where it then respond to the presence of damaged plant tissues and finally to a kairomone. High feeding activity of the 2nd and 3rd instar make it easier for the parasitoid to locate the host larvae than the 4th instar. In addition, the 2nd and 3rd instar are more susceptible to *C. plutellae* attack as already mentioned above that they lack strong defence mechanism to minimise and discourage parasitoid attack.

Figure 4.5 (P 41) shows that *C. plutellae* was more effective in parasitising the 2nd and 3rd instar on the sixth and fourth day of parasitism after which it started declining as the 3rd instar proceed to develop in the 4th instar. The mean larvae parasitized on the sixth and fourth day of peak parasitism by *C. plutellae* for the 2nd instar and 3rd instar was nine (9) larvae per day while the 4th instar which peaked on the second day of parasitism with the average of 4 larvae parasitized per day. After peak parasitism the parasitoid continued to parasitise but at a declining rate until it is died.

Fig. 4.5 Mean daily parasitism realized by a single female *C. Plutellae* on the 2nd, 3rd and 4th instar larvae of *P. xylostella* during its period female oviposition. activity.

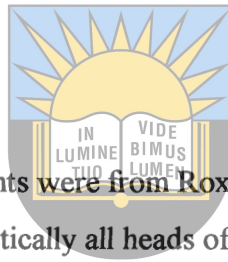


4.3 FIELD SURVEY ON FARMERS' SOCIO-ECONOMIC CHARACTERISTICS CONCEPTS ABOUT THE PEST.

This chapter describes the demographic profile and analyses the pest management strategies used by the small-scale farmers at Alice District, Melani and Roxeni. The demographic profile included sex, age, level education, farm management experience and special training that farmers could have been exposed to over and above the period spent on farming. Qualitative data included responses relating to farming problems that could have been affecting the quality of their products especially pests problems.

4.3.1 Demographic and socio-economic characteristics of the farmer.

4.3.1.1 Gender and age



Seventy three per cent of the respondents were from Roxeni and twenty seven per cent were from Melani in the Alice District. Practically all heads of households were resident at home. Fifty eight per cent of the respondents were males and forty two per cent were females. The spate of retrenchment taking place in this country saw the increase in the numbers of males participating in agricultural activities (Figure 4.6, P 43). This kind of gender distribution is somewhat normal in defining the role of women in agriculture today than ever before. Most of these rural women participate in agricultural activities because they are bread weaners and they have to take responsibility of keeping the family together. Some of them never got married but they have children to take care of and some of them may have been divorced or widowed and as a result they became heads of households. As indicated by Tshikolomo (1996) gender tends to influence the way in which an individual thinks and behaves and is therefore an important determinant of agricultural development. Whether a certain new technology (agricultural or otherwise) will or not will be acceptable to a household depend much on the attitude of the head of the household towards that technology .

Figure 4.6. Gender distribution of the contact farmers (Alice District, Roxeni and Melani, 1999)

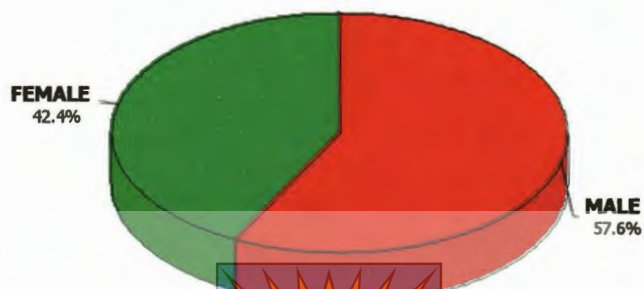
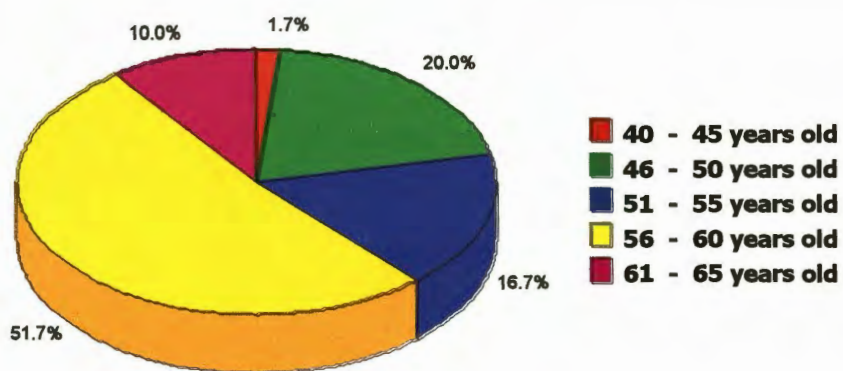
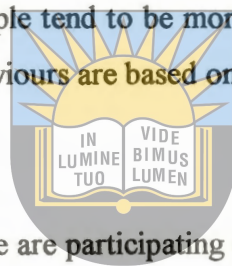


Figure 4.7. Age distribution of the contact farmers (Alice District, Roxeni and Melani, 1999)



University of Fort Hare
Together in Excellence

It appears that majority of the respondents were old people (51,7 per cent) ranging between 56-60 years old (Figure 4.7, P 43). Adult farmers ranging from 40-45. years constituted almost two per cent of the contact farmer population. Farmers who could be categorized as very old and aged constituted ten per cent and twenty per cent respectively. As noted by Bembridge (1984), chronological age may have an impairing effect on physical ability, which is important on family holdings. However research showed little or no mental deterioration at least up to 60 years of age. Increased in age may not seriously impair managerial ability, at least up to 60 to 65 years of age (Hobbs, Beal & Bohlen, 1964). Based on the latter, it can be concluded that the majority of participants have the necessary physical capability satisfactorily enough to carry out farming operations. The types of decisions made by elderly people and their ways of behaving tend to be different from those of their younger counterparts. In general, young people tend to be more ready to accept new innovations, while the elderly's decisions and behaviours are based on their cultural beliefs (Tshikolomo, 1996) .



In farming areas where young people are participating in agriculture activities, most of the farming practices that require physical strength are undertaken with efficiency. For an example, irrigation where you have to change the pipes, mechanical/physical weeding and harvesting. Older farmers over 60 years tend to be weak to carry out labour intensive farming practices. The latter statement translates the challenge that extension officers and researchers are faced with in adapting the level of innovation and technology to suit farmers of different ages.

4.3.1.2 Education

Education and its relationship to farming progressiveness has been studied by numerous researchers, many findings support evidence of a positive correlation between education and the adoption of improved practices and hence farming efficiency (Lionberger, 1960; Rogers & Shoemaker, 1971; Bembridge, 1972). This studies show that clear-cut relationships between farming efficiency and progressiveness and education are hard to establish, because the number of years of schooling is related to other factors likely to influence farming efficiency.

Figure 4.8 Distribution of farmers according to number of years spent in school (Alice District, Roxeni and Melani, 1999).

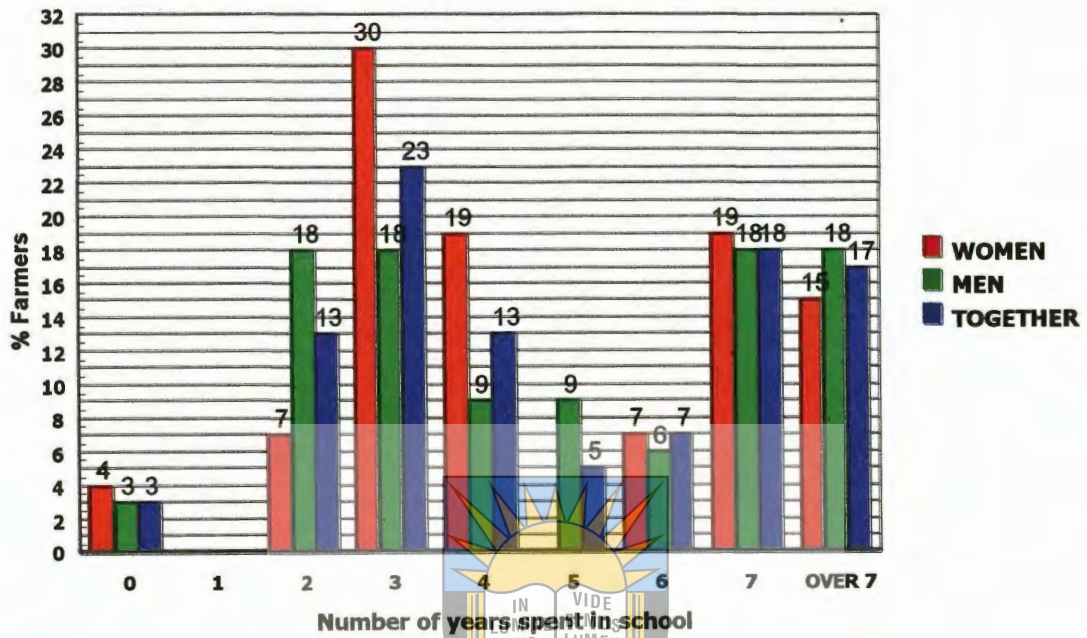
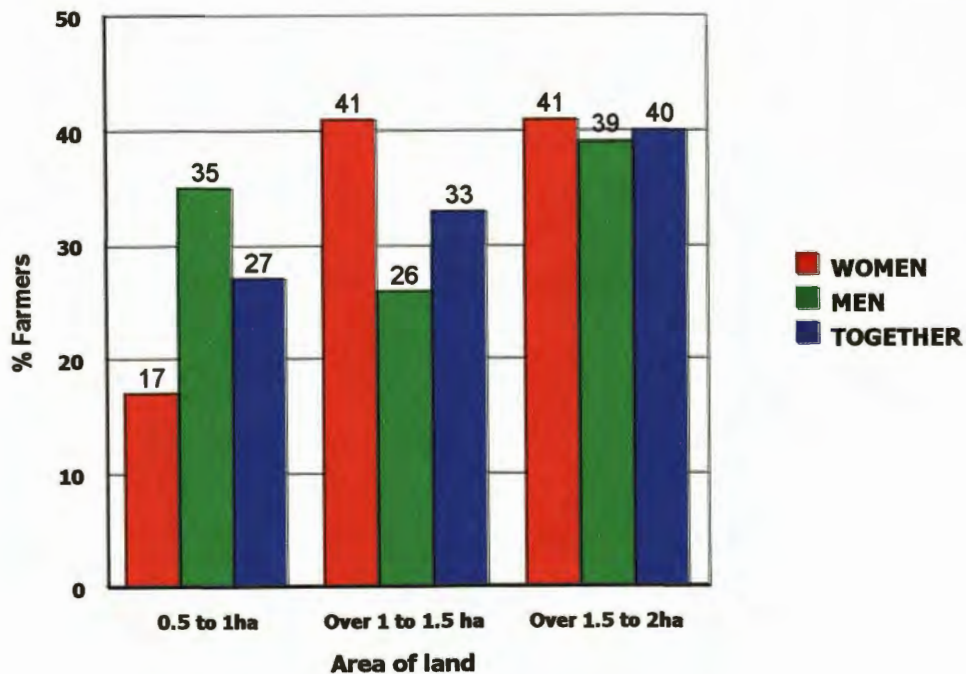


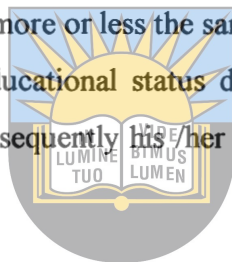
Figure 4.9 Area of land occupied by each respondent (Alice District, Roxeni and Melani, 1999)

University of Fort Hare
Together in Excellence



According to educationalists, people with less than 4 years of education are unlikely to have retained any degree of literacy (Bembridge, Steyn & Tuswa, 1982). Generally speaking, those with 5-6 years of schooling are likely to have a knowledge of written Xhosa and limited written English. It can be concluded from Figure 4.8 (P 45) that fifty three per cent of the respondents which are below five years in schooling are illiterate, approximately twelve per cent have some degree of literacy, while thirty five per cent are reasonably literate. The respondents lived and farmed in the same area for a long period of time and they were more acquainted with traditional subsistence farming practices under the supervision of the local extension officers.

The farmer's committee appeared to be more male-dominated at Melani than at Roxeni though their level of education was more or less the same. Rogers (1983) as cited by Chen & Du vel (1992) indicated that educational status determines the way of thinking and behaviour of an individual, and consequently his / her readiness to adopt new innovations brought by development agents



University of Fort Hare

4.3.1.3 Land tenure system. *Together in Excellence*

The land tenure system at Roxeni and Melani is based on permission to occupy the land on use (P.T.O). Forty per cent of the respondents are occupying 1,5 to 2 hectares of land (Figure 4.9 P 45). About thirty three per cent of the respondent were occupying 1 to 1,5 hectares of land and twenty seven are occupying 0.5 to 1 hectares. Both sexes appeared to have occupied almost the same amount of land i.e. males are occupying fifty two per cent while females are occupying forty eight per cent. Some of the farmers were not using all the land available to them either because they were engaged in other business or did not have enough capacity to handle large plots.

Inheritance is a factor prescribed by traditional succession but the present mode of ownership does not and land is used as security for loans. In addition, if land holdings are too small to provide family subsistence requirements, the outcome is bound to be a failure in terms of farming efficiency, even if there are no other constraints (Sadie, 1981).

Seventy percent and thirty per cent of the respondents were using 0.5 ha and 0.4 ha respectively for cabbage production throughout the year. Market demand is the key factor in determining amount of land allocation for a particular crop. The respondents were using the rest of the their plots to cultivate other crops such as carrots, onions, potato, beetroot, spinach cauliflower etc. Forty per cent of the respondents were growing five different crops annually (Figure 4.10, P 48). Five and nine per cent of the respondents grew annually less than 2 and over 5 different crops respectively. Whiles eighty six per cent of the respondents grew annually between 3 to 5 different crops.



University of Fort Hare
Together in Excellence

Figure 4.10 Number of different crops grown by each farmer (Alice District, Roxeni and Melani, 1999)

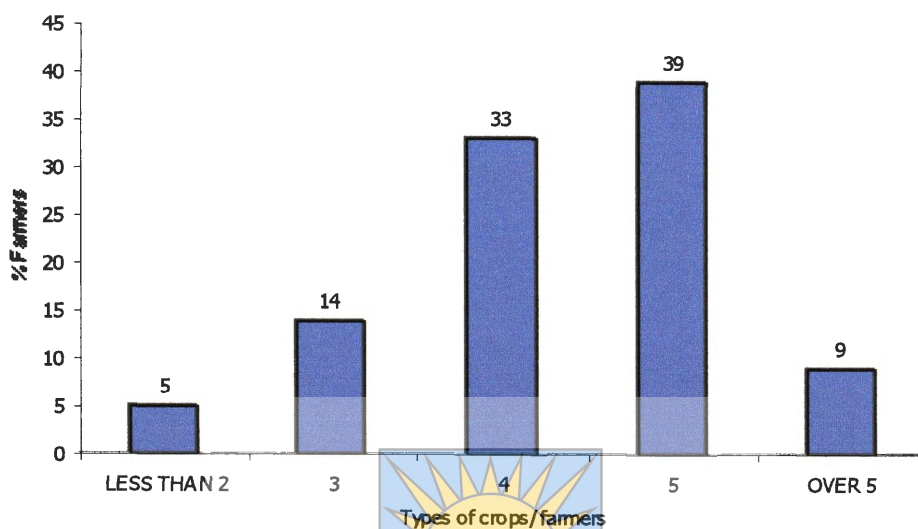
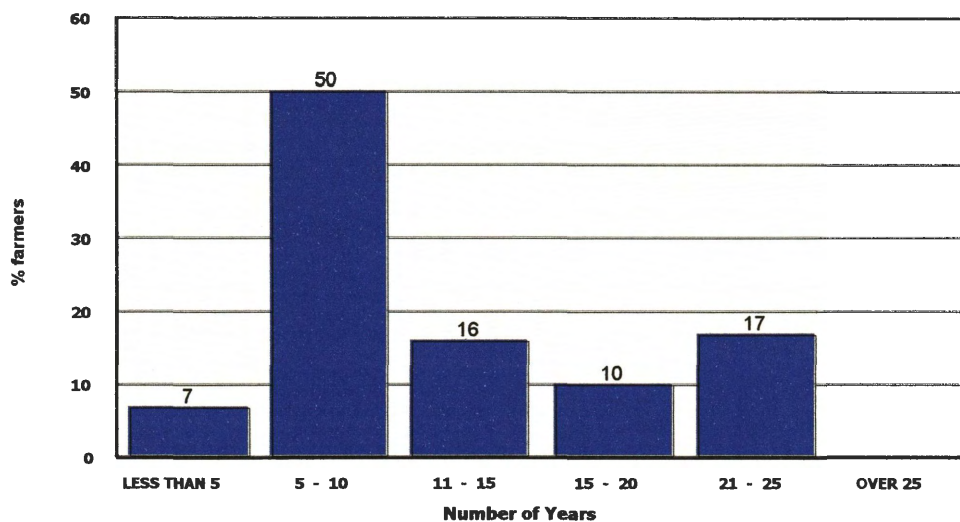


Figure 4.11 Farmer's experience in cabbage production (Alice District, Roxeni and Melani, 1999)

University of Fort Hare
Together in Excellence



4.3.1.4 Experience of the farmers in vegetables production (Cabbage)

The less experienced farmers constituted seven per cent of the farmer population. This group of farmers had one to five years experience in cabbage production. Fifty per cent of the respondents have spent between 5-10 years growing cabbages. The most experienced respondents constituted seventeen per cent of the farmer population. This group had 11-25 years of experience in cabbage production (Figure 4.11, P 48).

4.3.1.5 Inputs, labour and marketing

Small-scale farming is a dynamic business which, involves both human and non-human resource inputs (Ruthenberg, 1971). The non-human resource inputs may be categorised as land, capital and development inputs which may be initiated with capital. The human resource input may be subdivided into two mutually exclusive inputs namely labour and management i.e decision-making. These two general classes of resource inputs are closely inter-related, since a part of the task of the human resource is to make and implement decisions concerning the allocation of non-human resource inputs such as tillage, seed, fertilizer, pest control, etc.(Bembridge, Steyn & Tuswa, 1982).

It was very difficult to verify the input levels and expenditure as most, if not all farmers are not keeping records. Out of the number of the farmers interviewed, only twenty seven per cent have indicated the use of artificial mixed fertilizers at ratio 2:3:2 for Nitrogen, Phosphorus and Potassium(N.P.K) respectively . Seventy three per cent of the farmers either apply kraal manure or no fertilizer at all. Average yields were lower than 40 tons per hectare for five percent of the farmers (Fig. 4.12). In high input technology yield of annual average of 100 tons and a potential of 120 ton per hectare can be obtained (Brutsch, 1994). All farmers were applying pesticides to control pest. The pesticides used to control vegetables pest included Tamaron, Bravo, Metasystox, Malathion, Cypermethrin, Dithane and cutworm bait.

Many of the needs of the rural population, such as food, clean water and living standard, are not met by local production. This results in a cycle with the more productive members of the family having to seek work in the urban economy in order to meet their basic needs. This in turn results in labour shortage on the farms, leading to low levels of production. All the farmers interviewed indicated that labour was not a problem as all members of the family are assisting when required.

Farmers find it easy to cultivate and market locally. Farm produce is also sold to wholesalers, supermarkets, hawkers and local communities. Transport costs are not incurred by the farmers as the consumers collect on site. Short production cycle of four to five months is an added advantage for small scale farmers to have access to cash flow. In the Eastern Cape Province like elsewhere, cabbage is served with staple food and salad. It is highly nutritious cheapest vegetable affordable to an average household.



4.3.1.6 **Estimated average annual production of cabbage**

University of Fort Hare
Together in Excellence

As shown in figure 4.12 (P 51) thirty three per cent of the respondents were producing an average of 56-60 tons of cabbage annually. Only seven per cent of the respondents were producing more than 60 tons. The average annual production as shown by figure 4.12 was below 40 tons for five per cent of the farmers. The minimum annual production should be 50 tons per hectare, maximum 100 tons per hectare and a potential maximum a farm can produce is about 120 ton per hectare (Brutsch, 1994).

Figure 4.12 Distribution of respondents according to cabbage yield category (Alice District, Roxeni and Melani, 1999)

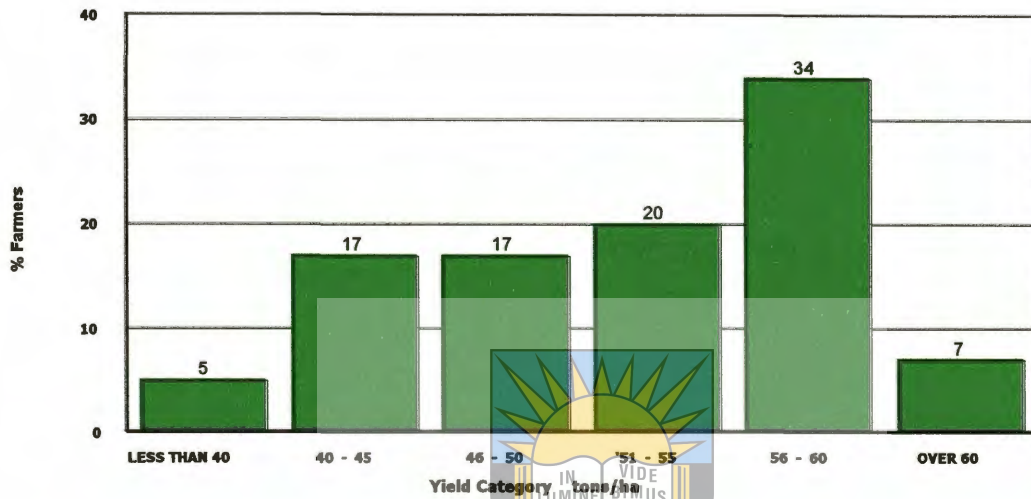
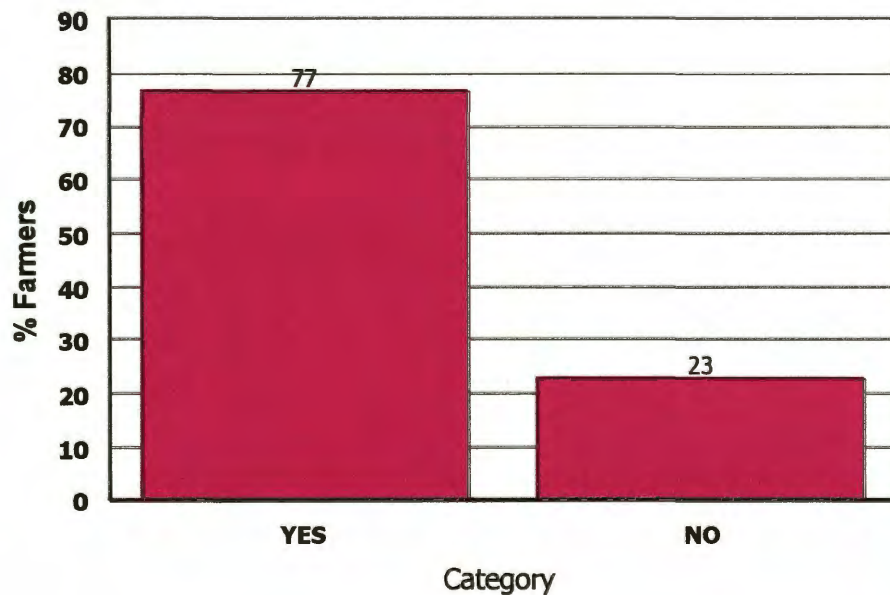
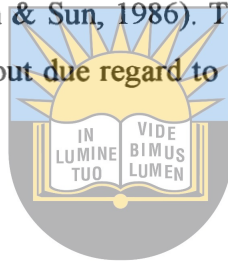


Figure 4. 13. Respondents indicating health and cost concern about the use of pesticides (Alice District, Roxeni and Melani, 1999)



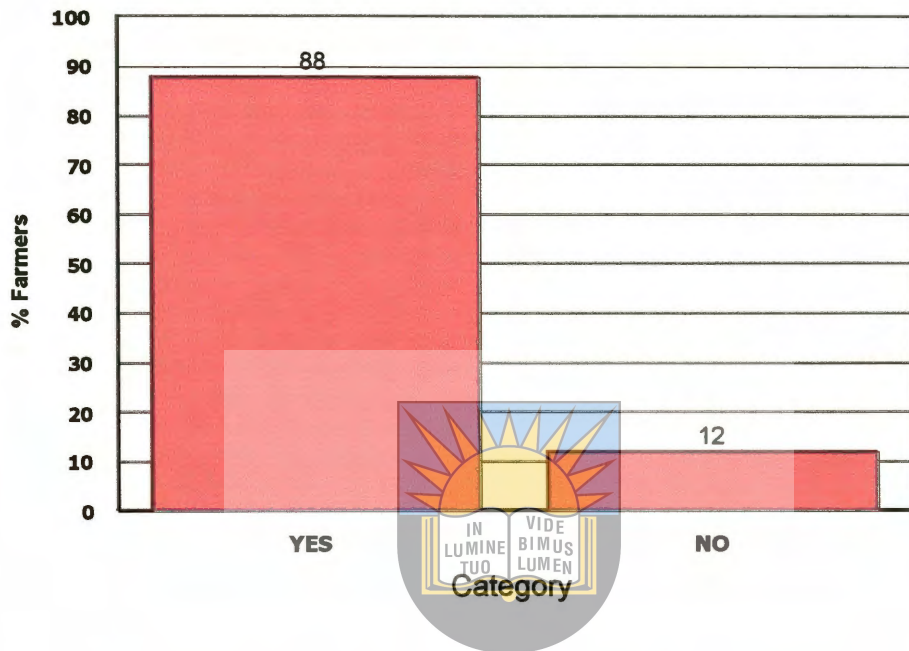
4.3.1.7 The use of pesticides

Seventy seven per cent of the respondents were concerned about the use of the pesticides either because they were costly or very unhealthy to use (Figure 4.13 P 51). Twenty three per cent of the respondents were not concerned about the cost of using pesticides nor element of consumer health risk (Appendix 3). None of the respondents had indicated the possibility of pests developing resistance against the pesticides used. No formal study was undertaken in this area to assess the impact of pesticides on the pest. The cabbage farmers practised weekly insecticides applications, and problems arising from such intensive use of different insecticides are well known (Figure 4.15, P 56). This pest has developed resistance to a wide variety of insecticide (Chen & Sun, 1986). The farmers still believe in pesticide application on a calender basis, without due regard to pest population and environmental damage.



University of Fort Hare
Together in Excellence

Figure 4.14. Number of respondents indicating that they are aware of the benefits of integrated pest management (IPM) (Alice District, Roxeni and Melani, 1999)



University of Fort Hare
Together in Excellence

When the respondents were asked whether they were aware of the benefits of integrated pest management (IPM), eighty six per cent answered yes and further indicated the labour and knowledge that has to go with it (Figure 4.13 P 53). Only thirteen per cent of the respondents answered no, either because they did not know about it or they have never been exposed to an IPM educational programme. Sixty one per cent indicated a need for additional support on IPM educational programme whiles thirty nine per cent showed no interest at all.

4.3.1.8 Economic importance of the target crop (Cabbage)

Vegetables as a group constitute an important component in man's diet, especially in the rural areas. Vegetables are rich sources of essential minerals and vitamins. They generally produce more nutrients per unit land area than staples such as maize. The economy of developing countries usually is agriculture-based. The majority of the rural population depend on farming for a livelihood; and a substantial number of farmers grow vegetables as secondary, if not a primary crop. Vegetable production has the potential, therefore, of improving the lives of people. Vegetable production is labour intensive. Production of vegetables creates a number of job opportunities in the rural and suburban areas and in the complementary fields of business that arise, such as marketing, processing, and transportation. Vegetables growers tend to earn higher income than most other farmers because of the relatively higher yield and value of the crops (Brutsch, 1994).

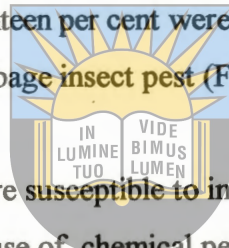
Cabbage is almost certainly the most popular leaf vegetable grown by the small scale farmers in the Eastern Cape, in spite of the fact that this crop is susceptible to insect pests and diseases. It is a highly adaptable crop with different cultivars doing very well under different climatic conditions.

4.3.1.9 Pest control practices

The use of insecticides is the only means utilized by farmers to control pests on cabbage. Most farmers indicated that they spray their cabbage at least once in two weeks but when the pest population is rife they spray 2-3 times a week. When aphids numbers increase the repetitive and heavy application of insecticides to control them is employed. There is no information on resistance to pesticides in this area.

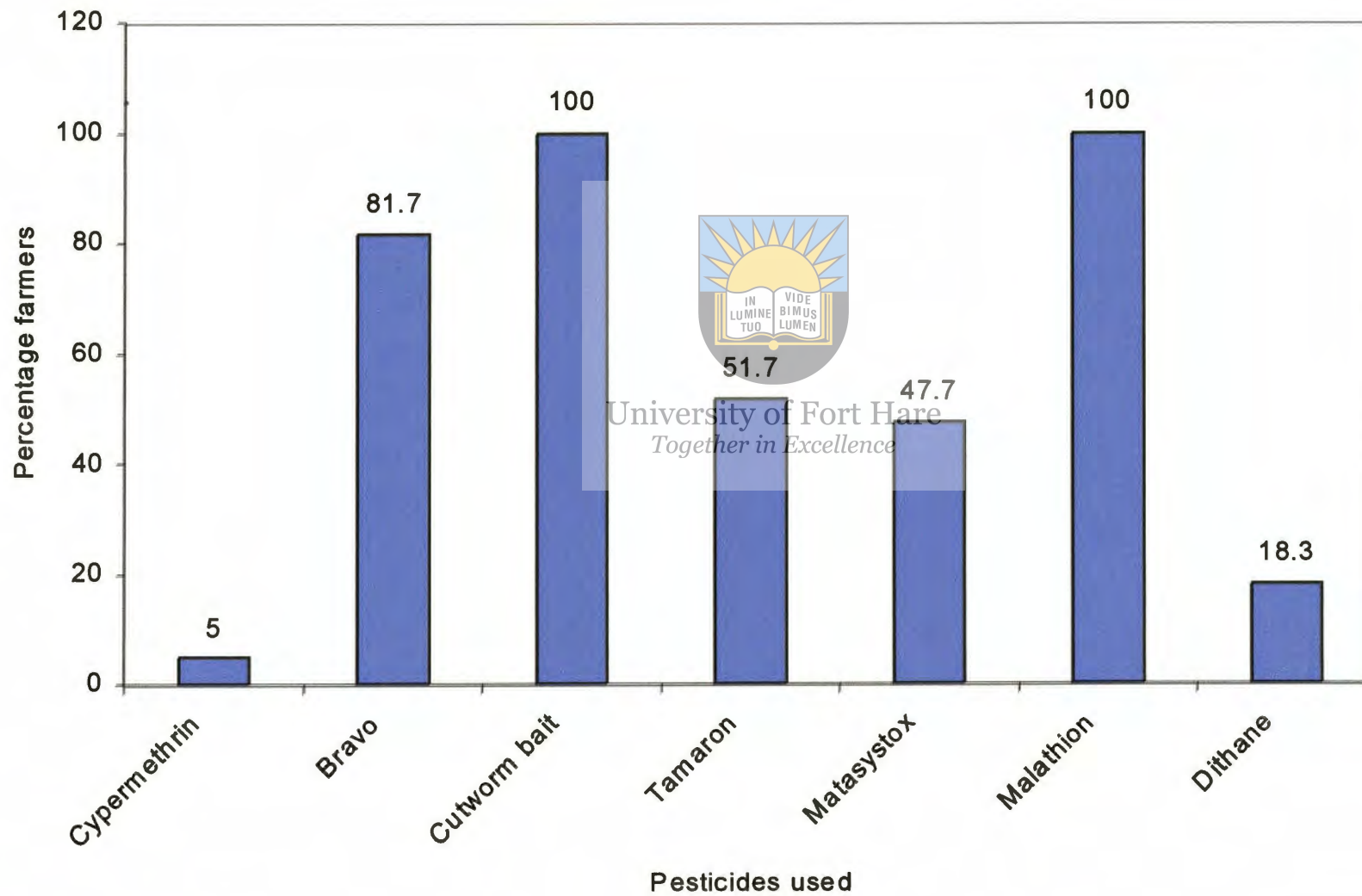
All the contact farmers interviewed were using Malathion and cutworm bait to control aphids and common cutworm respectively. Fifty two per cent of the farmers were using Tamaron and forty two per cent were using Metasystox to control *P.xylostella* . Five percent of the contact farmers were using Cypermethrin, Eighteen per cent were using Dithane and eighty two were using Bravo to control any other cabbage insect pest (Figure 4.15 P 56).

In general, parasitoids tend to be more susceptible to insecticides than do the host pests (Sastrodihardjo,1992). Indiscriminate use of chemical pesticides by the farmers usually leads to destruction of the parasite complex. As a result the natural control of cabbage pest almost entirely eliminated.



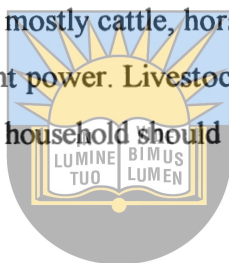
University of Fort Hare
Together in Excellence

Figure 4.15. Pesticides used by farmers to control vegetable pests (Alice District, Roxeni and Melani, 1999).



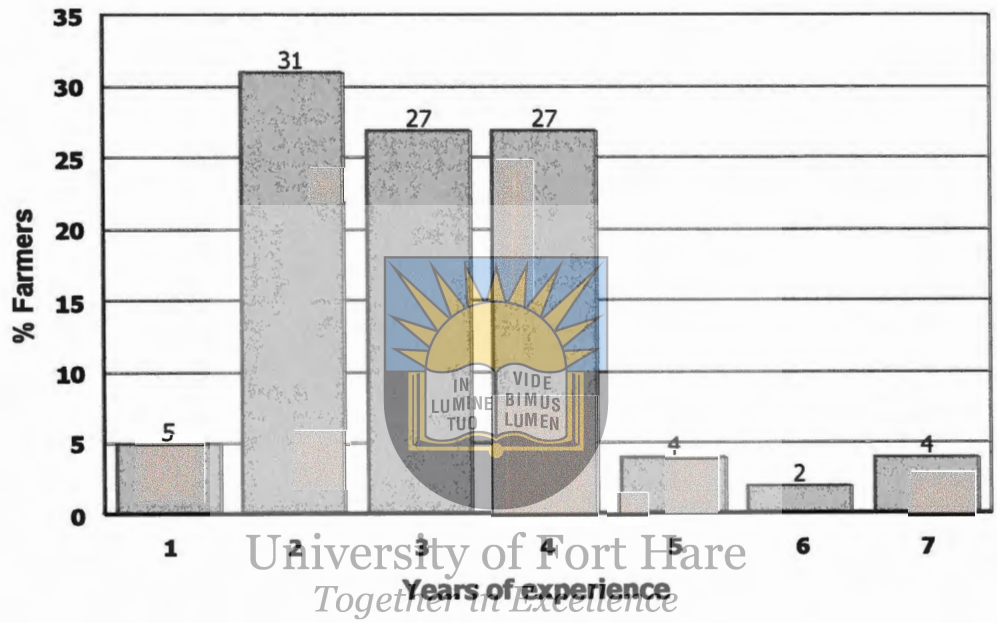
The majority of the respondents (27 %- 31 %) had kept livestock for 2-4 years farming. Only between one and three per cent of the respondents had kept livestock for 5-7 years (figure 4. 16 P 58). A small proportion of the respondents of about five per cent had kept livestock for one year. Most farmers indicated keeping livestock was limited by problems related to livestock theft and shortage of grazing land . So, they decided to start vegetable farming. Some are still keeping a few head of livestock at home.

Farmers are keeping both small and large stock in the homestead. Small stock are mostly goats and sheep while large stock are mostly cattle, horse and donkeys. The few horses and donkeys are basically used for draught power. Livestock graze in a communal land with no restrictions as to how many livestock a household should have, and this results in overgrazing (the tragedy of the commons).



University of Fort Hare
Together in Excellence

Figure 4.16 Number of years in livestock production by respondents (Alice District, Roxeni and Melani, 1999)



5 SUMMARY, CONCLUSIONS AND RECOMMENDATION

5.1 FIELD OBSERVATIONS

Based on these and earlier studies (Harcourt, 1963), certain generalization can be made regarding the dynamics of DBM population in the field. In addition to pesticides, there are three factors of critical importance to the prevalence of the pest. The first is weather which is responsible for most of the variation in survival of *P. xylostella*. Hence, it may be regarded as the principal factor that causes fluctuations in the populations outbreaks. The second critical factor is fecundity, also density independent, which is related to the crude protein content of the food plant and which declines on a gradual basis throughout the crop season. The third is the parasitoid complex which acts in a density dependent manner and which tends to stabilise populations (Table 4.4, P 34).

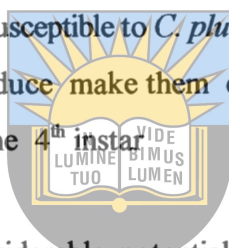
The infestation rate in winter was relatively low probably because of weather, low reproduction rate and poor quality food. Reduced damage by *P.xylostella* was caused to the host plants at this time of the year. The use of suitable winter cultivar usually facilitates good quality production during this time. However, the rate of infestation increased dramatically at the beginning of spring, bringing the average infestation rate above 20 larvae per cabbage. This degree of infestation can cause damage of economic importance. The use of selective pesticides by farmers to keep the pest below the injury level would be best move.

Observation on parasitism in spring showed that *C. plutellae* and *D. collaris* managed to parasitised 58% and 43% at Fort Cox and Sanyokwe respectively. *Cotesia plutellae* parasitism was far better than *D. collaris* in the two areas. Their combined average parasitism was 51%, which suggests that *P. xylostella* populations can effectively be reduced to approximately half (49%). However, the use of non-selective pesticides by farmers probably limited the control potential of these parasitoids. From the survey conducted all respondents indicated use of the chemical pesticides like Tamaron, Matasystox, Dithane, cutworm bait and Malathion in their farms. Most of these chemical pesticides used are not very friendly with the parasitoid complex that exists within the farming system. For example at Alice District, Melani and Roxeni fifty two per cent of the farmers were using Tamaron to control *P. xylostella*, but the mortality of

C. plutellae as a result of exposure to Tamaron can be as high as 99% (Kao & Tzeng 1986). Indiscriminate use of insecticides by the farmers appears to eliminate the parasitoids and predators which, to some extent, can contribute towards reducing the pest problem. As an alternative to indiscriminate use of insecticides, use of selective insecticides could be adopted while educating the farmers about the benefits of preserving natural enemies of cabbage pests.

5.2 LABORATORY OBSERVATION

The average *C. plutellae* parasitism was 75.95% on the 2nd instar, 56.5% on the 3rd instar and 16.27% on the 4th instar. It appears that this parasitoid prefers the 2nd and 3rd instars to the 4th instar. The 2nd and 3rd instar are more susceptible to *C. plutellae* attack possibly because their feeding habits and kairomones they produce make them easy targets. These instars also lack the robust defence characteristics of the 4th instar.



This parasitoid *C. plutellae* has considerable potential in the integrated management of *P.xylostella* as has been reported in other parts of the world. In order to combat this pest, we must know those factors affecting the activities of *C. plutellae*. Currently the chemical pesticides used by the farmers may be impacting negatively on the population growth and development of the parasitoid. *Cotesia plutellae* would be most effective if the insecticides were used more judiciously.

5.3 SOCIO-ECONOMIC CONDITION AND REQUIRED RESOURCES.

The age distribution of farmers suggest that approximately ninety per cent of farmers have the necessary physical capability of undertaking farming operations on their own account, without necessarily having to depend entirely on hired labour or assistance from the family. Age in this regard can not be regarded as a limiting factor but managerial aptitude could be a limiting factor. In the past subsistence farming in the rural and semi-urban was left entirely in the hands of women while their spouse left to work in mines and cities. Currently with the high rate of retrenchments, things have changed to see men involved in agricultural industry hence gender balance in rural and semi-urban farming has become explicit. Gender in these two localities is

not a problem though the number of women (42%) are less than men (58%) but this does not seem to cause any limitation on the levels of crop production. Low levels of formal education suggest that approximately forty seven per cent of the farmers are likely to be responsive to written communication. Regarding to fifty three per cent farmers who are illiterate, inevitably some members of the family are bound to be literate and they can pass on information to other farmers. The latter statement does not condone the fact that illiteracy is a major constraint towards agricultural development in this region. As long as the farmers cannot develop a farm business plan convincing enough to the bank manager because of illiteracy, agricultural development will for long be arrested.

The majority of these vegetable farmers, with the exception of pensioners, almost depend entirely on the economic viability of their farms for survival. Although some are occupying very small plots (0,5 ha) to provide for family requirements, some are occupying bigger plots over 1,5 hectares and are not using all the land available to them either because most of those individuals do not have the financial means to enable them to use the land productively. In addition to the agronomic inputs another major problems the farmers have to contend with is pest control. Most of these subsistence farmers practice mixed cropping and whatever is planted in their plots, if it is to make any yield, it must be protected from pests. This calls for buying and applying pesticides which in some cases may be of different kinds. The majority cannot afford that. Farmers indicated that as a result they go through the motions of planting and weeding but the crop they get is either badly damaged and unmarketable or there is literally no harvest at all. The parasitizing potential of one of the diamondback moth parasitoids namely *C. plutellae* indicated that this parasitoid is effective but there is need to inform the farmers about the potential of this and other natural enemies. In the case of the Diamondback moth there are other parasitoids such as *Cotesia plutellae*, *Diadromus collaris*, *Diadegma plutellae* etc. All these parasitoids are locally available but they are currently ignored and they are getting eliminated gradually by massive application of pesticides. If such natural enemies are managed well there may not be so much pressure on the resource-poor framers to constantly apply pesticides which they can ill afford.

In order to get money from the banking system farmers must have land to use as security.

This problem is compounded by the present land tenure system, permission to occupy (PTO) which does not provide security to allow farmers access to credit facilities. As a result it becomes a constraint to the development of crop farming. At Zanyokwe irrigation scheme, farmers are discouraged because they have to pay for high inputs and rented land. These types of land tenure systems (rented and permission to occupy) can be regarded as non-viable in terms of agricultural development.

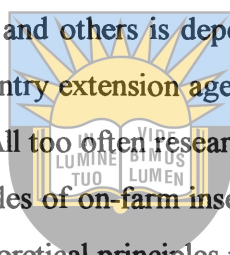
The practical problem with current systems of cultivation are farmer plots which are lying fallow in close proximity to the plot of an active farmer. The active farmer tries his/her best to control the pest but because the neighbouring plot is at best acting as a reservoir for pests thus defeating the control measures employed by the active farmer. This results in pests attacking the crop after few days after spraying and hence farmers are then forced to spray on a weekly basis and paying high cost for pest control. This kind of practice encourages excessive use of pesticides, development of pest resistance to chemical control, and destruction of beneficial insects. However, if biological control is part of the system, the present uncultivated plots may not become a limitation but a reservoir for natural enemies.



The use of insecticides is the only means available to farmers to control this pest as the pressure of producing good quality produce is ever increasing. Although eighty per cent of the farmers had indicated that they were aware of integrated pest management through extension work, information days or farmers days, they had very little practical knowledge about this mode of pest. The existence of *C. plutellae* on their farms does not mean much control presents to the farmers yet. What is apparent is that farmers will continue to use lot of chemical pesticides despite the potential for pest resistance and the damage they cause to the parasitoids. This cycle as indicated above can only be broken if farmers could be made aware of biological control and be encourage to conserve natural enemies within their agro-ecological systems. This process will go a long way in reducing the burden of relying on pesticides for pest control. The reduction of pesticide usage will contribute towards a healthy environment, healthy crops, reduction of high cost for pest control hence improvement of farm viability and better conservation of natural enemies.

The farmer field school (FFS) approach could be used to encourage the farmers to become key decision-makers in pest management and facilitation of discovery-learning. This approach uses non-formal education methods in a group context and should be central to farmer training in growing healthy crops, conserving natural enemies as well as creating environment awareness. It can be safely concluded that farmers need training in matters relating to biological control. Relevant personnel, particularly those in extension, would need to help farmers overcome their fears and any related negative perceptions, and to guide them to think in biological control terms. Implementation of this approach should be holistic, taking into consideration the different agricultural agencies, especially the research-extension farmer linkages which exists in this country.

The successful use of these strategies and others is dependant on educational efforts of the extension specialists, researchers, country extension agents, private consultants, agricultural pesticide representatives and farmers. All too often researchers, farmers and other agricultural consultants overlook the basic principles of on-farm insect management when faced with an insecticide resistant insect. Although theoretical principles may not always apply when working with farmers, it is important that the researcher/ educator become the solution to the crisis and not part of the problem.



University of Port Harcourt
Together in Excellence

To hasten the adoption of the technology and the conservation of *C. phutellae* in the field the following steps are recommended (Morallo-Rejesus & Sayaboc, 1992). Experts should spend more time with farmers setting up biological control systems, setting up more demonstration on field conservation of parasitoids and conducting training seminars for farmers. This process should be coupled with the use of selective insecticides biopesticides at minimum effective dose to allow the survival of not more than 50% of DBM for parasitization. If more funds are available studies along this line should be conducted to monitor the pest-paraistoid relationship. Developing effective low-cost and efficient mass-rearing technique for the host and parasitoids for large-scale production would be necessary. Also breeding and selecting a better strains of parasitoids resistant to insecticides would be a break through in IPM programmes. A thorough search for more potent biocontrol agents to augment *C. phutellae* not only for DBM but also for other cruciferous pests will be necessary

Table 4.7. Percentage host larval mortality and parasitism *C. plutellae* in the three instars of *P. xylostella*

DBM larval instars	Mean DBM larvae presented	Mean DBM parasitized by <i>C.plutellae</i>	Mean DBM adult obtained per instar	% Mortlity per instar	% Mean parsasitism
2 nd	92	70	11	11.1	75.92
3 rd	65	36	11	16.9	56.50
4 th	72	12	49	16.8	16.2

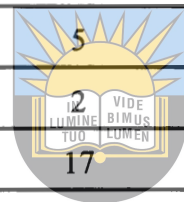
University of Fort Hare
Together in Excellence

Table 4.8 Average DBM parasitism by *C. plutellae* at 2nd instar based on the first 8 days of the female parasitoid

Days	1	2	3	4	5	6	7	8
Rep 1	7	9	7	9	8	7	10	7
Rep 2	7	9	10	6	10	10	10	8
Rep 3	5	7	8	9	7	10	9	6
Rep 4	8	7	6	6	10	10	7	7
Total	27	32	31	30	35	37	36	28
Mean	6.75	8	7.75	7.5	8.75	9.25	9	7

Table 4.9. Average DBM parasitism by *C. plutellae* at 3rd instar based on the first 5 days of the female parasitoid.

Days	1	2	3	4	5
Rep 1	8	7	4	10	5
Rep 2	5	3	5	8	6
Rep 3	3	5	9	10	9
Rep 4	2	2	3	6	7
Total	18	17	21	34	27
Mean	4.5	4.25	5.25	8.5	6.75



University of Fort Hare
Together in Excellence

Table 4.10 Average DBM parasitism by *C. plutellae* at 4th instar based on the first 7 days of the female parasitoid.

Days	1	2	3	4	5	6
Rep 1	3	4	1	1	1	0
Rep 2	0	1	0	0	1	1
Rep 3	1	7	7	3	2	2
Total	4	12	8	4	4	3
Mean	1.33	4	2.66	1.33	1.33	1

LITERATURE CITED

Abramham, E. V. & Padmanahan, M. D. 1968. Bionomics and control of the diamondback moth, *Plutella maculipennis* Curt. *Indian J. Agric sci.* 28 :513-19.

Altmann, J . A. 1988. An investigation of resistance in cabbage moth (*Plutella xylostella* L.) to pyrethroids in the Lockyer valley. PhD thesis. Queensland Agric. College, Lawes Australia. Pp 120-130.

Ankersmit, G. W. 1953. DDT resistance in *Plutella maculipennis* (Curt.)(Lepidoptera) in Java. *Bull. Entomol. Res.* 44: 421-25.

Anneeke, D. P. & Nurain, V. C. 1982. Insects and mites are cultivated plants in South Africa. Pp 100-123.



Atwal, A. S. 1955. Influence of temperature, photoperiod and food on the speed of development, longevity and other qualities of the diamondback moth, *Plutella maculipennis* (Curtis) (Lepidoptera: Tineidae), 3, 185-221.

Barclay, H. J. 1982. Models for pest control using predator release, habitat management and pesticide release in combination. *J.App.Ecol.* 19:337-348.

Barroga, S. F. 1974. A survey of diamondback moth population for resistance to the insecticides in the philippines. MS thesis. Univ. Philipines at Los Banos. Pp 117.

Beck, N. G. 1992. Lepidopterous pests on vegetable brassicas in Pukekohe, New Zealand: their seasonality, parasitism and management. Phd thesis. Univ. of Auckland, New Zealand.

Beddington, J. R., Free, C. A.& Lawton. J. H. 1978. Characteristics os succesful natural enemies in models of biological control of insects. *Nature (Lond.)* 273:513-519.

Bembridge, T. J. 1972. Extension in a Rhodesian Purchase Land Area. M.Sc. Thesis, University of Reading.

Bembridge, T. J. 1984. Report on the international exposition of rural development and a brief study tour of India Univ. of Fort Hare, Alice. Pp 131-140.

Bembridge, T.J., Steyn, G .J. & Tuswa, N. 1982. Present utilization of land: field crops of the Amatola Basin . Agric. and Rural Development Research Institute. Univ. Fort Hare. pp 45-80.

Brader, L. 1979. Integrated pest control in the developing world. *Ann. Entomol.*,24,225-254.

Bretherton, R. F. 1982. Lepidoptera immigration to the British Isles, 1969 to 1977. *Pro.Trans. British Entomol. Nat. Hist. Soc.* 15:98-110.



Brutsh, M. O. 1994. A vegetable training manual. Univ. of Fort Hare pp 1-117.

University of Fort Hare
Together in Excellence

Buranday, R. P. & Raros, R. S. 1973. Effects of cabbage tomato intercropping on the incidence and oviposition of the diamondback moth, *Plutella xylostella (L) Philipp.* *Entomol.* 2:369-374.

Chaney, W. E., Toscano, N. C., Bentley, W. J. & Natwick, E. T. 1998. UC Pest Management Guidelines. Cole crops. UC DANR. Agricultural and Natural Resources, University of California.

Chang, L.C. 1961. The dynamics and insecticidal control of cruciferous insects. *Plant.Pro.Bull.* 3:22-26.

Chelliah, S. & Srinivasan, k. 1984. Bioecology and management of diamondback moth in India. In: Talekar, N. S. and Griggs, T.D.(ed) Diamondback moth management. Proc 1st inter workshop Asian Vegetable Research and Development Centre - Tainan, Taiwan 63-73.

Chen, J. H. & Duvel, G. H., 1992. The influence of rural leaders on agricultural development in Swaziland. *South African Journal of Agricultural Extension*, 21:14-22.

Chen, S. S. & Su, C. N. 1986. Resistance of diamondback moth (Lepidoptera: Plutellidae) to a combination of fenvalerate and piperomul butoxide. *J. Econ. Entomol.*, 79, 22-30.

Cheng, E. Y., Kao, C. H. & Chiu, C. S. 1992. Resistance, cross-resistance and chemical control of diamondback moth in Taiwan: recent developments. In: Talekar, N. S. and Griggs, T.D.(ed) Diamondback moth management. Proc 1st inter workshop Asian Vegetable Research and Development Centre - Tainan, Taiwan. Pp. 465-75.

Chilcutt, C. F. & Tabashnik, B. E. 1997. Independent and combined effects of *Bacillus thuringiensis* and the parasitoids *Cotesia plutellae* (Hymenoptera: Braconidae) on susceptible and resistant diamondback moth (Lepidoptera: Plutellidae). *J. Econ. Entomol.* 90:397-403.

Chin, T. 1974. Studies on the seasonal appearance of the diamondback moth in relation to environmental factors. *Taiwan Agric. Q.* 10:81-84.

Chuo, T. H. & Ooi, P. A. C., 1986. Evaluation of three parasites in the biological control of diamondback moth in the Cameron Highlands, Malaysia. In: Talekar, N.S. and Griggs, T.D.(ed) Diamondback moth management. Proc 1st inter workshop Asian Vegetable Research and Development Centre - Tainan, Taiwan 173-184.

Corbett, G. H. & Pagden, H. T. 1941. A review of some recent entomological investigations and observations. *Malay. Agric. J.*, 29, 347-375.

Debach, P. 1974. Biological control by natural enemies. London: Cambridge Univ. Press. Pp 323.

Dover, J. W. 1985. The responses of some Lepidoptera to labiate herb and white clover extracts. *Entomol. Exp. Appl.* 42:243-47.

Dover, J. W. 1986. The effect of labiate herbs and white clover on *plutellae xylostella* oviposition. *Entomol. Exp. Appl.* 42:243-47.

Dube, R. B. & Chand P. 1977. Effect of food plants on the development of *plutella* (L) (Lepidoptera, Plutellidae) *Entomol* 2:139-140.

Evans, I. B. P. 1939. Solving the Union`s pasture, crop and insect problems. Annual Report of the Division of plant industry. Fmg. South Africa. No. 117,22 .

Flexner, J. L., Lighthard, B. & Croft, B. A. 1986. The effects of microbial pesticides on non-target, beneficial arthropods. *Agric.Ecosys. Environ.*, 16, 203-254

French, R. A. 1967. Long distance of movement of two migrant lipidoptera in relation to synoptic weather conditions . *Biometerology* 2: 565-569.

Gray, R. A. H. 1915 .Prevention of egg laying on turnip by the diamontback moth *J. Board Agric.*23:222.

Gunn, D. 1917. The small cabbage moth(*Plutella maculipennis* Curtis). *Union South Africa Dep.Agric.Bull.* No8, Pp. 10.

Hama, H. 1992. Insecticide resistance characteristics of the diamondback moth. In: Talekar, N.S. (Ed) Diamondback moth and other crucifer pests. proc 2nd international workshop. Asian Vegetable Research Developement Centre. Tainan. Taiwan. pp. 455-63.

Harcourt, D. G. 1954. The biology and ecology of diamondback moth, *Plutella Maculipennis*, Curtis, Eastern.

Harcourt, D. G. 1963 . Major mortality factors in the population dynamics of the diamondback moth, *Plutella maculipennis* (Curt) (Lepidoptera : Plutellidae) . Memo. Entomol. Soc. Can. 32: 55-66.

Harcourt , D. G. 1986. Population dynamics of the diamondback moth in Southern Ontario. In: Talekar, N. S. and Griggs, T. D (ed) Diamondback moth management. Proc 1st inter workshop Asian Vegetable Research and Development Centre, Tainan, Taiwan 3-16.

Harcourt, D. G. 1957. Biology of the diamondback moth, *plutella maculipennis* (Curt) (Lepidoptera: Plutellidae), in eastern Ontario II . Life - history, behaviour, and host relationship. *Can. Entomol.* 89:554-563.

Hardy , J. E. 1938. *Plutella maculipennis* Curt ., its natural and biological control in England. *Bull.Entomol. Res.* 29 : 3430- 3472.

Hassan, S. A. & Guo, M. F. 1991. Selection of effective strains of eggs parasites of the genus *Trichogramma* (Hymenoptera; Trichogrammatidae) to control the European Corn borer. *Z. Angen Entomol.* 432-561



Heiman,G.W. 1992. Basic statistics for the behavioral sciences. Houghton Mifflin Comp. 120-309

University of Port Harcourt
Together in Excellence

Hely, P. C., Pasfield, G & Gellatley J. G. 1982. Insect pests of fruit and vegetables in NSW. Inkata Press, Melbourne.

Hobbs, D. J., Beal, G.M. & Bohlen, J. M. 1964. The relation of farm operator values and attitudes to their economic performance. Rural Society No 33, Iowa State University.

Hou, R. F. 1986. Mass rearing of diamondback moth. In: Talekar, N.S. and Griggs, T. D. (Ed) Diamondback moth management. Proc 1st International Workshop Asian Vegetable Research and Development Centre. Tainan, Taiwan. 89-96.

Hutchison, W. D., Bolin, P. & Hines, R. 1997. Biological control of insect pests of cabbage and other crucifers. Minnesota Extension Service, University of Minnesota. *Midwest Biological Control News* Pp 51-53.

Idris, A. B. & Frafillis, E. 1997. Nectar-collecting behaviour of *Diadegma insulare* (Hymenoptera: Khneumonidae), a parasitoid of Diamondback moth(Lepidoptera: Plutellidae) *Environ. Entomol* - 26:114.

Idris, A. B & Grafius, E. 1993. Field studies on the diamondback moth, *Plutella xylostella* (L.) (Lepidoptera : Plutellidae) and parasitism by *Diadegma inslare* (Hymenoptera : Ichneumonidae). *J.Econ. Entomol.* 86:1196-1202.

Jayarathnam, K. 1977. Studies on the population dynamics of the diamondback moth, *Plutella xylostella* (Linnaeus) (Lepidoptera : Yponomeutidae) and crop loss due to the pest in cabbage. PhD. thesis. University of Agricultural Sciences. Bangalore. PP 215.

Johnson, D. R. 1953. *Pluttella maculipennis* resistance to DDT in Java. *J. Econ. Entomol.* 46:176.



Kadir, H. A. 1992. Potential of several baculoviruses for the control of diamondback moth and *Crociodomia binotalis* on cabbage. In: Talekar, N.S. (Ed) Diamondback moth and other crucifer pests. proc 2nd international workshop. Asian Vegetable Research Development Centre. Tainan. Taiwan., Taiwan, 182-192.

Karnervo, V. 1936. The diamondback moth (*P. maculipennis* Curt.) as a pest of cruciferous plants in Finland. 86:1-86 (in finnish with English summary).

Kao, S. S. & Tzeng, C. C. 1992. Toxicity of insecticides to *Cotesia plutellae*, a parasitoid of diamondback moth. In: Talekar, N.S. (Ed) Diamondback moth and other crucifer pests. proc 2nd international workshop. Asian Vegetable Research Development Centre. Tainan. Taiwan., 287-296.

Kirsh , K., and Schmutterer , H. 1988. Low efficacy of *Bacillus thuringiensis* (Berl) formulation in controlling the diamondback moth. *Plutella xylostella* (L) in the Philippines. *J. App.Entomol.* 105:249-55.

Kmec , T & Weiss, M. J. 1997. Seasonal abundance of Diamondback moth (Lepidoptera: Yponomeutidae) *Crambe abyssinica* - *Environ Entomol* 26: 483-488.

Koshihara, T & Yamada, H. 1976. A simple mass-rearing, Technique of the diamondback moth, *Plutella xylostella* (L.), on germinating rape seeds. (In Japanese with English summary). *Jpn. J. Appl. Entomol. Zool.* 20:110-114.

Li, C .W. 1981. The origin, evolution, taxonomy and hybridization of Chinese cabbage. In Chinese cabbage: In: Talekar , N. S. and Griggs, T. D. (Ed) Diamondback moth management: proc 1st International Workshop Asian Vegetable Research and Development Centre Tainan, Taiwan pp 3-11.

Lim, G. S. 1986. Biological control of diamondback moth. In: Talekar , N. S. and Griggs, T. D. (Ed) Diamondback moth management: proc 1st International Workshop Asian Vegetable Research and Development Centre Tainan, Taiwan 43-54.

Lim, G. S., Loke, W. H., Chan, H. H., & Syed A. R., 1988. Pest management of vegetables in Malaysia. Paper presented at the informal expert Consultation on IPM in major vegetables Crops in Asia, Nov.14-16, 1988, FAO,RAPA, Bangkok. P 79.

Lionberger, H. F. 1960. Adoption of new ideas and practices. Iowa State University press.

Meyrick, E. 1928. A revised handbook of British Lepidoptera. London: Watkins and Doncaster. Pp 803.

Miles, H. W. 1924. The diamondback moth, *Plutella maculipennis* Curt. Kirton Agric. Inst. Ann. Rep 1923 pp 45-48.

Mithel Everett, R. , Tingel, F. C., Navosero-warde, R.C. & Kehat, M. 1997. Impact of *Cotesia plutellae* (Hymenoptera : Braconidae) on control of diamondback moth (Lepidoptera : Plutellidae) in cabbage. Pp 56-59.

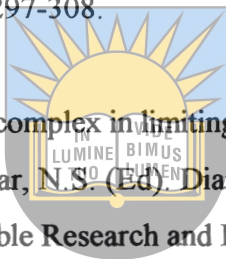
Mitchell Everett, R., Tingle, F. C., Navasero-Ward, R.C. & Kehat, M. 1997.

Diamondback moth (Lepidoptera: Plutellidae) : parasitism by *Cotesia plutellae* (Hymenoptera: Braconidae) in cabbage. *Fla. Entomol.* 80:477-489.

Mitchell Everett, R., Tingle, F. C., Navasero-Ward, R.C. & Kehat, M. 1998. Impact of *Cotesia plutellae* (Hymenoptera : Braconidae) on control of diamondback moth (Lepidoptera : Plutellidae) in cabbage. Pp 126-28.

Morallo-Rejesus, B., & Sayaboc, A. S. 1992. Management of diamondback moth with *Costesia plutellae*: prospects in the Philippines. In: Talekar, N.S. (Ed) Diamondback moth and other crucifer pests. Proc. 2nd International Workshop. Asian Vegetable Research and Development Centre, Tainan, Taiwan 297-308.

Mustata, G. 1992. Role of parasitoid complex in limiting the population of diamondback moth in Moldavia, Romania. In: Talekar, N.S. (Ed) Diamondback moth and other pests. Proc. 2nd inter workshop Asian Vegetable Research and Development Centre, Tainan, Taiwan 203-211.



University of Fort Hare
Together in Excellence

Nemoto, H., Yano, E. & Kiritani, K., 1992. Pheromonal control of diamondback moth in the management of crucifer pests. In: Talekar, N. S. and Griggs, T.D.(ed) Diamondback moth management. Proc 1st inter workshop Asian Vegetable Research and Development Centre - Tainan, Taiwan 91-97.

Ohno, T., Asayama, T & Ichikawa, K. 1992. Evaluation of communication disruption method for suppressing diamondback moth infestations at two different areas using synthetic sex pheromone. In: Talekar, N. S. (Ed) Diamondback moth and other crucifer pests. Proc 2nd international workshop. Asian Vegetable Research Development Centre. Tainan. Taiwan. pp.109-14.

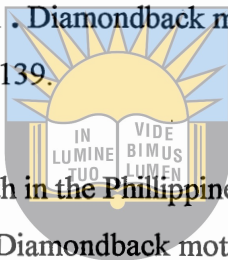
Ooi, P. A. C. 1992. Role of parasitoids in managing diamondback moth in Cameron Highlands. Proceedings of the second international workshop. Shanshua, Taiwan: Asian Vegetables Research and Development Centre . pp.255-265

Ooi, P. A. C. 1986. Diamondback moth in Malaysia. In: Talekar, N. S. and Griggs, T.D.(ed) Diamondback moth management. Proc 1st inter workshop Asian Vegetable Research and Development Centre - Tainan, Taiwan 25-34.

Paramonov, S. 1953. The principal pest of oil seed plants in Ukraine. L. Angrew Entomol (in German). 35: 63-81.

Patil, S. P. & Pokharkar, R. N. 1971 . Diamondback moth, a serious pest of crucifers. Res. J. Mahatma . Agric. Univ. 2:134-139.

Poelking, A. 1992. Diamondback moth in the Philippines and its control with *Diadegma semiclausum*. In: Talekar, N.S. (Ed) Diamondback moth and other crucifer pests. proc 2nd international workshop. Asian Vegetable Research Development Centre. Tainan. Taiwan. 271-278.



University of Perpetual Help
Together in Excellence

Risch, S. J. 1981. Insect herbivore abundance in tropical monocultures and polycultures : an experimental test of two hypotheses. Ecology 62:1325-40.

Rogers, E. M. 1983. Diffusion of innovations. Third Edition. Division of MacMillan Publishing Co., Inc. New York. pp 120-25.

Rogers, E. M., & Shoemaker, F. F. 1971. Communication of innovations: A Cross-cultural Approach. The free press, New York.

Root, R. B. 1973. Organisation of a plant-arthropod association in simple and diverse habitats : the fauna of collards (*Brassica Oleracea*). Ecol. Monogr. 43:94-125.

Sadie, J. L. 1981. Manpower development policy for Southern Africa. Conf. Proceedings, South Africa: The challenges of the eighties. Africa Institute, Pretoria.

Salinas, P. J. 1986. Studies on diamondback moth in Venezuela with reference to other Latin American countries. In: Talekar, N. S. and Griggs, T.D.(ed) Diamondback moth management. Proc 1st inter workshop Asian Vegetable Research and Development Centre - Tainan, Taiwan 17-24.

Sarnthoy, O., Keinmeesuke, P., Sinchaisri, N. & Nakasuji, F. 1989. Development and reproductive rate of diamondback moth *Plutellea xylostella* from Thailand. Appl. Entomol. Zool. 24, 202-208.

Sastrosiswoyo, S. & Sastrodihardjo, S. 1986. Status of biological control of diamondback moth by introduction of parasitoid *Diadegma eucerothaga* in Indonesia. In: Talekar, N.S. (Ed) Diamondback moth and other crucifer pests. proc 2nd international workshop. Asian Vegetable Research Development Centre. Tainan. Taiwan. 185-194.

University of Fort Hare

Together in Excellence

Sheehan, W. 1986. Response of specialist and generalist natural enemies to agroecosystem diversification: a selective review. *Environ. Entomol.* 15:456-61.

Shelton, A. M., & Wyman, J. A. 1992. Insecticide resistance of diamondback moth in North America pp. 447-54.

Soares, G.G. & Quick, T. C. 1992. Mvp, a novel bioinsecticide, for the control of diamondback moth. In: Talekar, N.S. (Ed) Diamondback moth and other crucifer pests. proc 2nd international workshop. Asian Vegetable Research Development Centre. Tainan. Taiwan. Taiwan. 129-138.

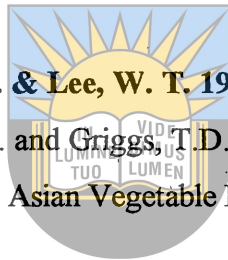
Srinivasana, K. 1984. Visual damage thresholds for diamondback moth, *Plutella xylostella* (Linnaeus), and leafwebber, *Crociodolomia binotalis* Zeller, on cabbage. *Univ. Agric. Sci., Hebbal, India* . P 166

Srinivasana, K. & Krishna Moorthy, P. 1992. Development and adoption of integrated pest management for major pests of cabbage using Indian mustard as a trap crop. In: Talekar, N.S. (Ed) Diamondback moth and other crucifer pests. proc 2nd international workshop. Asian Vegetable Research Development Centre. Tainan. Taiwan.Pp. 511-21.

Sun , C. N. 1992. Insecticide resistance in diamondback moth. Proceedings of the second international workshop. Shanshua, Taiwan: Asian Vegetables Research and Development Centre.Pp.419-26

Sun, C. N., Cui , H., & Feng, H. T. 1978. Diamondback moth resistance to diazinon and methomyl in Taiwan. J. Econ. Entomol. 71:551-54.

Sun, C. N., Wu , T. K. , Chen, J. S. & Lee, W. T. 1986. Insecticide resistance in the diamondback moth. In: Talekar, N. S. and Griggs, T.D.(ed) Diamondback moth management. Proc 1st inter workshop Asian Vegetable Research and Development Centre - Tainan, Taiwan. Pp359-372



University of Fort Hare

Together in Excellence

Stilling, D. P. 1985. An introduction to insect pests and their control.

Singh, S. P. & Singh, D. 1982. Influence of cruciferous host plants on the survival and development of *plutella xylostella* L. J. Res. Punjab. Agric. Univ. 19:100-104.

Tabashnik , B. E., Cushing , N. L., Finso, N. & Johnson , M. W. 1990. Field development of resistance to *Bacillus thuringiensis* in diamondback moth (Lepidoptera: Plutellidae) *J. Econ. Entomol.*,8,1671-1676.

Tabashnick, B. E. & Mau, R. F. L. 1986. Suppression of diamondback moth (Lepidoptera : Plutellidae) oviposition by overhead irrigation . *J.E con. Entomol.* 79:189-91.

Talekar, N . S. & Lee, S. T . 1985. Seasonality of insect pests of chinese cabbage and common cabbage in Taiwan. *Plant pro. Bull* (Taiwan) 27:47-52.

Talekar, N. S., Lee, S. T. & Huang, S W. 1986. Intercropping and modification of irrigation method for the control of diamondback moth. In: Talekar, N. S. and Griggs, T.D.(ed) Diamondback moth management. Proc 1st inter workshop Asian Vegetable Research and Development Centre - Tainan, Taiwan Pp. 145-55.

Talekar, N. S. & Shelton, A. M. 1993. Biology of ecology and management of the diamondback moth . *Annu. Rev. Entomol.* 38:275-301.

Talekar, N. S. & Yang, J. C. 1991. Characteristics of parasitism of diamondback moth by two larval parasites. *Entomophaga* 36:95-104.

Tshikolomo, K. A, 1996. Communication and decision making in the Phaswana area of Northern province.MSc thesis. Univ. Fort Hare , South Africa, Alice pp 25-200.

Thorsteinson, A. J. 1953. The chemotactic responses that determine host specificity in an oligophagous insect(*plutella maculipennis* (Curt.): Lepidoptera). *Can. J. Zool.* 31:52-72.

University of Fort Hare

Together in Excellence

Tsunoda, S. 1980. Eco-physiology of wild and cultivated forms in *Brassica* and allied genera. In :*Brassica crops and wild allies: Biology and Breeding*, ed.S. Tsunoda, K.Hinata, C. Gomez-Comp, Pp 109-20.

Thygesen, T. 1968. Insect migration over long distance. *Ugeskr. Agron.* 8:115-20.

Ullyet, G. C. 1947. Mortality factors in populations of *plutella maculipennis* curt. (Tineidae :Lep) and their relation to the problem of control. *Entomol. Mem. Agri. S. Afri.* 2pt.P 6

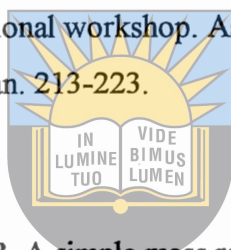
Vostrikov, P. 1915. Tomatoes as insecticides. The importance of Solanaceae in the control of pests of agriculture. *Novotcherkossk* 10:9-12 .

Waage, J. & Cherry A. 1992. Quantifying the impact of parasitoids on diamondback moth, In: Talekar, N.S. (ed) *Diamondback moth and other crucifer pests.* Proc 2nd

International Workshop. Asian Vegetable Research and Development Centre. Tainan. Taiwan. Pp 245-254.

Wakisaka, S., Tsukuda, R. & Nakasuji, F. 1992. Effects of natural enemies , rainfall, temperature and reproduction of the diamondback moth. In diamondback moth and other crucifer pests. In: Talekar, N.S. (Ed) Diamondback moth and other crucifer pests. proc 2nd international workshop. Asian Vegetable Research Development Centre. Tainan. Taiwan. Pp 92-368.

Waterhouse, D. F. 1992. Biological Control of diamondback moth in the pacific. In: Diamondback moth and other crucifer pests. In: Talekar, N.S. (Ed) Diamondback moth and other crucifer pests. proc 2nd international workshop. Asian Vegetable Research Development Centre. Tainan. Taiwan. 213-223.



Yamada, H. & Koshihara, T . 1978. A simple mass rearing method for the diamondback moth *Plant pro.*28:253-56.

University of Fort Hare
Together in Excellence

Yang, J. C., Chu, Y. I. & Talekar, N. S., 1994. Studies on the characteristics of parasitism of *plutella xylostella* (LEP: PLUTELLIDAE) by a larval parasite *Diadegma sem: calusum* (HYM: ICHNEUMONIDAE) *Entomophaga* 39: 39-406.

Appendix 1

ASSESSMENT OF THE DIAMONDBACK MOTH, *PLUTELLA XYLOSTELLA* (L) (LEPIDOPTERA : YPONOMEUTIDAE) INFESTATION AND PRESENCE OF ITS NATURAL ENEMIES IN EASTERN CAPE REGION



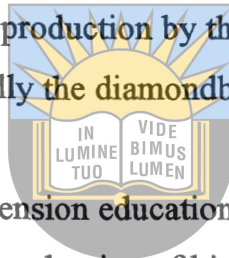
University of Fort Hare
Together in Excellence
QUESTIONNAIRE

DATE : SEPTEMBER / OCTOBER 1999

RESEARCH OBJECTIVE AND RATIONALE

Questionnaire to assess the following

1. Pest problems limiting cabbage production by the small scale farmers in Alice.
2. Extent of cabbage pests especially the diamondback moth (DBM).
3. Potential for recommending extension educational strategies or methods that would be effective in facilitating adoption of biological control of cabbage pests among small scale farmers.
4. Potential for use of parasitoids in an integrated pest management especially diamondback moth.



University of Fort Hare
Together in Excellence

1. Name _____

2. Gender: Male 1. 2 Female

3. Age: _____

4. Educational level: Number of years in schooling _____

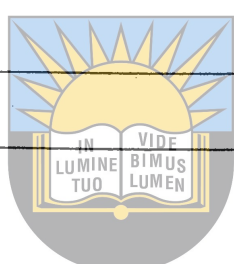
: Post-school qualification _____

5. Location (District) _____

6. Land Tenure System _____

7. Area of land _____ Ha

8. Previous Farming Experiences



Enterprise	Years	 University of Fort Hare <i>Together in Excellence</i>	<input type="checkbox"/>
Crop			<input type="checkbox"/>
Livestock			<input type="checkbox"/>
Mixed			<input type="checkbox"/>

9. Crop Production: Involvement in Cabbage Production:
 1 Full-Time 2 Part-Time

10. How many years have you been growing cabbage _____

11. Size of land planted to cabbage _____ Ha

12. How many different crops do you grow annually? _____

13. Give an estimate of an average annual cabbage production based on the past two years (1997-1998) _____

14. List the cabbage varieties you grow in winter and summer on your farm

VARIETY	WINTER	AREA(Ha)

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

VARIETY	SUMMER	AREA(Ha)

15. Which of the following cabbage pest(s) can you identify

Cabbage Pest	Mark (✓) in appropriate box
1. Cabbage moth	
2. Aphids	
3. Flea beetles	
4. Diamondback moth	
5. Common cutworm	

--

16. What are the major problems responsible for loss in the quantity and quality of cabbage production.

_____ University of Fort Hare
 _____ Together in Excellence

17. How many farm assistants/labours/workers do you employ?

Employees	Permanent	Casual
Farm Assistant		
Workers (Irrigation)		
Harvest and Post-Harvest		
Pest Scouts		
Pesticide/Fungicide Application		

18. Which of the cabbage pest(s) do you regard to be the major problem on your farm?

- 1. Cabbage moth
- 2. Aphids
- 3. Flea Beetles
- 4. Diamondback moth
- 5. Common Cutworm

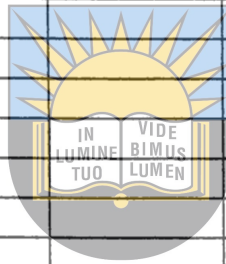
--

19. What pest and disease control management strategies do you use on your farm?

Control Practice	Yes 1	No 2
1. Cultural		
2. Biological		
3. Chemical		
4. Combination of the above		
5. Other (specify)		

20. Please indicate, when do you use control practice applicable to your farm.

Time	Cultural	Biological	Chemical	Combination
1. First weeks of planting				
2. First month of planting				
3. Second month of planting				
4. Third month of planting				
5. Fourth month of planting				
6. Before harvest				
7. Occasionally				
8. Throughout the season				
9. Don't know				



University of Fort Hare
Together in Excellence

21. Chemical control of the cabbage pests

Pest	Pesticide used	Frequency of application	Estimated cost in rands
1. Cabbage Moth			
2. Aphids			
3. Flea Beetles			
4. Diamondback Moth			
5. Common Cutworm			

22. Are the pesticides you are using effective in controlling the pests?

1. Yes

2. No

23. If not what is likely to be the problem. Explain.

24. Do you have to apply the pesticides more often than the recommended application.

1. Yes 2. No

25. If Yes, may you explain



University of Fort Hare
Together in Excellence

26. List the common chemicals that you use on your farm

27. When is diamondback moth most acute:

1. Winter season

2. Spring season

3. Autumn season

4. Summer season

28. Indicate whether you know about the natural enemies of diamondback moth (parasitoids)

1. Yes 2. No

29. Have you heard of biological control?

1. Yes 2. No

30. If Yes, have you ever used it on your farm?

1. Yes 2. No

31. How many years have you been using biological control of the diamondback moth?

_____ year

32. Do you know (about) Integrated Pest Management?

1. Yes 2. No

33. If Yes, have you ever used it on your farm?

1. Yes 2. No

34. How many years have you been using integrated pest management?

_____ year

35. Do you conduct larval diamondback scouting?

1. Yes 2. No

36. What area of cabbage production on your farm is managed by integrated/chemical or biological control?

Strategy	Area
1. Integrated control	
2. Chemical control	
3. Biological control	
4. Other (specify)	

<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>



University of Fort Hare
Together in Excellence

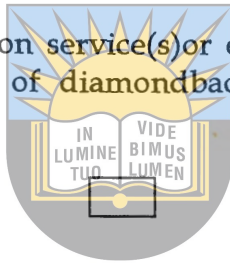
37. Are you satisfied with the level of financial returns with your diamondback moth control strategies.

1. Yes 2. No

38. If not satisfied, please provide an explanation

39. Did you ever receive any extension service(s) or education training on integrated pest management or any aspect of diamondback moth control from chemical companies

1. Yes 2. No



40. If Yes, may you briefly describe

University of Fort Hare
Together in Excellence

41. What is your opinion about the extension system?

42. Did you ever receive any extension service(s) or educational training on integrated pest management or any aspect of diamondback moth control from a state or government institution

1. Yes

2. No

43. If Yes, how often?

44. Would you require additional extension support or advice on integrated pest management

1. Yes

2. No

45. If Yes, what are your major needs?



University of Fort Hare
Together in Excellence

46. Are you aware of the benefits of the integrated pest management in cabbage production

1. Yes

2. No

47. If Yes, Explain reasons why you would reject to use integrated pest management

48. If you ever use or reject integrated pest management, do you rely heavily on chemical control strategy

1. Yes

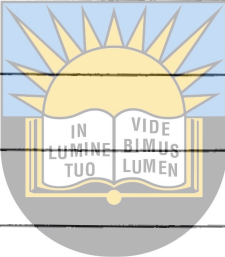
2. No

49. Are you concerned about the use of pesticides?

1. Yes

2. No

50. If yes, please explain



51. If No, would you like to be trained or exposed to the concept and practice of integrated pest management.

1. Yes

2. No

EASTERN CAPE PROVINCE

1. EAST GRIQUALAND-KEI REGION

- 1a Mount Ayliff Subregion
- 1b Lusikisiki Subregion

2. EASTERN REGION

- 2a Elliot Subregion
- 2b Umtata Subregion

3. CENTRAL REGION

- 3a Butterworth Subregion
- 3b Amatola Subregion
- 3c Albany Subregion

4. WESTERN REGION

- 4a Karoo Subregion
- 4b Algoa Subregion

5. NORTHERN REGION

- 5a Aliwal North Subregion
- 5b Queenstown Subregion



- MAGISTERIAL BOUNDARIES
- REGIONAL BOUNDARIES
- SUB-REGIONAL BOUNDARIES
- REGIONAL OFFICES
- SUB-REGIONAL OFFICES

Prepared by, D.L. Heuer
DÖHNE IS

Appendix 3

QUERRY	GALELA	MLUMBI E	MBILINI T	MBANE T	MLUMBI S	NGUNGE	SIBAITA R	TSHETSH FENI	BABA S	THEMBAN	DAWUWA	ZWENI M	HLABA N	GANTOS	BUZANI P	ALI A	SOBOOIS	MBANE T	BOLOSHA	
2	2	1	1	1	1	1	1	1	1	2	1	1	2	2	1	1	1	2	1	2
3	47	60	57	57	59	55	56	60	60	50	50	60	50	50	60	60	50	45	51	54
4	4	3	7	7	8	8	8	9	3	4	6	3	6	10	5	2	2	2	4	7
7	1.5	1.8	1.5	1.8	1.8	1.8	1.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.8	1.8	1.8
8 CROP																				
L/STOKE	2	8	2	3	4	3	4	3	3	4	4	3	4	4	4	5	3	2	7	2
MIXED																				
9	1	1	1	1	1	1	1	21	1	1	1	1	1	1	1	1	1	1	1	1
10	9	12	10	8	4	10	6	21	22	20	20	20	24	24	22	23	24	10	8	13
11	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	
12	4	6	4	4	4	7	4	5	5	5	5	5	5	5	5	5	5	7	4	
13	45	50	60	40	40	60	57	55	56	55	55	61	55	55	60	50	55	60	38	75
15	1																			
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3																				
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	NO FERT DUCKS	NO FERT DUCKS	NO FERT DUCKS	NO FERT DUCKS	NO FERT DUCKS	NO FERT DUCKS	NO FERT DUCKS	NO FERT DUCKS	NO FERT DUCKS	NO FERT DUCKS	NO FERT DUCKS	NO FERT DUCKS	IRRIG FERT	NO FERT DUCKS	IRRIG PEST	IRRIG PEST	IRRIG PEST	NO FERT DUCKS	NO FERT DUCKS	NO FERT DUCKS
17 FARM AS!	2	2	2	1	1	1	1	2	2	2	2	2	2	2	2	2	2	1	1	1
WORKER!	3	2	2	2	1	2	2	3	2	2	3	3	2	2	2	3	3	2	2	2
HARV & P	2	2	3	3	1	2	2	2	3	3	2	2	3	2	2	2	2	3	2	2
PEST SCOUTS																				
PESTICIDI	2	2	2	2	2	2	3	2	2	2	2	2	2	2	3	2	2	2	2	2
18	1																			
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3																				
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1																			
2																				
3	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4																				
5																				
20	1																			
2																				



University of Fort Hare

33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34																				
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	1																			
2	1.5	1.5	1.5	1.5	1.8	1.8	1.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.8	1.8	1.8
3																				
4																				
37	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
38																				
39	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
40		DISEASE	DISEASE	WEEDS	DISEASE	DISEASE	MEETING:	METINGS	MEETING:	MEETING:	MEETING:	MEETING:	MEETING:	DISEASE	MEETING:	MEETINGS		DISEASE	DISEASE	
41		PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
42		NO GOOE	NO GOOE	NO GOOE	NO GOOE	GOOD	V POOR	V GOOD	GOOD	GOOD	GOOD	NO GOOE	NO GOOE	GOOD	GOOD	GOOD	GOOD	V POOR	V GOOD	V POOR
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	1	0	0	0	0	0	1	1	0	0	1	1	0	0	1	1
45	KNOW MORE	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC
46	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
47	NO REAS!	NO REAS!	NO REAS!	NO REAS!	NO REAS!	NO REAS!	NO REAS!	NO REAS!	NO REAS!	NO REAS!	NO REAS!	NO REAS!	NO REAS!	NO REAS!	NO REAS!	NO REAS!	NO REAS!	NO REAS!	NO REAS!	NO REAS!
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1
50	COSTLY	COSTLY	COSTLY	COSTLY		COSTLY	COSTLY	COSTLY	COSTLY	COSTLY	COSTLY	COSTLY	COSTLY	COSTLY	COSTLY	COSTLY	COSTLY		COSTLY	COSTLY
51	HEALTH	HEALTH		HEALTH		HEALTH	HEALTH	HEALTH	HEALTH	HEALTH	HEALTH	HEALTH	HEALTH	HEALTH		HEALTH				



University of Fort Hare
Together in Excellence

QUERRY	GIYAMA S	XALAMBA	XABALI T	MLUMBI E	MLUMBI \	MLUMBI E	MBANE E	MYAPHA:	MTSHEMI	MTSHEMI	LENYANE	BOOI F F	BOOI T T	LENYANE	JANDA T I	LENYANE	MKUMBI \	FENI S S	TYHUTHU	KOKO B J
2	2	1	1	2	2	1	2	2	1	2	1	1	2	2	2	2	1	1	1	1
3	56	53	60	53	49	50	48	56	56	59	59	62	57	58	59	63	61	50	60	60
4	8	3	8	7	3	5	7	4	4	3	2	2	3	3	3	0	0	3	3	6
7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1	1	1	1	1	1	1	1	1	1	0.9	0.9	0.9
8 CROP																				
L/STOKE	1	5	2	7	2	4		2	4	3	3	2	3	4	2	2	2	3		4
MIXED								4												
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	10	6	16	12	11	5	7	6	4	8	4	8	7	9	8	10	8	20	20	22
11	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4
12	4	7	4	4	3	7	8	4	2	4	3	3	4	3	2	3	3	5	5	5
13	60	49	60	39	40	43	40	54	47	45	49	60	55	51	45	40	45	55		56
15	1																			
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3																				
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	NO FERT	IRRIG	NO FERT	NO FERT	IRRIG	NO FERT	NO FERT	NO FERT	NO FERT	NO FERT	IRRIG	NO FERT	NO FERT	IRRIG	NO FERT	NO FERT	NO FERT	IRRIG	IRRIG	NO FERT
	DUCKS	DUCKS	DUCKS	DUCKS	DUCKS	DUCKS	DUCKS	DUCKS	DUCKS	DUCKS	DUCKS	DUCKS	DUCKS	DUCKS	DUCKS	DUCKS	DUCKS	DUCKS	DUCKS	DUCKS
																		PEST	PEST	PEST
17 FARM AS:	1	2	1	1	2	2	1	1	2	1	2	2	2	2	1	2	1	1	2	2
WORKER:	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	3
HARV & P	2	2	3	2	2	2	2	3	1	2	1	2	2	2	2	2	2	1	2	2
PEST SCOUTS																				
PESTICID:	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2
18	1																			
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3																				
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1																			
2																				
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4																				
5																				
20	1																			
2																				



University of Fort Hare
Together in Excellence

33		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
34																					
35		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
36	1																				
2		1.8	1.8	1.8	1.8	1.8	1.8	1.8	1	1	1	1	1	1	1	1	1	1	0.9	0.9	0.9
3																					
4																					
37		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
38																					

39		1	0	1	1	1	1	1	0	0	1	0	1	0	0	0	0	1	1	1
40	DISEASE		DISEASE	DISEASE	DISEASE	DISEASE	DISEASE	DISEASE			DISEASE	DISEASE	DISEASE					MEETING	MEETING	MEETINGS
41	PM		PM	PM	PM	PM	PM				PM	PM	PM					PM	PM	PM
41	V POOR	V POOR	V GOOD	V POOR	GOOD	V POOR	V GOOD	V POOR	V POOR	V POOR	V POOR	V GOOD	V GOOD	V GOOD	POOR	V POOR	V POOR	GOOD	NO GOOD	GOOD

42		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43																				

44		1	1	1	1	1	1	1	0	0	0	0	0	0	1	1	0	1	1	1	1
45	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC

46		1	1	1	1	1	1	1	0	0	0	0	1	1	1	0	0	0	1	1	1
47	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS

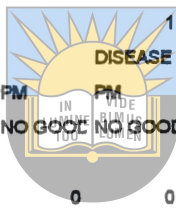
48		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49		1	1	1	1	1	1	1	0	0	0	0	0	0	1	1	0	0	1	1	1
50	COSTLY	COSTLY	COSTLY	COSTLY	COSTLY	COSTLY	COSTLY							COSTLY	COSTLY			COSTLY	COSTLY	COSTLY	
51									1	1	1	1	1	1			1	1			



University of Fort Hare
Together in Excellence

33		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
34																					
35		0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
36	1																				
	2	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.8	1.8	1.8	1.8	0.9	1.8	0.9	1.8	0.9	1.5	1.5
	3																				
	4																				
37		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
38																					

39		1	0	1	1	1	1	1	1	1	1	1	0	1	0	1	0	0	1	1	
40		DISEASE	WEEDS	WEEDS	WEEDS	DISEASE	DISEASE	WEEDS	DISEASE	DISEASE	DISEASE	DISEASE	DISEASE	MEETINGS	MEETING	MEETING	DISEASE	DISEASE			
41		PEST M	PESTS	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	IRRIG	PM	PM			
		V GOOD	V GOOD	NO GOOD	GOOD	GOOD	GOOD	GOOD	NO GOOD	NO GOOD	NO GOOD	NO GOOD	V POOR	V POOR	GOOD	V POOR	NO GOOD	V POOR	GOOD	NO GOOD	NO GOOD
42		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



University of Fort Hare
Together in Excellence

44		1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	0	1	1	1
45		KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC	KNOW MC
46		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
47		NO REAS	NO REASON		NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS	NO REAS
48		0	0	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0	0
49		1	1	1	1	1		1	1			0	1	1	1	1	0	1	1	1	1
50		COSTLY	COSTLY	COSTLY	COSTLY	COSTLY	COSTLY	COSTLY		COSTLY	COSTLY	COSTLY	COSTLY	COSTLY	COSTLY	COSTLY		COSTLY	COSTLY	COSTLY	COSTLY
				HEALTH		HEALTH	HEALTH			HEALTH	HEALTH	HEALTH		HEALTH	HEALTH	HEALTH		HEALTH	HEALTH		