IDENTIFICATION AND DOCUMENTATION OF ETHNOBIOLOGICAL METHODS USED BY RURAL FARMERS TO CONTROL STALK BORERS ON MAIZE IN THE EASTERN CAPE PROVINCE OF SOUTH AFRICA

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DECLARATION

I, Nolitha Leonora Mlanjeni, declare that this dissertation is my work. It is being submitted for the degree, Master of Science (Ethnobotany) at the University of Fort Hare. It has not been submitted before for any degree or examination at any other university.

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ABSTRACT

Maize contributes substantially to food security in the Eastern Cape province of South Africa. It is a staple food to many of the province's rural and urban inhabitants. Insect pests are one of the factors that hamper its productivity and as a result, deprive farmers of good yields. The adverse effects of insecticides and the high cost associated with them and the cost of transgenic seeds are some of the challenges faced by small-scale farmers in rural areas. Alternative control methods which include the use of indigenous techniques to control pests are now sought.

A study to identify and document ethnobiological means used by rural farmers to manage insect pests of maize was conducted in the rural areas of the Eastern Cape Province. A total of 217 participants were interviewed on the matter, using semi-structured but detailed questionnaires. Rural farmers due to their linkage to agriculture activities and the fact that they are considered as custodians of agricultural indigenous knowledge were selected as respondents. Only maize producing and IsiXhosa speaking people were chosen to contribute. Main focus was on the demography of respondents, crop production activities and insect pest control. Pretesting of the questionnaire in order to assess the appropriateness of questions and comprehension by both farmers and enumerators was done. Data was analysed using descriptive statistics.

Fifty five percent (55 %) of the respondents were females and the highest number of participants was from the Chris Hani District Municipality. Majority of the people were unemployed or pensioners. Most had only attended primary school and the mean age was 59 years. Apart from maize, respondents were cultivating other crops such as cabbage, Swiss chard, potatoes etc. Stalk borers followed by cutworms were the main pests of maize in these areas. Respondents used mainly insecticides, followed by alternative substances, which also included cultural control methods such as planting date manipulation. Few respondents used plants as control agents for insect pests. Some people did not control pests even though they were a problem in their fields. The most used plant was *Chenopodium ambrosiodes* L, while the most used substance was Madubula (a detergent). The most used insecticide was carbaryl from the carbamite family. Respondents listed different preparation techniques for all the control methods mentioned. These techniques revealed different times of preparation, quantities of ingredients, amounts applied on plants, modes of application and intervals of application.

Rural farmers in the study areas used different atypical methods which may play a significant role in pest management today. Some of the products may have a positive influence on agriculture, while some are dangerous to humans and environmental health. Further research which will investigate their potential use in pest control needs to be done.

CHAPTER 1

GENERAL INTRODUCTION

Zea mays L. commonly known as maize, is one of the most important staple foods in sub-Saharan Africa (FAO, 2007). It originated in Central America and was first introduced to Africa in the 17th century (Seshu-Reddy, 1998).

The crop is a source of human and livestock dietary carbohydrate and is the most important grain crop in South Africa (DAFF, 2011). The yield of maize in South Africa is constantly higher than that of other countries in the Southern African Development Community (SADC) region (Baloyi *et al*. 2012). In 2011, for example, the country produced more than 10 million metric tonnes of maize which contributed up to 55 % of the overall SADC produce (Grant *et al*., 2012). Maize is grown all over South Africa (Fanadzo *et al*., 2009), though the Free State, Mpumalanga, KwaZulu- Natal, Northern Cape and Northwest Provinces are the primary producers (Sibiya *et al*., 2013).

In the Eastern Cape Province, maize is produced mainly by small-scale farmers for subsistence purposes and surplus is normally sold to surrounding communities (Mandikiana, 2011). The crop contributes substantially to food security in the province (Wallade *et al*., 2001). Regrettably, however, the maize plant faces a major problem of insect pests (Ande *et al*., 2010; Obopile *et al*., 2008; Kfir *et al*., 2002; Sibanda *et al*., 2000) such as maize stalkborers, cutworms, the maize black beetles, maize spotted beetles, maize loopers and bollworms (Bell, 2005). In the Eastern Cape Province (as in the rest of the country) maize stalk borers, namely *Chilo partellus* S. (Lepidoptera: Cambridae), *Sesamia calamistsis* H (Lepidoptera: Noctuidae) and *Busseola fusca* W. (Lepidoptera: Noctuidae) are the major pests of maize on the field (Waladde *et al*., 2001). *Busseola fusca* commonly known as the maize stalk borer and *Chilo partellus* commonly known as the spotted sorghum borer cause the largest economic loss on maize in the country (Kfir *et al*., 2002). *Sesamia calamistis*, commonly known as the pink stalk borer, is economically insignificant in South Africa and occurs at very low infestation levels (Overholt & Maes, 2000).

Generally, in South Africa, yield losses on maize due to stalk borer attacks range between 10 % and 100 % (van Rensburg & Flett, 2010). Even a 10 % loss to maize yield would translate to an estimated average annual loss of about one million tonnes of maize which is valued at approximately US$ 130 million (Mandikiana, 2011).

Resource poor farmers often cannot afford the high prices of commercial pesticides for the control of insect pests such as maize stalk borers. As an alternative, they adopt cultural methods, such as intercropping and field sanitation, with some plant products (Kamanula *et al*., 2011). These traditional herbal remedies are usually different among subsistence farmers residing in different regions of the same country. This according to Cherty & Belbahri (2008) is due to the fact that indigenous knowledge is accrued through close interaction with nature and natural resources. It is largely influenced by language, culture, tradition, belief, folklore, rites and rituals of those particular people.

A study conducted in the Eastern Cape Province covering Indwe, Queenstown, Lady Frere, Mthatha, Whittlesea, King William's Town and Alice, on the indigenous pest management methods of controlling *Sitophillus zeamais* M. revealed that subsistence farmers in the province do have some knowledge of the indigenous control methods of pests (Odeyemi *et al.*, 2006). The author however noticed that this knowledge was being eroded especially among the young farmers due to lack of documentation.

Indigenous practices of using herbs to control insect pests have been dismissed by some researchers due to lack of sufficient research work to demonstrate their potential (Silesh *et al*., 2009). This is because, the effectiveness of indigenous practices is often judged against insecticidal control. For a farmer who cannot afford insecticides, even low efficacy can still be considered effective (Kamanula *et al*., 2011). It is the belief of this author that, these practices should not be dismissed as inefficient and unsustainable, rather they should be validated. Their limitations need to be seen as means for generating contextual and site specific knowledge. Research and development on Integrated Pest Management (IPM) for use by African farmers requires incorporation of indigenous knowledge about natural products and their local use.

The Eastern Cape Province is categorized as being one of the poorest provinces in South Africa. It is largely comprised of rural areas and maize is planted mainly as a staple food. This is where the proper recording and documentation of indigenous pest control methods on maize stalk borers is most important.

CHAPTER 2

LITERATURE REVIEW

2.1. Maize production in South Africa

Zea Mays L (maize) is the most important summer grain in South Africa (Klopper, 2008). Approximately 2.7 million hectares of South Africa's land was used to produce maize during the 2011/2012 season and the final crop yield was estimated at about 11.83 million tonnes (DAFF, 2013). This, according to Smale et al. *(*2011), is mostly on large-scale commercial farms where the land planted per farm averages to 380 hectares (ha) each. Contrary to the rest of the sub-Saharan Africa where maize production is dominated by smallholder farmers, in South Africa smallholder farmers contribute less than 15 % of the national production (Smale *et al*., 2011). The average annual gross value of the maize amounts to R5 481 million (Keetch *et al*., 2005). However, its national average annual gross value accounts for a minor fraction of the household income of black rural families (Smale *et al.*, 2011).

The sub-Saharan Africa produces, on average, between 18-24 million tons of maize per annum, with 55 % of that produced in South Africa when conditions permit (Grant *et al*., 2012). South Africa exports maize to Botswana, Lesotho, Namibia, Swaziland, Zimbabwe, Kenya, Mozambique, Zambia, Mauritius and in some years, to Japan (DAFF, 2011). According to the 2011/12 export values, maize was ranked 4th at R 4 778 million after citrus fruit, wine and chemical wood pulp (DAFF, 2012).

Maize is an adaptable crop grown over a range of agro climatic zones. In South Africa, it is grown throughout the country under diverse environments including both dry land and rain fed conditions (Fanadzo *et al.*, 2009). About one quarter of maize grown commercially in South Africa is under irrigation, and to improve on yields commercial farmers use advanced maize hybrids, including genetically modified seeds. The amount of fertiliser applied by commercial farmers is normally 75 kilograms per hectare (kg/ha), much higher than elsewhere in Africa. Consequently, in the Northern Cape Province of South Africa, where all of the commercial maize grown is planted under irrigation, yields are recorded at around 10 tonnes per hectare (t/ha) (Smale *et al*., 2011). As expected, small-scale resource poor farmers, who mostly reside in the rural areas of the country, experience different outputs. Yields in these small-scale farms are generally low, ranging approximately from 1.8 to 3.5 t/ha (Baloyi *et al*., 2012; Fanadzo *et al*., 2009). These yields are within the range reported by the small-scale farming sector in the rest of the sub-Saharan Africa, which averages at 1.2 t/ha against a potential of 7 t/ha (Fanadzo, 2007; Pingali & Pandey, 2001). Insect infestations have been observed to range between 30 - 70 % in fields of small-scale farmers where no insecticide was applied compared to less than 30 % on commercial farms where insecticides were applied (Sithole, 1987).

Recently, there have been reports of decline of land under maize production in South Africa, though; productivity has increased (Grant *et al.*, 2012). The results are contrary to the rest of the sub Saharan Africa, where a decrease in maize production would mean a decrease in productivity (Jayne, 2010). This could be due to the fact that smallholder farmer's make-up more than 50% of total maize farmers in the SADC region and contribute more than 50 % of the produce in the region (Grant *et al*., 2012). The South Africa commercial maize sector on the other hand, is supported by marketing and pricing policy issues that focus primarily on keeping food prices at tolerable levels for urban consumers. Along with that, the policies ensure the continued viability of the large commercial farm sector, while providing very little attention on smallholder maize production or marketing (Smale *et al*., 2011). Furthermore, support for commercial maize production, as it is for the rest of the commercial agriculture sector in South Africa, is received from agricultural education and training as well as research and development in the country (Rodriguez & Niemeyer, 2004; Simalenga *et al*., 2000). Besides, commercial maize farmers have invested substantially to improve commercial maize production in the country.

A study conducted by Fraser *et al*. (2003) in the Eastern Cape Province revealed that although black small-scale farmers often have access to land, they lack access to implements and other resources as a result they concentrate on home gardens in order to provide some measure of food supplementation. Lack of resources, implements and knowledge could be some of the reasons why there is much variability on yields between small-scale and large scale maize growers in South Africa. For example, most of the arable land that is cropped in the Eastern Cape Province is planted with maize, even though, much of the land remains idle. According to Ortmann & Machethe (2003), poverty levels in the Eastern Cape, make it difficult for small-scale farmers to conquer some of the challenges associated with crop production. The high cost of inputs needed to improve the low potential of lands available to small-scale farmers; access to water and other long term investments associated with agriculture make the load heavier.

Current trends indicate an increased drive both from government and non-governmental organisations to develop the small-scale activities into commercial farms (Quinn *et al*., 2011). This is the case not only for maize producing small-scale farms but for all agricultural commodities. Literature regarding subsistence farming emphasizes a need for research institutions to understand indigenous knowledge systems in order to adapt their technologies to the local farmers' situation (Norton *et al*., 1999). This in turn will increase the acceptability of training and management which will be necessary for the small-scale farmers to increase their productivity and if possible go commercial.

2.2. Importance of maize in South Africa

2.2.1. Maize as a food source

Over 50 % of maize grown in South Africa is used for human consumption and 35 % of the total diet consumed by South Africa's population is made up of maize (Grant, *et al*. 2012). It is only a small percentage of the crop that is eaten as fresh maize (*umbona omtsha*), which is boiled or roasted as a snack (Mkile, 2001). Many are times; maize is consumed primarily as a prepared product, e.g, maize meal. A number of dishes including *Umnqgusho* (samp and beans cooked together with water), *Umxhaxha* (maize and pumpkin/ wild watermelon cooked in water), *Umqa* (pumpkin or wild watermelon mixed with ground maize or maize meal and cooked in water) *Isophu* (mealies and beans boiled together to make a soupy substance) and *Isigezenga* (bread or pudding made of boiled and crushed green maize) are prepared from maize (Mtumtum, 2012; Sobahle, 1982). Also a beverage called *amarhewu* and an alcoholic drink called *umqombothi* are made from maize (Nuss & Tamunihardjo, 2011).

2.2.2 Nutritional status of maize

Although maize supplies many macro and micronutrients necessary for human metabolic needs, it lacks B vitamins and the essential amino acids, lysine and tryptophane (Nuss & Taminihardjo, 2011). White maize in particular, which is the preferred type of maize by the South African consumers lacks provitamin A carotenoids, which are essential for eyesight, immunity and general growth. In addition, some minerals in the maize grain have low bioavailability due to high concentrations of phytate (Nuss & Tanumihardjo, 2010). This nutritional deficiency of maize has been most felt in countries where maize is consumed mainly as a staple food especially in poor households where the crop is consumed solely without any supplementation. For example, during the 1970’s in South Africa, the lack of protein and energy in maize manifested itself on the black population, which was the main user of the crop, in the form of diseases such as kwashiorkor, tuberculosis, growth retardation, pneumonia and gastro – enteritis (Booysens, 2001). In 2003, the South African government made it mandatory for all maize meal and wheat flour to be fortified (Government Gazzette, 1972). This was necessary as many in South Africa depend on maize and its by-products for food.

Remarkably, rural people in South Africa as is in the rest of Africa, tend to intercrop maize with pumpkins and / beans (Silwana, 2005). This intercropping provides more household available nutrients per unit area when compared to monocropping and in some cases can be used to manage insect and weeds (Abate *et al*., 2000).

2.2.3 Other uses of maize

Maize is also the most important ingredient in animal feeds. The African Feed Manufacturers' Association (AFMA) estimates that maize accounts for between 50 % and 60 % of the volume of animal feed produced in South Africa (Grant *et al*., 2012). The FAO estimates that about 53 % of maize produced in South Africa is used for non-food use, with 88 % of that as animal feed. This is contrary to the rest of the sub-Saharan Africa where more than 70 % of maize is used for human consumption (Abbassian, 2009). The poultry industry is regarded as the largest consumer of maize as animal feed in South Africa exceeding beef feedlots (Grant *et al*., 2012).

Unlike the national trend, rural people in South Africa cultivate maize for food and only leftovers from homestead meals and poor quality grain is given to animals (McAllister, 2001). In the Eastern Cape for example, livestock such as cattle are only allowed to graze on maize stalks after cob harvesting has been done. This is normally during winter, when the grass in the veld is limited and of poor nutritional status.

Maize also serves as a raw material for manufactured products such as paper, paint, textiles, medicine and food (DAFF, 2012), hence, maize is one of the important employers and earners of foreign currency in South Africa.

2.3 The effect of maize stalk borers on maize productivity in South Africa

Of the various insect pests attacking maize in Africa, the lepidopteran stalk borer complex is by far the most injurious (Kfir *et al*., 2002.). They feed on all parts of a maize plant, including leaves, stalk, sheath, ear collar and ears. Feeding by borer larvae leading to tunnelling usually results in crop losses as a result of death of the growing plant parts above the soil (dead hearts), early leaf senescence, reduced translocation, lodging and direct damage to the ears (Hordzi & Botchey, 2012). Stalk borer damage in some instances may reduce yields by 10% to 45 % (Keetch *et al*., 2005). Also, damage to cob may create conditions conducive for the development of secondary fungal infections such as *Fusarium verticillioides,* which may lead to the production of mycotoxins (Marasas *et al*., 2003). These mycotoxins may cause sicknesses such as cancer, if consumed by humans (Gianessi *et al*., 2002).

Three stalk borer species attack maize in South Africa. They are *Busseola fusca* Fuller, *Sesamia calamistis* Hampson and *Chilo partellus* Hampson (Kfir, 1998).

Busseola fusca, indigenous to Africa, was first recognised as a pest of maize in South Africa, where much of the early work on its biology and control was done (Klopper, 2008). It has also been recorded in many other parts of Africa as a pest of maize, but no reports of its occurrence has been received in places outside the continent (Klopper, 2008; Abate *et al*., 2000). It is the major pest of maize in South Africa (van Rensburg & Flett, 2010) and caused annual losses of up to 10 % of the national crop during the early part of the 20^{th} century (Mally, 1920). It is estimated that *B. fusca* can cause 100 % yield loss under certain conditions (Van Den Berg & Ebenebe, 2001). Recent losses due to *B. fusca* have been estimated to result in a 5 – 75 % yield reduction (Gouse *et al*., 2005). Its association with maize is believed to date back to 1550 AD when the crop was introduced to Africa from America (Klopper, 2008; Sobahle, 1982). It is the extension of maize cultivation in Africa that must have caused the spread of the pest to the rest of Africa including South Africa (Mally, 1920). In the Eastern Cape, whilst it was found from 28 m above sea level (a.s.l.), the pest predominated at altitudes above 800 m a.s.l (Waladde *et al*., 2001).

Chilo partellus, on the other hand has been reported to have invaded Africa from India before 1930 (Hutchison *et al*., 2007). In South Africa, the pest was first observed in 1958 in the Northern Cape Province (Van Hamburg, 1979). It is now reported to inhabit much of eastern and southern Africa and is believed to be a major pest of maize and sorghum in both regions (Hutchison *et al*., 2007). For example, in Kenya, it was observed to account for more than 80 % of stalk borers (Overholt *et al*., 1994). In South Africa, the pest is known to affect maize and sorghum plants cultivated at 1500 m a.s.l or below, (Rebe, 2002; Waladde *et al*., 2001). The estimated yield losses due to *C. partellus* on maize and sorghum in South Africa often exceed 50 % (Revington, 1986). Generally, yield losses due to the pest range from 24-36 % in maize and 2-88 % in sorghum (Overholt *et al*., 1994).

Sesamia calamistis, which although not recorded as harmful as the other stalk borers, is indigenous to Africa, and is found all over the continent especially in the sub-Saharan Africa (Kruger, 2006). In the Eastern Cape Province, similar to *B. fusca*, it was found along the coastal belt, also at medium and high altitudes (Waladde *et al*., 2001). Similarly, during a survey by Seshi-Reddy (1983) in Kenya, *S. calamistis* was found in many areas, from sea level to 1400 m above sea level. It has also been observed that it causes serious maize stand losses mostly on seedling stages of maize planted under irrigation in the North West and Limpopo Provinces (Kruger, 2006). Although, it is considered as a non-significant pest in East and Southern Africa (Overholt & Maes, 2000), data obtained by Waladde et al. (2001) in the Eastern Cape province suggested density ranges of between 0 and13 larvae/plant.

The challenge brought by stalk borer infestations affects small-scale farming as well. According to Gouse (2005), small-scale farmers from Mpumalanga, Eastern Cape, KwaZulu-Natal and Limpopo provinces reported stalk borers as the dominant insect pests in their areas of cultivation. Waladde et al. (2001), also reported that stalk borers were found to be the main problem in the Eastern Cape. Infestations were recorded to be 26 % and 75 %. A survey conducted by Sibiya et al. (2013) in

KwaZulu-Natal revealed similar results. About 70 % of farmers in the Amazizi district of the Northern Drankesburg region mentioned stalk borers as the most prevalent insects on maize in their area, while 54 % of the respondents went further to mention the insects as the most problematic.

2.4 Control of maize stalk borers in South Africa

Generally, the insect pest management research in Africa, has concentrated much on chemical control (application of insecticides), host plant resistance (control using resistant varieties), cultural practices and biological control which employs the use of predators, pathogens and parasitoids (Abate *et al*., 2000). This, according to Zethner (1995), is due to the fact that a significant amount of integrated pest management related research has been conducted by national programs and international agricultural research centres in Africa. In South Africa, there is little information on traditional methods, which include the use of local available resources such as plant extracts to control insects pests especially maize stalk borers. However, due to the adverse effects of insecticides (Hordzi & Botchey, 2012), including their ever increasing prices, the lack of success with biological control agents (Kfir *et al.*, 2002) and the resistance shown by *B fusca* to Bt-maize (van Den Berg, 2012), there is an increase on the search for alternative control methods.

2.4.1. Chemical control

The over reliance of South Africans on insecticides is illustrated by the fact that in year 2010, this country had more than 500 registered pesticides (PAN, 2010) and it was one of the four largest importers of pesticides in sub- Saharan Africa (Osbanjo *et al*., 2002). Of the insecticides registered, carbofuran, carbaryl, deltamethrin, endosulfan, trichorfon and sythentic pyrethroids are amongst those used to control maize stalk borers in South Africa (Van Rensburg & Van den Berg, 1992).

Unfortunately, insecticide sprays have been found to be effective only when used against young larvae (Moore, 1993). Once older larvae penetrate the stalks or get inside the whorl it becomes difficult to control them through insecticide sprays (van der Berg & Viljoen, 2007). Nevertheless, promising results were observed with the application of insecticide granules such as betacyfluthrin in plant whorls as soon as damage was observed (Rebe; 2002). A 25 % decrease in yield loss which was as a result of a 78 % reduction of larvae numbers in plant whorls was observed when granular insecticides were applied (Van den Berg & Van Rensberg, 1993).

Though granular insecticides may be effective inside the whorl, depending on the timing of application, they may not always be practical in large commercial farms (Van den Berg, 1997) as it is often difficult to apply them. In addition, high costs will limit their use in resource poor farming systems (Van den Berg & Rebe, 2001), especially, considering the fact that farmers may have to deal with more than one generation of these insects in one season and a challenge of mixed populations at certain altitudes (Rebe, 2002). Expenses due to chemical control can equal 56 % of the gross margin above cost for an average yield (Van Hamburg, 1979) and the cost of one spray application could amount to 28 % of the crop value (Van Rensburg & Van Hamburg, 1975). Again, exposure to chemicals may be unsafe for rural small-scale farmers due to their tendency of mixing chemicals with their bare hands, reusing empty pesticide containers for food and water storage and not knowing exactly when and where to apply the chemical (Dreves, 1996).

2.4.2. Host plant resistance

In 1997, South Africa was the first country in the continent of Africa to produce maize induced with an insect resistant bacterium, *Bacillus thuringiensis* (Bt) (Mushenje *et al*., 2011). *Bacillus thuringiensis* is a soil dwelling bacterium that produces large amounts of insecticidal δ-endotoxins (which are inactive protein toxins referred to as *Cry* proteins) when it sporulates into a resting stage (Hibeck & Andow, 2004). Bt Yellow maize containing Event MON810 was first planted during the 1998/99 maize production season (Gouse *et al*., 2006). The staple food of most of the population, Bt white maize (also containing the same gene encoding for *Cry* protein), was first planted during the 2001/02 season and its large-scale production was in the 2002/3 season (Van den Berg, 2012). It was in 2006 when South Africa started commercially releasing event Bt11 which also has the same gene that encodes for *Cry 1AB*. The main target of Bt maize are cereal stalk borer species, *B fusca* and *C. partellus* (Gouse *et al*., 2006).

The general highlight of using insect resistant maize is the increased income through savings on insecticides and labour costs, plus improved yields due to better stalk borer control (Gouse *et al*., 2005). In the case of small-scale farmers, there is also a significant reduction in labour associated with insect management when maize is cultivated (Kruger *et al*., 2012; Mushunje *et al*., 2011) and farmers have time to concentrate on other things such as weeding.

However, the high price of seeds and the fact that the farmer will have to purchase it every year may deter small-scale farmers from using Bt maize. Taking into account the point that Bt maize is only valuable in seasons when stalk borer pests are available, and damage caused is above the economic thresh-hold makes the alternative (conventional seeds or landraces) a better option to small-scale farmers. Stalk borer populations fluctuate and may differ from year to year, and to predict which year the population will be low or at a peak is difficult (Annecke & Moran, 1982).

To small-scale farmers who cannot afford the price of chemicals and as result are not spraying against insect pests such as stalk borers, Bt maize may not be the solution. It would be a waste of money in seasons when borer infestations are below the economic damage level. A study conducted by Gouse et al. (2006) revealed that small-scale farmers who had bought Bt maize seeds in KwaZulu-Natal province during a season when stalk borer numbers were low, were in a worse off financial situation compared to those who had bought less expensive conventional seeds. Again, resistance tendencies have been observed from *B. fusca* to Bt-induced maize (Kruger *et al*., 2012; Van Rensburg, 2007). Since the first dissemination of host resistant crops, there have been concerns with regard to resistance development of target pests and possible harm to the environment and humans (Gould, 1998). If resistance occurs farmers relying on Bt maize will have no choice, due to a lack of better alternatives, reverse to using broad-spectrum insecticides (Van Den Berg, 2012).

2.4.3 Cultural Control

Cultural control is among the oldest traditional practices and normally cannot be used as a tactical means for controlling stalk borers (Dent, 1991). It includes techniques such as destruction of crop residues, intercropping, crop rotation, manipulation of planting dates and tillage methods (Van den Berg *et al*., 1998). Many cultural practices are labour intensive, but they have little adverse effects on the environment and are readily available without extra investment in equipment. Although cultural control options for stalkborer management appear promising, most African farmers have not adopted them (Nwanze & Mueller, 1989). Cultural control is severely constrained by the lack of management capabilities of farmers, especially in areas where farming communities lack the support of an adequate extension service (Harris, 1989). An understanding of stalkborer behaviour and the relationships with their respective crops are important for the development of efficient cultural control (Kfir *et al*., 2002).

2.4.4. Biological control

Biological control of insects entails the use of predators, pathogens and parasitoids to control insect pests. Of the three biological control measures, the use of parasitoids to control maize stalk borers has received extensive research work in South Africa (Kfir, *et al*., 2002; Kfir, 1997; Kfir, 1994; Harris & Nwanze, 1992).

Parasitoids

Studies by Van Achterberg and Walker (1998), Kfir (1994), Zwart (1998), Polaszek et al. (1998) indicated that many parasitoid species occur on maize and sorghum stalk borers in South Africa. Thirteen different species of natural enemies were found from *C. partellus* and *B. fusca* in the former Transvaal area (now includes some parts of Gauteng and Mpumalanga Provinces) (Kfir, 1990). Eighteen parasitoid species were recorded from *B. fusca* infesting maize and grain sorghum in the Highveld region of South Africa and some parts of KwaZulu-Natal Province (Kfir, 1995). *Cotesia seamiae* (Cameron) (Hymenoptera: Braconidae), along with two pupal parasitoids, *Dentichasmias busseolae* (Heinrich) Hymnenoptera: Ichuemonidae) and *Procerochasmias nigromaculatus* (Cameron) (Hymenoptera: Ichuemonidae) were reared from pupa of *C. partellus* and *B. fusca* respectively in the Eastern Cape Province (Waladde *et al*., 2001). Total parasitism in the Eastern Cape Province was recorded between 12 % and 17 % (Waladde *et al*., 2001), larval parasitism of *B. fusca* in Delmas, KwaZulu-Natal Province fluctuated below 20 % and occasionally peaked between 40 % and 60 % and 80 % to 100 % of pupal parasitism of *B. fusca* was observed at Cedara in KwaZulu-Natal Province (Kfir, 1995).

However, the activity of these parasitoids has not been enough to inhibit an economically significant damage by stalk borers and could not avert the dispersal and subsequent wide distribution of *C. partellus* after its introduction into South Africa (Kfir, 1997). This has led to an introduction of several other natural enemies from countries such as the Philippines, Taiwan and Brazil (Moore, 1993). Unfortunately, close to none of those introduced natural enemies appear to have established in South Africa (Kfir *et al*., 2002) and those that had established failed to reduce targeted stalk borer populations to below the economic damage levels (Kfir, 1994). Climate compatibility has been pointed out as one of the key factors influencing the establishment of exotic parasitoids in South Africa (Conlog, 1997).

Predators

Predators such as the ants, *Dorylus helvous* (L), *Aenictus sp*., the mouse, *Mastomys natalensis* (Smith), larvae of *Astylus atromaculatus* (B) (Coleoptera: Melyridae) and larvae and adults of *Heteronychus arator* (F) have been recorded against stalk borers in South Africa (Watmough & Kfir, 1995). Similarly, ants *Tetranomorium guineense* Bernard (Hymenoptera: Formicidae) and *Pheidole megacephala* Fabricus (Hymenoptera: Formicidae) have also been reported to destroy almost 90 % of eggs and first instar larvae of *C. partellus* in Uganda (Mohyuddin & Greathead, 1970).

Pathogens

In the Highveld region of the Mpumalanga Province, a nucleopolyhedrosis virus (NPV), which was found to occur throughout the growing season and also in winter, caused mortalities during months when larval populations of *B. fusca* were at a peak (Kfir, 2000). An *Entomophthora sp*. was reported as the most common fungal pathogen of *C. partellus* in South Africa (Hoekstra and Kfir, 1997). *Nosema partelli* (W&K), a protozoa endemic to South Africa, has been recovered in field and laboratory populations of *C. partellus* (Walters & Kfir, 1993).

2.4.5 Plant extracts

The practice of using plant derivatives or botanical insecticides dates back to two millennia in ancient Egypt, China, Greece and India (Thacker, 2002). They have long been advertised as attractive alternatives to synthetic chemical insecticides because botanicals reputedly pose little threat to the environment and human health (Isman, 2006). At present there are four major types of botanical products used for insect control, namely, pyrethrum, rotenone, neem and essential oils. Along with these, are three others in limited use: ryania, nicotine and sabadilla (Isman, 2006). A study conducted in 1897 in South Africa, revealed that a *Derris elliptica* Benth root extract decoction sprayed or poured over as a suspension on maize plants was able to kill maize stalk borers and grasshoppers (Ripley &

Hepburn, 1928). A similar study conducted by Adda *et al*. (2011), revealed that *Hyptis suaveolens* extract compared favourably with the mostly used insecticide in Benin in reducing *S. calamistis* densities on maize. These studies further revealed that in the context of integrated pest management, the aqueous extract of *H. suaveolens* may play a significant role in pre-harvest maize protection against stalk borers.

Again, neem derivatives have also been found effective in controlling stalk borers (Ganguli & Ganguli, 1998). Water extracts of fresh neem leaves provided a good control of maize stalk borers when applied into plant whorls in Mozambique (Segenren, 1993). Ande *et al*., (2010), revealed that moss extracts hold some promise with regards to the control of stalk borer infestations on maize. Farmers in Northern Zambia and Northern Tanzania have confirmed to using *Tephrosia spp*. juice to control maize stalk borers (Wortmann *et al*., 1998). Seeds soaked in hot water mixtures of preparations from neem seed or leaves, bark of *Balamites aegyptiaca*, leaves or roots of *Euphorbia paganorum*, *Parkia biglobosa* or cowpea pod product are reported to protect emerging seedlings from stalk borer, termite and bird damage (Abate *et al*., 2000). Chilies and hot pepper, chillies and Mexican marigold, tobacco and neem trees are some of the plants traditionally used by Kenyans to manage maize stalk borers (Kareru, 2009). Malawians, have attested to the use of, amongst others, *Tephrosia vogelil*, *Mucuna spp*, *Agave sisaina*, *Cassia spp* etc to control maize stalk borers (Phiri, 1991).

2.5 Current study

In the Eastern Cape Province of South Africa a study conducted by Odeyemi et al. (2006) revealed that small scale subsistence farmers in the province do have knowledge on indigenous control methods of pests. The authors however noted that the knowledge on these indigenous methods was being eroded especially among the young farmers due to lack of documentation. Various plants such as, *Nicotiana tabacum* L, *Roella glomerata* A.DC, *Lantana Camara* L. *Tagetes minuta* and *Aloe ferox* Mill. have been recorded as some of the plants used by small-scale farmers in the province to control insect pests (Odeyemi *et al*., 2006). Currently there are no records of which plants small-scale farmers use against maize stalk borers in the province, and no records of non-plant methods that small-scale farmers could be using to deter these pests from devouring their crops.

From literature, most subsistence farming communities possess traditional knowledge of pests that affect their crops and alternative approaches to their control (Chherty & Belbahri, 2009). The strong point to farmers' knowledge is that it is the product of frequent observation of crops during the whole cropping season, and it comprehends continuities within the diverse landscape (Nyirenda, *et al*., 2011). Documenting and validating this knowledge is especially useful to set a research agenda and for the basis of constructive collaboration between researchers and farmers (Van Melle *et al*., 2001). An understanding of traditional knowledge and practices may give an insight and understanding of local resources, different ways of controlling pests as well as the ecological knowledge of local communities (Nyirenda, *et al*., 2011). Furthermore, extrapolations from indigenous traditional practices have uncovered plant chemicals that are useful in pest management today, for example, azadirachtin (neem) rotenone (from Derris spp) and pyrethrum (Taylor, 2005).

2.6 The aim and objectives of this study

The study is aimed at identifying and documenting plants and other none plant materials used by subsistence maize farmers for the control of *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae) and *Chilo partellus* Swinhoe (Lepidoptera: Crambidae) and *Sesamia calamistis* (Lepidoptera:) Hampson in the Eastern Cape , South Africa.

Specific objectives are:

1. To conduct an ethnobotanical survey of plant species used for the management of stalk borers on maize in the Eastern Cape Province
2. To conduct a survey on other methods used by rural-small scale farmers to manage stalk borers on maize in the Eastern Cape Province

CHAPTER 3

MATERIALS AND METHODS

3.1 General description of the study site

The Eastern Cape Province is about 169 580 square kilometres, which is approximately 13.8 % of land in South Africa (SSA, 2011). It falls within S32°12'52, 84" and E26°24'14, 60". Apart from its semi-arid and subtropical climate in certain areas and erratic rainfall, the province is known for its diverse vegetation. It occupies an area where the biomes of South Africa converge (Rutherford & Westfall, 1994). It is home to 6 562 053 people (ECSECC, 2012), of which 86.3 % are black (SSA, 2011) and 78.84 % speak IsiXhosa as their first language (SSA, 2013). The province is largely made up of former homelands, Transkei and Ciskei, and most of its inhabitants reside in rural areas. Rural areas in South Africa are characterized by high degrees of poverty (Punt *et al*., 2005) and as a result the Eastern Cape Province is the second poorest province in the country following Limpopo (ECSECC, 2012). Illiteracy remains one of the Eastern Cape's challenges, as 10.5 % of the province's population aged 20 and above has never been to school and only 9 % has studied further than Grade 12 while most of the population (36 %) has done some secondary education (SSA, 2011). Many of Eastern Cape's inhabitants are involved in agricultural activities, and most small-scale farmers in the province practice mixed farming which includes livestock keeping and crop production. Maize is a staple food for many rural and urban inhabitants of the province.

3.2 Study population

In this study, the population sampled were maize producing small-scale farmers residing in the rural areas of the Eastern Cape Province. Rural small-scale farmers were selected as the study population due to their linkage to agriculture activities and the fact that they are considered to be the custodians of agricultural indigenous knowledge. It is believed that they have had the opportunity to experiment with, assess and validate the knowledge.

3.3 Sampling procedures

The stratified purposive sampling technique was used in this study. It involved dividing the purposefully selected targeted population into strata with a goal of discovering elements that are similar or different across the sub-groups (Tashakkori & Teddlie, 2003). The first criterion in this study was that respondents should be maize producers. This was with the understanding that rural farming in the Eastern Cape Province includes crop production and livestock keeping. Therefore, by assistance from the Extension and Advisory Services Directorate of the Eastern Cape Department of Rural Development and Agrarian Reform, maize producing respondents were identified. Respondents were not cultivating maize only, many were also livestock keepers. The most important thing was that maize production was one of their agricultural enterprises. The target respondents were IsiXhosa speakers only. The criterion was that, in districts (Fig 1) where maize production was most prominent and respondents were IsiXhosa speakers, viz, OR Tambo and Chris Hani, three local municipalities were selected and in others Amathole were selected. In Alfred Nzo and Joe Gqabi few people were interviewed due to language constraints. No interviews were conducted in the Cacadu District due to its urban nature.

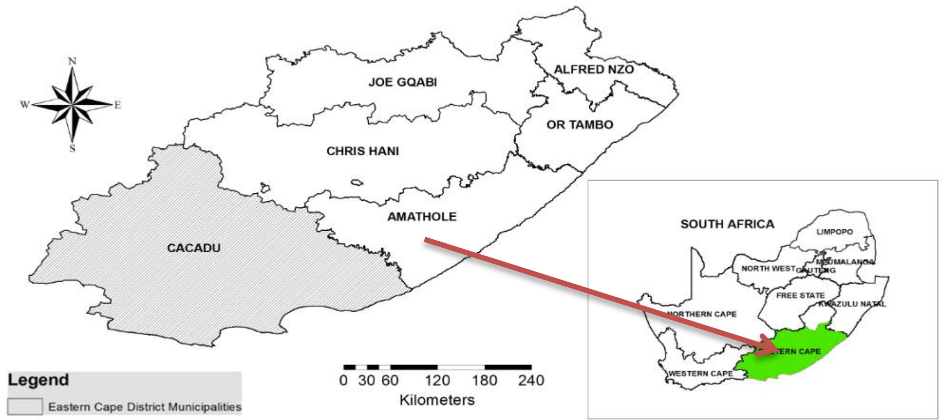

Figure 1: The geographical location of the Eastern Cape in South Africa, and the district municipalities that make-up the Province. (*Map developed by the Geo-Information Systems for Departmental Planning Directorate at the Döhne Agricultural Development Institute for the purposes of the study*).

3.3.1 Sampling of the respondents at Amathole District Municipality (ADM)

The ADM is divided into eight Local municipalities (LM). These are made up of 26 rural towns. A total of 50 respondents residing in villages were interviewed. The respondents were divided as follows: Under the Mnquma LM, 10 were from Butterworth (Ceru and Cegcuwana villages) and 10 were from Centane (Ntonjeni village), while in the Amahlathi LM, 10 were from Stutterheim (Border Post and Nomzamo) and 17 were from Kesikammahoek (Nqolonqolo, Rabula, Tshoxa, Gwiligwili, Bomvana, Bumbane and Ntsitho villages) (Fig, 2).

3.3.2 Sampling of respondents at Alfred Nzo District Municipality (ANDM)

ANDM is located on the north-eastern side of the Eastern Cape Province and is comprised of two LM (BT & DPLG, 2007). It is regarded as the most impoverished district in the province, and is probably the most under developed (SSA, 2013). It is home to IsiXhosa, Zulu and SeSotho speakers (MDDA, 2009). Only one LM (Umzimvubu) was selected and farmers interviewed were from the rural areas around the towns of Mount Ayliff (25 respondents) and Mount Frere (10 respondents) (Fig 2). Due to language barrier, there was no representation from Matatiele Local Municipality (MLM). Most residents of the MLM are SeSotho speakers (BT &DPLG, 2007).

3.3.3 Sampling of respondent at Joe Gqabi District Municipality (JGDM)

JGDM, made up of four LM, is a largely mountainous district, with an uneven and dry topography that does not support subsistence farming while most of the flat and arable land belongs to the commercial farming sector (Duma, 2010). As a result, the Joe Gqabi district is one of the 13 poorest, poverty stricken districts of South Africa (Webber, 2012). Rural people in the district speak mostly Sesotho and IsiXhosa languages. Through the help of a local extension officer, respondents from two LM, that is, Elundini (Mount Fletcher: Luzie Village) (13 respondents) and Senqu (Sterkspruit:Voyizana, Zava, Khiba, Naledi and Khoba Villages) (19 respondents) were identified and interviewed (Fig 2).

3.3.4 Sampling of respondents at Chris Hani District Municipality (CHDM)

The CHDM, a comparatively poor district, with agriculture as the main occupation is comprised of eight LM (The Water Dialogues Synthesis Report, 2009). The mostly used language in the district is IsiXhosa (94.4 %) (SSA, 2001). The CHDM is comprised of both commercial and small-scale farming systems. Agriculture is regarded as the only sector within the district economy with the potential for future development (DWA, 2011). Respondents were selected from three of the district's LM, namely Sakhisizwe (Cala: Langanci, Manz'amdaka, Ndwane, Roma Manzimahle, Cala Pass) (34 respondents), Engcobo (Engcobo) (6 respondents) and Intsika Yethu (Cofimvaba: Ncorha, Qamata, Hange and Qutsa) (13 respondents) (Fig 2).

3.3.5. Sampling of respondents at O.R. Tambo District Municipality (ORTDM)

The ORTDM is made up of five LM (ECSECC, 2012), of those LM, three were selected for the study, namely: Mhlontlo (Tsolo: Cheka and Mdibanisweni villages) with 18 respondents, Nyandeni (Libode: Elukhanyisweni village) with 12 respondents and Port Saint Johns (Port Saint Johns: Ntafufu, KwaNomvala, Kwa Gingqi, and Thombo villages) with 23 respondents (Fig, 2). The district is considered to have the richest natural resource and the most fertile areas in South Africa (McCann, 2005) such that agriculture has been identified as the sector of opportunity in the region (ORTDM, 2010). The ORTDM is comprised of seven LM, and covers some 80 % of the area previously designated as the Transkei (ORTDM, 2010). Most of the district's inhabitants are IsiXhosa speakers and reside in rural areas (SSA, 2011).

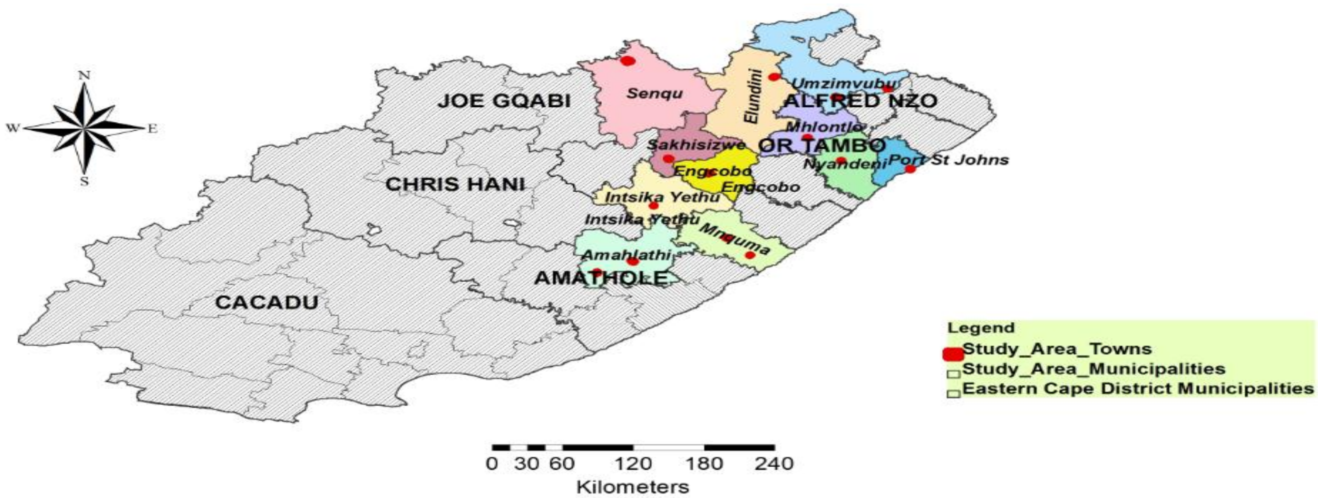

Fig 2: The geographic locations of the study towns (*Map developed by the Geo-Information Systems for Departmental Planning Directorate at the Döhne Agricultural Development Institute for the purposes of this study*).

3.4 Data Collection

Data were collected through semi structured but detailed questionnaires which were administered to respondents individually from the selected study areas. The study was conducted during the months of July to November 2012. The identification of maize producing communities and social facilitation in those communities were done in collaboration with the Extension Services Directorate (ESD) of the Eastern Cape Department of Rural Development and Agrarian Reform (EC-DRDAR). To gain access to the villages, village leaders and respondents in this study, the author sought assistance from extension officers responsible for those specific areas. This was due to the fact that rural famers tend not to respond favourably to outsiders (Mwangi, 1998). Therefore, when conducting a study or transferring a technology to them one must seek help from people they trust. In this case extension officers and village leaders were used. Through the help of extension officers respondents together with village leaders were gathered either in community halls or offices of the EC-DRDAR. Introductions and purpose of the meeting were done by the extension officer responsible for the area in collaboration with the author, and the actual administration of questionnaires was done by the author and scientific technicians working at the Döhne Agricultural Development Institute, in Stutterheim, Eastern Cape Province.

The content of the questionnaire (Appendix 1) included demographic questions which entailed queries on the participant's age, gender, education level, occupation and marital status. Furthermore, questions on crop production concentrated much on crop enterprises grown and the importance of maize in relation to the other crops. Respondents were asked to rank the crops according to the level of importance. The benefits of cultivating maize and the insect pests that affect the plant were also asked. Pest control methods employed against the insect pests and in the case of use of insecticidal plants and other methods that are not conventional, respondents were asked to indicate their source of information. Again, the people were asked to specify and describe each method used and indicate the insect pest of which it was used against. The description of method included the name of plant/plants in the case of insecticidal plants, insecticide in the case of chemical control etc. The description included preparations of insecticides, for example a participant was expected to state ratios of ingredients in cases of mixtures, amount used on plant, mode of application and where it is applied on maize to control specific pests.

Plants mentioned by respondents were collected and properly identified at the Döhne Agricultural Development Institute Herbarium, in Stutterheim and the valid plant names were confirmed using specialised literature such as Dold & Cocks (1999); Van Wyk et al. (1997) and Bromilow (1995). This is important as sometimes the same plant species could have different names depending on the district and the local language. Insects, insecticides and other substances indicated by respondents were also verified through assistance from extension officers. Where a pest, a substance or chemical could not be verified to species level, trade name or active ingredient, it is stated in the text. In instances where pest/plant/insecticide/ other substance specimens were not available at the time of interview, enumerators relied on pictures, farmer's description and knowledge of the extension officer responsible for the area. The farmers' perception and knowledge regarding the insect was also recorded. All interviews were conducted in IsiXhosa. Pre-briefing of extension officers and scientific technicians was done prior to each meeting in order to make sure that all the responsible individuals understood what was to be done.

3.4.1 Parameters measured

Demography of respondents: Although this theme does not feature in the objectives of the study, it was considered necessary to present and interpreted the data as it was believed that the background of the respondents could assist in explaining the findings from the sample of respondents who participated in this study. Demographics have therefore been described in terms of gender, age, education level, occupation, marital status of respondents participating in the current study.

Crop production: Under this topic, are results on crop enterprises grown, their ranking according to importance and farmer's reasons for producing maize

Insect pest prevention and control: Presentation is done on methods used by farmers to manage insect pests in their fields.

3.4.2 Pretesting of questionnaire

Pretesting of questionnaires gives the researcher an opportunity to identify interview items that tend to be mis-understood by the participants, which may inhibit one in obtaining the needed information (Sekaran, 2003). Pre- testing was done at Nqampu village, in Stutterheim, where five small-scale farmers were interviewed and some changes were made to the draft questionnaire, before final interviews were conducted. The pretesting helped in examining the appropriateness of the questions and the comprehension both by the farmers and the scientific technicians involved with data collection. Data was analysed using descriptive statistics.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Demography of the respondents

A total of 217 people were interviewed in different localities of the Eastern Cape Province. Out of those, 96 were males and 121 were females (Table 1). The highest number of respondents was recorded at CHDM while the least number of respondents was recorded at Joe Gqabi. This was to be expected, since CHDM, ORTDM and AMDM met all the criteria set for the study; consequently more interviews were conducted in these districts than in JHDM and ANDM where there were language constraints.

The mean age group of respondents was 59 years. The least number of respondents was recorded at ages below 35 years. The age of the respondents could have been affected by the observed tendency of people in the active working ages of 25 to 39, to migrate from rural areas to bigger towns for work purposes (Makiwane & Chimere 2003). According to the authors, most of those left behind are people who cannot participate in the formal economy due to several factors including their level of education. To confirm that, majority of the population in the study were people who had only attended grades 5-7. Very few people regarded themselves as farmers meaning most were growing maize for subsistence purposes. This confirms reports by Ortman & Machethe (2003) which state that most people in rural areas grow crops for sustenance and not to sell.

Table 1: Demography of respondents who participated in the study

Data	**Alfred Nzo**	**O.R Tambo**	**Amathole**	**Joe Gqabi**	**Chris Hani**	**Total**
Respondents	35 (16.1%)	50 (23%)	47 (21.7%)	32 (14.8%)	53 (24.4%)	217
Mean Age	56	51	63	58	66	59
Male: Female	5 (5.2%):	18 (18.8%):	24 (25%):	10 (10.4%):	39 (40.6%):	96 (44.2%):

ratio	30 (24.8%)	32 (26.5%)	23 (19%)	22 (18.2%)	14(11.8%)	121 (55.8%)
Education Level						
None	0	2 (22.2%)	5 (55.6%)	1 (11.1%)	1 (11.1%)	9 (4.1%)
Grade 1-4	3 (7.9%)	9 (23.7%)	10 (26.3%)	7 (18.4%)	9 (23.7%)	38 (17.5%)
Grade 5-7	10 (14.1%)	10 (14.1%)	17 (23.9%)	11 (15.5%)	23 (32.4%)	71 (32.7%)
Grade 8-10	13 (20%)	15 (23.1%)	11 (16.9%)	3 (1.4%)	15 (23.1%)	65 (30%)
Grade 11-12	8 (28.6%)	14 (50%)	2 (7.1%)	1 (3.6%)	3 (10.7%)	28 (12.9%)
Tertiary	1 (16.7%)	0	2 (33.3%)	1 (16.7%)	2 (33.3%)	6 (2.8%)
Occupation						
Unemployed	13 (15.1%)	26 30.2%)	18 (20.9%)	16 (18.6%)	13 (15.1%)	86 (39.6%)
Pensioner	14 (15.7%)	11 (12.4 %)	23 (25.8 %)	11 (12.4 %)	30 (33.7 %)	89 (41 %)
Farmer	7 (28 %)	7 (28 %)	4 (16 %)	3 (12 %)	5 (20 %)	25 (11.5 %)
Employed	1 (5.9 %)	6 (35.3%)	3 (17.6 %)	2 (11.8 %)	5 (29 %)	17 (7.8 %)
Marital Status						
Married	27 (15.9%)	42 (24.7%)	36 (21.2%)	24 (14.1%)	41 (24.1%)	170 (78.3%)
Widowed	6 (23.1%)	3 (11.5%)	7 (26.9%)	3 (11.5%)	7 (26.9%)	26 (12%)
Single	1 (5.6%)	4 (22.2%	4 (22.2%	5 (27.8%)	4 (22.2%	18 (8.3%)
Divorced	1 (33.3%)	1 (33.3%)	0	0	1 (33.3%)	3 (1.4%)

3.2 Crop production

Participants reported that they were producing a variety of crops (Table 2). This crop complex comprised mainly maize since it was a prerequisite crop for the study. Other crops were, cabbage (*Brassica oleracea* L.); Swiss chard (*Beta vulgaris* L.); potatoes (*Solanum tuberosum)*; beans (*Phaseolus vulgaris*); pumpkins (*Curcubita pepo* and *Cucurbita maxima*) and beetroot (*Beta vulgaris* L) etc. The crops grown by respondents are similar to crops recorded by Odeyemi et al. (2006) and Perret (2002) from other studies conducted in the province on rural farms.

Responding to the importance of maize in comparison with the other crops in a scale of 1-10, majority of the people ranked maize as number 1 (Table 3). This is consistent with the rest of the country because according to SAinfo (2014) maize is the most important crop in South Africa. The highest percentages in this regard were recorded in the ORTDM and CHDM, whilst the least percentage was recorded in ADM.

Respondents mentioned four uses of maize (Fig 3). The most cited was household use while the least was income generation. The benefits for cultivating maize as illustrated by the respondents are comparable to findings by SSA Rural Survey (2007) and Perret (2002) in studies conducted in the province. Perret (2002) recorded only 5 % of subsistence farmers who farmed for profit, while SSA Rural Survey (2007) reported only 3 % of households. Most participants in both studies were farming in order to feed their families as it was in the current study.

Amongst the pests mentioned by respondents, stalk borers (*isihlava*) (*Chilo partellus*, *Bessuola fusca and Sesamia calamistis*) were the most cited followed by cutworms (*umbundane*) (*Agrotis sp*) (Table 4). Most of the pests cited in this study have been reported by other authors in the province and in other places. For example, maize stalk borers, which have been stated by most of the participants, were previously reported as major pests of maize in the Province by Wallade et al. (2001), while cutworms were mentioned as second most important pests of maize in South Africa by Erasmus et al. (2010). African bollworms, black maize beetles and spotted maize beetles have been recounted by Bell (2005) in KwaZulu Natal Province. This confirms assertions by Atteh (1984), which state that farmers are often able to identify the pests affecting their crops, and can also rank the pests according to the degree of damage they cause to crops.

Although the people seemed to be conversant with pests of maize in their areas of cultivation, gaps in their knowledge were also noted. For example, a grasshopper (*Zonocerus variegatus*) was mistaken with a locust. Also, respondents could not differentiate between *B. fusca* and *S. calamistis*. Same as with cutworms, although participants were familiar with the insect's feeding patterns, they could not differentiate between species, even using colours.

The mis-identification of a grasshopper could have been due to the fact that the insect is not prevalent as others in the study areas. Respondents may not have had a chance to study it as they may have had with cutworms and stalk borers due to level of occurrence. The fact that the participants could not differentiate between *S. calamistis* and *B. fusca* larvae, also between the cutworm species complex is an indication that they may need training on the life cycle, life history and general biology of the pests affecting maize in their areas of cultivation. The ability to differentiate between the species involved may assist farmers to know a) When to vigilantly scout for insects in their field, b) When to apply insecticides, and c) Where to apply insecticides. Farmers will also be able to notice when the species complex has changed. For example, *C. partellus* has been observed by scientists to be displacing *B. fusca* in lower altitudes and is even competing with *B. fusca* on higher elevations (Rebe *et al*., 2004; Mbapila *et al*., 2002; Waladde *et al*., 2001; Kfir, 1997). The peak times of this insect are different from *B. fusca*'s (Rebe, 2002) and though generations may overlap sometimes; sometimes they do not. Meaning if, the representation of a certain species in the species complex is changing, this may affect the time when maize gets attacked by these pests. Information on such may assist a grower to plan the proper time of planting.

Some participants from the ANDM and ORTDM have identified the omnivorous earwigs, *F. senegalensis* as one of the pests of maize in their areas of cultivation. Scientists' opinions differ on the matter of whether this insect is a foe or a friend to crops. For example, Picker et al. (2004), advocates that these insects are scavengers that feed on rotting fruit, debris, dead insects and sometimes living insects. This means that if these insects are present on maize, they could be beneficial as predators of pests. As predators, earwigs have been recorded, against *Spodoptera frugiperda* (Smith), a pest of maize (Wyckhuys & O'Neil, 2006) and some aphids. However, the same insect was considered a pest of millet in the Sudanese-Shelian region of Niger. Even though after analysing gut content of more than 500 individuals, it was observed that arthropods were in actual fact, an important part of its diet while plants were not (Romeu-Dalmau *et al*., 2011).

Snails were also identified as pests of maize by respondents. Herbivorous garden snails feed on several kinds of fruit trees, garden plants and vegetables. Rauti & Barker (2002) and Srivastava (1992) have reported African land snail, *Achatina fulica* Bowdich and other Achatinidae as pests of maize in India. Since the snails referred to by respondents in this study were not identified scientifically, the author cannot confirm whether they are the same species reported by these authors. In the Eastern Cape, damage by snails has been recorded on agricultural crops such as cabbages and Swiss chard. (Mkize, 2003).

Table 2: Crops produced by respondents

Crops	Alfred Nzo	OR Tambo	Amathole	Joe Gqabi	Chris Hani	Total
Maize	35 (100%)	50 (100%)	47 (100%)	32 (100%)	53 (100%)	217 (100%)
Cabbage	33 (94.3%	49 (98.0%)	45 (95.8%)	31 (96.9%)	40 (75.5%)	198 (91.2%)
Spinach	32 (91.4%)	48 (96.0%)	38 (80.9%)	29 (90.6%)	33 (62.3%)	180 (83%)
Potato	31 (88.6%)	47 (94.0%)	41 (87.2%)	25 (78.1%)	39 (73.6)	183 (84.3%)
Pumpkin	24 (68.6%)	32 (64.0%)	36 (76.6%)	27 (84.4%)	39 (73.4%)	158 (72.8)
Carrot	18 (51.4%)	17 (34.0%)	13 (27.7%)	7 (21.9%)	13 (24.5%)	68 (31.3%)
Tomato	1 (2.9%)	8 (16.0%)	3 (6.4%)	3 (9.4%)	2 (3.8%)	17 (7.8%)
Peas	1 (2.9%)	2 (4.0%)	6 (12.8%)	5 (15.6%)	4 (7.6%)	18 (8.3%)
Beans	20 (57.1%)	32 (64.0%)	30 (63.8%)	19 (59.4%)	37 (69.1%)	138 (63.6%)
Beetroot	22 (62.9%)	29 (58.0%)	26 (55.3%)	18 (56.3%)	21 (39.6%)	116 (53.5%)
Onion	13 (37.1%)	20 (40.0%)	12 (25.5%)	3 (9.4%)	8 (15.1%)	56 (25.8%)
Butternut	3 (8.6%)	8 (16%)	2 (4.3%)	0	1 (1.9%)	14 (6.5%)
Green-pepper	4 (11.4%)	13 (26.0%)	5 (10.6%)	0	1 (1.9%)	23 (10.6%)
***Other**	4 (11.4%)	4 (11.4%)	6 (17.1%)	3 (8.6%)	6 (17.1%)	23 (10.6%)

**Other included crops such as wild watermelon; amadumbe; sorghum; broccoli; cauliflower; sweet potato; squash etc. The mention of these crops was very minimal.*

% per district was calculated as follow: $= \frac{\text{Total no. of people mentioning the crop}}{\text{Total no. of respondents per district}} \times 100$

Table 3 : Importance of maize in relation to the other crops

Rank	Alfred Nzo (N = 35)	OR Tambo (N = 50)	Amathole (N= 47)	Joe Gqabi (N = 32)	Chris Hani (N = 53)	Total (N = 217)
1	19 (54.3%)	36 (72%)	23 (48.9%)	19 (59.4%)	39 (73.6%)	136 (62.7%)
2	3 (8.6%)	7 (14%)	11 (23.4%)	1 (3.1%)	5 (9.4%)	27 (12.4%)
3	2 (5.7%)	4 (8%)	6 (12.8%)	4 (12.5%)	2 (3.8%)	18 (8.3%)
4	5 (14.3%)	3 (6%)	2 (4.3%)	3 (9.4%)	2 (3.8%)	15 (6.9%)
5	1 (2.9%)	0	3 (6.4%)	3 (9.4%)	1 (1.9%)	8 (3.7%)
6	4 (11.4%)	0	1 (2.1%)	0	1 (1.9%)	6 (2.8%)
7	1 (2.8%)	0	0	2 (6.3%)	1 (1.9%)	4 (1.8%)
8	0	0	0	0	0	0
9	0	0	1 (2.1%)	0	1 (1.9%)	2 (0.9%)
10	0	0	0	0	1 (1.9%)	1 (0.46%)

% was calculated as follows: $= \frac{\text{Total no. of respondents rating the crop X 100}}{\text{Total no. of respondents per district}}$

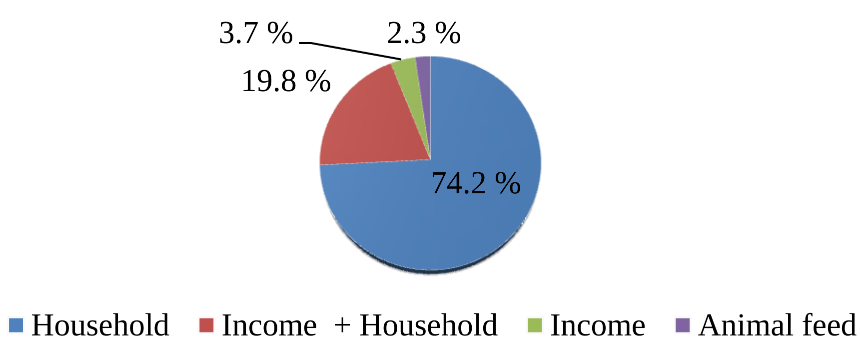

Figure 3: Maize benefits as indicated by respondents in the study

% was calculated as follow: $= \frac{\text{Total no. of people mentioning the benefit X 100}}{\text{Total no. of respondents}}$

Table 4: Insect pests of maize in the Eastern Cape Province

Insects	Joe Gqabi (N = 32)	Amathole (N = 47)	Alfred Nzo (N = 35)	OR Tambo (N = 50)	Chris Hani (N = 53)	Total (N= 217)
Stalk borer	25 (78.1 %)	35 (74. 4 %)	29 (82.8 %)	40 (80 %)	46 (86.8 %)	175 (80.6 %)
Cutworm	19 (55.3 %)	19 (40.4 %)	14 (40 %)	22 (44 %)	38 (71 %)	112 (51.6 %)
Spotted Beetle	2 (6.3 %)	2 (4.3 %)	3 (14.3 %)	4 (8 %)	5 (9.4 %)	18 (8. 3 %)
Black Beetle	1 (3.1 %)	0	0	0	0	1 (0.5 %)
Earwigs	0	0	2 (5.7 %)	7 (14 %)	0	9 (4.1 %)
A. Bollworm	0	0	1 (2. 3 %)	0	1 (1.9 %)	2 (0.9 %)
Snail	0	0	0	0	1 (1.9 %)	1 (0.5 %)
Grasshopper	1 (3.1 %)	0	0	2 (4 %)	0	3 (1.4 %)

% was calculated as follows: $\frac{\text{Total no. of respondents citing an insect pest X 100}}{\text{Total no. of respondents per district}}$

3.3 Control methods against pests of maize

Majority of people used insecticides (36 %), followed by alternative methods (34 %) and use of plant extracts (12 %). The percentage of respondents who were not controlling pests at all though they were experiencing a problem was 30 % (Table 5). The preferential use of insecticides over other control methods in the study areas is in accordance with the results of a similar study carried out by Odeyemi et al. (2006) which revealed that chemical insecticides were the predominant control method used against pests in the Province. This is contrary to findings by Balmain & Stevenson (2001) in Ghana where majority of farmers' surveyed preferred plant based products over other methods.

Overall insecticides, followed by alternative methods and nothing were cited mostly by those at ages 21 -65, while plant extracts were mostly cited by the elderly (66 years and older). This is similar to findings by Deng et al. (2009) in Kenya, where younger people preferred the use of insecticides over other methods. In that particular study, lack of knowledge on indigenous methods, their efficacy and mode of action were some of the reasons cited by famers for not using other methods. Similarly, lack of documentation, lack of trust between small-scale farmers, poor recognition of indigenous knowledge, disappearance of culture and practices are some of the factors highlighted by Lwoga (2009) which affect the adoption of indigenous and alternative methods by farmers in Tanzania.

The majority of people who mentioned the use of insecticides were in the ORTDM, while majority of alternative methods and substances were cited in the ADM. The use of plant extracts was more prevalent in the ANDM. The respondents who were using nothing though experiencing a problem were mostly recorded in the CHDM. The localized information on control methods is not unique to the population of this study as a similar finding has been reported by Kamanula et al. (2011) in a study conducted in Zambia and Northern Malawi. In that particular study, information on plants with insecticidal properties was found to be localised. Meaning, there were localities in the same country where the knowledge on the plants was abundant and others where very few or none of the famers interviewed were knowledgeable.

The results on respondents who were not using any control method complement findings by Steyn (1988) in Peddie, Eastern Cape, where farmers were reported not to control stalk borers and cutworms on maize, although it was recommended to them. The same was also reported by Sibiya et al. (2013) in a study conducted in KwaZulu-Natal and Ogendo et al. (2003) in studies conducted in Kenya. According to Keetch et al. (2005), small-scale farmers do not control insects due to difficulty in detecting damage caused by pests; inability to predict infestations; lack of knowledge on how to scout for insects and the high costs of chemicals.

Table 5: Control methods as indicated by respondents per district

Methods	Alfred Nzo (N= 35)	OR Tambo (N= 50)	Amathole (N = 47)	Joe Gqabi (N = 32)	Chris Hani (N= 53)	Total (N= 217)
Plant extracts	8 (23 %)	3 (6 %)	3 (6.4 %)	3 (9.4 %)	8 (15.1 %)	**25 (12 %)**
Alternative	8 (23 %)	15 (30 %)	27 (57.4 %)	10 (31.3 %)	14 (26.4 %)	**74 (34 %)**
Insecticides	15 (43 %)	27 (54 %)	10 (21.3 %)	13 (41 %)	14 (26.4 %)	**79 (36 %)**
Nothing	10 (29 %)	14 (28 %)	14 (30 %)	10 (31.3 %)	17 (32.1 %)	**65 (30 %)**

% was calculated as follows: Total no. of respondents citing a control method X 100
Total no. of respondents per district

3.3.1 Plant extracts

3.3.1.1 List of plants used

A total of 21 plants were mentioned by the 12 % of the respondents who had referred to the use of insecticidal plants to control maize pests. However, the frequency of citation of the plants differed (Table 6). *Chenopodium ambrosioides* was the most used plant, followed by *Tagetes minuta*, *Aloe ferox*, *Nicotiana tabacum* and *Eriocephalus punctulatus*.

Chenopodium ambroisides which has been mentioned against stalk borers and beetles in this study, has been cited by a number of authors including Wohlenberg & Lopes da Silva (2009); Mozzonetto (2002) and Gadano et al. (2002) as a plant with insecticidal properties. The most bioactive ingredient of the plant is an essential oil ascaridole, which is a well – known caterpillar repellent substance (Gadano *et al*., 2002). Studies by Zhue et al. (2012) have revealed that the essential oil of Chinese *C. ambrosioides* and its three main ingredients (Z) – ascaridole, isoascaridole, and p-cymene were promising as potential control agents against *Blutella germanica* L. Farmers in Congo also use the plant to control pests of bean and ground nut pests. Kazembe & Nkomo (2012) have recounted its extracts as effective repellents against mosquitos.

The citation of *T. minuta*, *N. tabacum* and *A. ferox* in the study areas is representative of the Eastern Cape Province since these three plants were also reported by Odeyemi et al. (2006) in a similar study conducted in the province. According to these authors, aqueous extracts of *T. minuta* are prepared and sprayed on crops in order to control pests. Similarly respondents in the current study have stated the use of aqueous extracts of the plant, alone or mixed with other plants against stalk bores. *Tagetes minuta* has been reported to repel mosquitos, safari ants and to kill mosquito larvae (Sadia, 2013; Marudufu *et al*., 1978) and to have insecticidal and acaricidal properties (Ogendo *et al*., 2013; Tomovo *et al*., 2005). For example, ground *T. minuta* was found efficient in killing maize weevils in a study conducted by Parwada et al. (2012), while flora and foliar extracts of the plant were reported to have potential against adult Mexican bean weevils, *Zabrotes subfasciatus* (Boheman) (Weaver *et al*., 1994). According to Moyo & Masika (2013); Syoun et al. (2007) and Sarin (2004), it is the terpens in the oil of *T. minuta* that has aphicidal and insecticidal properties.

Use of aqueous extracts prepared from leaves of *N. tabacum* and in some instances leaves burnt near an infested field in order to repel insects have been reported by Odeyemi et al. (2006) in the Eastern Cape. In the current study, respondents did not only cite extracts from leaves, there were also instances where the whole plant was used, alone or with other plants against stalk borers. These findings expand on information already available on farmers' knowledge regarding the insecticidal activities of this plant. *Nicotiana tabacum*'s insecticidal activity is associated with a respiratory poisoning property attributed to the active ingredient nicotine (Stoll, 1988). The Institute for Zero Waste in Africa (IZWA) (2010) has also identified that *N. tabacum* can control arthropod pests such as snails. However, although snails have been mentioned as pests of maize in this study, respondents did not associate the plant with the control of this pest.

Aloe ferox, stated as a multi-purpose traditional medicine with antioxidant, antimicrobial, anti-inflammatory, anti-cancer, anti-malaria and athlemintic activities (Chen *et al*., 2012), is believed to also possess insecticidal properties. For example, dichloromethane and ethanol extracts of *A. ferox* leaves exhibited the highest activity with 98 % & 86 % adult mortality respectively of *Anopheles arabiensis* in a study conducted by the SA Medical Research Council (MRC) (Mavhundza, 2014). While the IZWA (2010) listed *Aloe spp* and *A. annumm* as some of the insecticidal plants which are useful in controlling a range of insect pests including cutworms, caterpillars, aphids, termites, ants etc. Earlier reports in the Eastern Cape Province had mentioned the use of *A. ferox* ash on vegetables as a repellent against insect pests (Odeyemi *et al*., 2006). Moreover, aqueous extracts of *A. ferox* were reportedly applied on crops in order to control pests. Currently, respondents use aqueous extracts of the plant against stalk borers, while a combination of the plant with an insecticide was also used against stalk borers and cutworms.

The use of *E. punculatus* as an insecticidal plant was also cited by Samie & Nefefe (2012) in a study conducted in Lesotho, where farmers were reported to use smoke from burning the stem and leaves of the plant to control insect pests that attack stored grains and other durable commodities. However, in the current study, preparation methods were different. Leaves of *E. punculatus* were boiled together with leaves of *A. ferox* in water mixed with copper sulphide or the plant was mixed with animal urine and then soaked in water overnight. In some instance, respondents mentioned soaking of both leaves and stalks of the plant. The difference noted between the preparations methods in these studies could be attributed to the fact that the preparations were directed to different types of insects. It may be that for stored grain insects farmers use *E. punculuctus* as a fumigant while formulations are prepared in order to control field insects.

Most of the lesser mentioned plants in this study have also been reported to possess insecticidal properties by a number of writers. For example, *A. cepa* has been described as insecticidal against *S.*

zeamias (Adedire & Ajayi, 1996) and this activity was attributed to a fumigant mode of action (Inyang & Emosairue, 2005). While, extracts from *P. viridiflorum* caused more than 50 % mortality on *A. arabiensis* in study conducted by the MRC (Maharaj et al., 2011). Oils of *B. pilosa* were effective as mosquito repellents according to Kazembe & Nkomo (2012) and crude extracts of *C. rotendus* gave 80 % mortality to diamondback moth (DBM) larvae (Visetson *et al*., 2001). *Allium sativum* on the other hand repelled and inhibited feeding by the banana weevil, *C. sordidus* in a study conducted by Inyang & Emosairue (2005). *Tulbhagia violacea*, alone or with additives lowered population densities of aphids and white flies on tomato in a study conducted in the Limpopo Province of South Africa (Nzanza & Mashela, 2012*). Sonchus oleraceus* showed potential as a botanical insecticide against the storage wheat flour pest, *Tribolium castaneum* Herbst in a study conducted in Sudan (El-Kamali, 2009). Whereas *Nicotiana glauca* is amongst plants grown in mixed cropping with the main crop in order to control insect pests in Botswana (Berger, 1994). *Nicotiana glauca* has however, been listed as a category 1b invader plant in South Africa as a result of which its cultivation is prohibited (Dold & Cocks, 2000).

Some of these plants are reported in literature as medicinal plants e.g *S. giganteum* which is being used by the Zulu and Xhosa people to cure stomach ulcers (Hutchings *et al*., 1996) and *S. aculeastrum* which is used by traditional healers to cure various diseases in humans and animals (Koduru *et al*., 2006). In the Eastern Cape, *L. ocymfolia* is often used to treat epilepsy and bronchial diseases (Oyedeji & Afolayan, 2005). While *Rumex obstusifolius* is used against diarrhoea, parasitic worms and laryngitis (Bisi-Johnson *et al*., 2010). On the other hand, *A. amatymbica* due to its wide use in traditional medicine has been described as one of the threatened plants in South Africa (Dold & Cocks, 2002). While *A. afra* is used industrially in South Africa in medicines and ointments (DAFF, 2012)

The methods used for preparation of plant materials for the control of maize insect pests

The 25 respondents who had reported to use plant extracts, listed 28 preparation methods (Table 7). These were further classified into 4 main extraction practices; namely soaking, boiling, burning and mixing of ingredients. Thirteen (13) were prepared using the soaking method, followed by 11 which were prepared through mixing, 3 prepared through boiling and 2 through burning. To prepare the botanical insecticides respondents used different parts of plants which were either leaves only; leaves and stalk or bark; whole plants (includes roots/bulb, fruit or pods and flowers); roots/bulbs/cloves only; or pods only. From the 28 preparation methods, 13 were prepared using leaves only, 10 using whole plant, 4 using leaves and stalk etc.

There were fewer citations on exact quantities applied on each maize plant. Twenty three (23) of the overall preparation methods on plant extracts did not include quantities. It was only in 5 preparation methods where the use of measurements was indicated. Measurements were made using scales such as small amount, 2 tablespoons per plant, half size of spade head and half a cup.

Respondents cited 6 insecticide applicators on maize. These were spade, grass broom, bare hand, watering can and smoke. The most cited modes of application were small containers such as old baby formula tins and coke cans (15), followed by the use of watering cans (7).

Respondents mentioned whorl, whole plant, soil around the plant, whole plant and soil, leaves and entire field as points where the botanical mixtures were applied on maize plants so as to manage pests. The most cited were 17 mixtures applied on the whole plant, followed by 7 applied on the whorl.

The main target insect pests of these botanical insecticides were the maize stalk borers. Only three preparation methods were efficient in controlling other maize insect pests. Of the three, two were stated against cutworms and one able to control the black maize beetle.

The most frequently cited preparation method was the soaking in water for 7 days leaves and stalk of *Tagetes minuta* plants. This preparation method was cited 7 times at 28 % of all citations on preparation methods.

Results on intervals of application indicated a wide range, starting from once, 3 days, 5 days, 7 days to 14 day intervals. The most cited interval was once 14 days, followed by 7 day interval. The least mentioned intervals were 5 days.

The use of formulations by respondents in this study is characteristic of small scale farmers, since authors such as Sibiya et al. (2013); Kamanula et al. (2011), Lwoga (2009), Deng et al. (2009) and Agea et al. (2008) have alluded to similar activities by small scale farmers in KwaZulu-Natal, Zambia and Malawi, Tanzania, Kenya and Uganda respectively. The methodology of preparing the mixtures differed from plant to plant. In some methods the whole plant or parts of the plant were soaked in water, mixed with other plants or substances such as Madubula. While in some other cases plants were crushed and dried, burnt or boiled in water. These findings are similar to those of Mugisha-Kamatenisi (2008) in a study conducted in Kenya, where farmers indicated to either use the whole plant or just a specific part of plant as it is, or crushed and sometimes dried to control insect pests.

What was apparent though in this study was the inability of participants to indicate how much of each ingredient was used in a mixture and how much of the formulation was applied on maize plants. This could have been caused by the fact that there were no standardized methods of preparing the formulations. As a result there were few participants who measured ingredients when the mixtures were prepared. Also, there was a tendency for the same formulation to have different times of preparation, different modes of application, different intervals of application and be used to control different types of pests. For example a mixture of *C. ambrosioides* plants with water was stated to control both the black maize beetle and stalk borers. While intervals of application for *N. tabacum* plants mixed with 5L of water were either 3 days or 7 days. This trend may compromise the efficacy of the insecticide since insects differ in morphology and physiology. For example, a farmer may not get satisfactory results when using the same formulation to control stalk borer larvae which are soft bodied insects and beetles with a hard chitin. This may be due to the fact that the effect an insecticide may have on a soft bodied insect might not be the same with a hard bodied one, in particular if it is a contact insecticide and the dosages are the same. Secondly, different insect species may respond differently to the same treatment due to a number of factors such as habitat and stage of development at which the insect is in.

Participants mentioned different parts of the plant which the formulations were applied. Most of these were based on the feeding patterns of the target insect pest. Mostly for stalk borers, the mixtures were applied on the whorl, leaves, or whole plant while for cutworms mostly it was whole plant & soil and soil around the plant. This means that the respondents were aware of feeding preferences of these insects. These findings compare favourably with results obtained by Atteh (1984) in a study conducted in Nigeria, where Kabba farmers were found knowledgeable of pest bionomics amongst other things. What could not be established in the current study was whether the respondents were also aware of the life cycle of the pests, peak times and how many generations a year does the pest have? This information would influence the time when control methods were applied. An effective insecticide applied at the wrong time will fail to control the pest. Gathering from the fact that respondents could not distinguish between *B. fusca* and *S. calamistis*, or the different cutworm species prevalent in the Eastern Cape, one can safely assume that they lacked some of the vital information needed in order to be able to control pests effectively.

Table 6: Plants used for the control of maize insect pests

Family	Scientific name	Isixhosa name	Plant type	Citation
Solanaceae	*Solanum Aculeastrum* Dun.	Umthuma	Shrub	8
	Solanum giganteum Jacq.	Icuba lasendle	Shrub	8
	Nicotiana tabacum L.,	Icuba	Perennial herbaceous	28
	Nicotiana glauca Graham.	Icuba lesiXhosa elide	Shrub	4
	Capsicum annuum L.,	Ipele-pele/Upele-pele	Perennial herbaceous	8
Asteraceae	*Artemisia afra* Jacq.	Umhlonyane	Herbaceous Shrub	8
	Targetes minuta L.,	Untsangu-ntsangu/Unukayo	Annual herbaceous	44
	Bidens pilosa L.,	Umhlabangubo	Annual herbaceous	8
	Eriocephalus punculutus DC.	Isirhalarhala	Shrub	24
	Sonchus oleraceus L.,	Ihlaba	Annual herbaceous	4
Alliaceae	*Tulbhagia violacea* Harv.	Isivumba mpunzi/utswelana	Perennial herbaceous	4
	Allium sativum L.,	Igarlic	Perennial herbaceous	8
	Allium cepa L.,	Itswele	Perennial herbaceous	8
Lamiaceae	*Leonotis ocymifolia* (Burm.f.) lwarsson	Isihlungu	Shrub	8
Apiaceae	*Alepidea amatymbica* Eckl & Zeyh	Iqwili	Perennial herbaceous	16
Pittosporaceae	*Pittosporum viridiflorum* Sims	Umkhwenkwe	Tree	12
Chenopodiceae	*Chenopodium ambrosioides* L.,	Unukayo/Unukani	Perennial herbaceous	68
Cyperaceae	*Cyperus rotundus* Linn.	Ingca	Perennial sedge	4

Polygonaceae	*Rumex Obtusfolius* L.,	Idolo lenkonyane	Perennial herbaceous	8
Asphodelaceae	*Aloe ferox* Mills.	Ikhala	Succulent tree	32
Poaceae	*Tristachya leucotrix* Nees.	Inkwenkwe yolusa Amathole	Perennial grass	4

% was calculated as follows: $\frac{\textit{Total no. of respondents citing a plant X 100}}{\textit{Total no. of respondents citing plant extracts}}$

Table 7: The methods used for the preparation of plant materials for the control of maize insect pests

Preparation method	Target insect	Citation (N=25)
Tagetes minuta and *Allium cepa* plants are soaked in 20 L of water for 3 day. The aqueous extract is then applied on the whorl of the plant using a watering can on intervals of 7 or 14 days until insects are controlled.	Stalk borer	1 (4 %)
Solanum geganteum and *Atermisia afra* plants are soaked in water for 3 days. The aqueous extract is then applied on the whorl or whole plant to control stalk borers or soil around each plant to control cutworms. This is done once during the growing season for stalk borers and on a 7 day interval until insects are controlled for cutworms.	Stalkborer/ cutworms	2 (8 %)
Tagetes minuta leaves and stalks are soaked in water for 7 days. The aqueous extract is then applied on whole plant using a watering can on intervals of 14 days until insects are controlled.	Stalk borer	7 (28 %)
Eriocephalus punculutus leaves and stalk are soaked in 10 L of water for 5 days. The aqueous extract is then applied on the leaves of the plant using a grass broom once per growing season.	Stalk borer	2 (8 %)
One handful of *Nicotiana tabacum* leaves is soaked in 20 L of water for few hours. The aqueous extract is then applied on leaves of plants on 14 day intervals until insects are controlled.	Stalk borer	2 (8 %)
A sack field with *Chenopodium ambrosioides* leaves and kraal manure is soaked in water for few days. The tea extracted from that is then applied on the whole plant using a watering can on a 14 day interval until insects are controlled.	Stalk borer	3 (12 %)
Ten or more *Chenopodium ambrosiodes* plants are soaked in water for 4 days. The aqueous extract is then applied on the whole plant using a small container on intervals of 7 days until insects are controlled.	Stalk borer	3 (12 %)

Tulbhagia violacea and *Tagetes minuta* leaves are soaked in 20 L of water for few hours. The aqueous extract is then applied on the whole plant using a cup once per growing season.	Stalk borer	1 (4 %)
Eriocephalus punculutus leaves mixed with *Procavia capensis* (Rock hyrax) urine is soaked in water overnight. The extract is then applied on the whole plant using a grass broom once per growing season.	Stalk borer	1 (4 %)
Chenopodium ambrosioides leaves are soaked in water mixed with kraal manure for few days. The extract is then applied on the whole plant using a small container on intervals of 7 days until insects are controlled.	Stalk borer	3 (12 %)
Chenopodium ambrosioides leaves are soaked in water for 3 weeks in a closed container. The aqueous extract is then applied on the whole plant using a small container once per growing season.	Stalk borer	2 (8 %)
Chenopodium ambrosioides leaves are boiled in 20 L of water and soaked overnight. The aqueous extracts are then applied on the whole plant and soil around it using a small container once during the growing season.	Stalk borer	3 (12 %)
Leaves of *Eriocephalus punculutus* and *Aloe ferox* are boiled in water with copper sulphide. The aqueous extract is then applied on the leaves of the plant using a spade head on 3 or 5 day intervals until insects are controlled.	Stalk borer	3 (12 %)
Solanum aculeastrum, *Bidens pilosa* and *Cyperus rotundus* plants are boiled in water and allowed to cool. The aqueous extract is then applied on the whole plant using a watering can on intervals of 3 days until insects are controlled.	Stalk borer	1 (4 %)
Tristachya leucotrix plants are burnt in the infested field. The smoke from the fire and the smell of the burning plants repel insects away from the plants. This is done once in a growing season.	Stalk borer	1 (4 %)
Solanum Aculeastrum, *Bidens pilosa* and *Cyperus rotundus* Plants are burnt in the infested field. The ash from the plants is then applied on the whole plant using bare hands once per growing season.	Stalk borer	1 (4 %)
Dried and crushed leaves and stalk of *Alepedia amatymbica*, leaves and bark of *Leonitis ocymifolia* and *Pittosporum viridiflorum* plants are mixed together. The mixture is then applied on the whorl of the plant using a bottle once during the growing season.	Stalk borer	1 (4 %)
Dried and crushed leaves and stalk of *Alepidea amatymbica* and leaves and bark of *Leonitis ocymifolia* are mixed with water. Two tablespoon sizes of the mixture are then applied on the whorl of the plant once per	Stalk borer	1 (4 %)

growing season.		
Dried and crushed leaves of *Alepidia amatymbica* and dried and crushed bark of *Pittosporum viridiflorum* are mixed together. The mixture is then applied on the whorl of the plant using a [1]small container once per growing season.	Stalk borer	1(4 %)
Dried and crushed leaves of *Alepidia amatymbica* and dried and crushed bark of *Pittosporum viridiflorum* are mixed with water. The mixture is then applied by hand on the whorl of the plant once per growing season.	Stalk borer	1 (4 %)
Allium cepa leaves and bulbs are cut into small pieces. They then mixed with hot water and [2]Madubula. The mixture is applied on the whole plant using a watering can on 7 day intervals until insects are controlled.	Stalk borer	1 (4 %)
Chenopodium ambrosioides plants are mixed with 5 L of water. The aqueous extract is applied on whorl using a cup on 3 day intervals until insects are controlled.	Stalk borer/ Black maize beetle	2 (8 %)
Crushed *Nicotiana tabacum* leaves are mixed with 5L of water. A small amount of the aqueous extract is applied on the whole plant using a watering can on a 3 or 5 day interval until insects are controlled.	Stalk borer	4 (16 %)
Crushed *Nicotiana tabacum*, *Sonchus aleraceus* and *Nicotiana glauca* plants are mixed with water. The aqueous extract is then applied on the whole plant using a small container on a 7 or 14 day interval until insects are controlled.	Stalk borer	1 (4 %)
Crushed *Allium savitum* cloves, small pieces of *Capiscum annumm* and 1 table spoon of sunlight dishwashing liquid soap are mixed together with 2 L of water. The mixture is then applied on whole plant using a small container on a 14 day interval until insects are controlled.	Stalk borer	2 (8 %)
Crushed *Aloe ferox* leaves are mixed with water and the aqueous extract is applied on the whole plant using a watering can on a 3 or 5 day interval until insects are controlled.	Stalk borer	3 (12 %)
Crushed *Aloe ferox* leaves are mixed with Bulalazonke and water. The mixture is then applied on the whole plant using a watering can once during the growing season.	Stalk borer/ cutworm	1 (4 %)
Rumex obstisfolius leaves are mixed boiled water and sunlight bar soap. The mixture is applied on the plant using a watering can once during the growing season.	Stalk borer	2 (8 %)

[1]Small containers included tablespoons, hairspray containers, cups, baby formula tins and small bottles normally bought with brand; [2] Madubula is a household disinfectant for general use with Tar Acid as an active ingredient; [3]Bulalazonke is a dust powder insecticide with Mercaptothion as an active ingredient.

% was calculated as follows: $\frac{\text{Total no. of citations per preparation methods X 100}}{\text{Total no. of respondents citing preparation methods}}$

3.3.2 Alternative methods

3.3.2.1 List of alternative substances used

Respondents revealed 22 alternative non-plant substances including cultural methods used in rural areas to combat stalk borer and other insect pests' infestations on maize. Alternative substances were mainly Madubula; ash; lime; kraal manure; cattle dip, copper sulphate; sunlight bar, table salt (sodium chloride) and cultural methods included change of planting date and removal of infested plants.

The practice of using Madubula, a disinfectant, as an insecticide in order to control stalk borers is not unique to the population in the study areas. It was also mentioned by Sibiya et al. (2013) in a study conducted in KwaZulu – Natal Province. The use of ash on the other hand, was previously reported by Tesfaye & Gautam (2003) in Ethiopia and India and Berger (1994) in Kenya. In the current study some respondents mentioned that they applied ash, manure and lime in the whorl to deter oviposition by female stalk borers. Literature on the biology of *B. fusca* states that eggs are normally laid between the leaf sheath and stalk, after hatching the young larvae feed on the leaves in the whorl (Tefera *et al*., 2010). While for *C. partelus* females prefer the whorl for oviposition (Hutchison *et al*., 2008). According to Tesfare et al. (2010), female moths of *C. partellus* select a smooth surface for oviposition. This means by applying ash/lime/kraal manure on whorl of the plants respondents may be able to deter oviposition by *C. partellus* and also disturb feeding by neonate larvae of *B. fusca*.

Respondents are also using kraal manure as a deterrent against stalk borers and cutworms. According to Phelan et al. (1995), preliminary evidence suggests that fertilization practices can influence the relative resistance of agricultural crops to insect pests. Increasing soluble nitrogen levels in plant tissue by applying chemical fertilizers was found to decrease pest resistance. In a study conducted by Chau & Heong (2005) on rice stalk borers; there was an increased presence of pests on treatments with chemical fertiliser, while there was a decrease on those treated with manure. Also an increased occurrence of natural enemies such as spiders was observed on manure treated plots. This according to the authors is due to decrease in Total Nitrogen and Phosphorus on manure treated plants and increase in Potassium and organic Potassium. Several other studies conducted in South Africa confirm this phenomenon. Sorghum plants without fertilizers were less preferred for oviposition by *C. partellus* (Van den Berg & Van Rensburg, 1991), while a reduction in nitrogen-fertilization rate from 50 kg per hectare to 30 kg per hectare is recommended in sugarcane fields to decrease *Eldana Saccharina* (Lepidoptera:) infestations (SASA, 1994). An increase in the survival of *S. calamistis* larvae and acceleration in larval development with increased nitrogen content of maize was also observed (S´etamou *et al*., 1993). It must be noted though that this was never observed with *B. fusca* (Van Rensburg *et al*., 1989).

Participants also attested to the use of cattle dip as an alternative control for beetles, cutworms and stalk borers. The most commonly used dip in the Eastern Cape Province is an acaricide with 5 % m/v Deltamethrin, trading as Delete x5. Deltamethrin, according to Mehlhorn (2008), is a non-systematic fast acting insecticide and acaricide with contact and stomach action. On livestock it is used against a number of ectoparasitic species such as screw-worms, ticks and flies. The use of cattle dip to control pests of maize is not unique to respondents in this study, since according to Arnold (1928) arsenic and carbolic cattle dips were recommended in Zimbabwe for use against maize stalk borers. Also Kymac, a sheep dip with a *Derris elliptica* extract as one of the active ingredients was used in South Africa against *B. fusca* (Ripley & Hepburn, 1928). According to the WHO's (2010b) description of an illegal pesticide, it would improper for farmers to use livestock dip to control these pests. Only an insecticide registered for that purpose can be used as such.

Copper sulphate and sulphur were also mentioned by respondents. A combination of the two substances as a control for stalk borers is amongst the listed alternative methods. According to Olkowski et al. (1995), sulphur and copper are toxic to arthropods. Sulphur is mostly used against mites while copper is normally used as barrier against snails. Though snails were mentioned as pests of maize in this study, there was however no association of copper sulphate or sulphur with snails. These substances were only mentioned against caterpillars.

The use of liquid soaps, soap bars and powdered soap was also prevalently cited by participants. The soaps were either used alone or with additives such as plants or other alternative substances. A mixture of laundry soap with *T. minuta* was mentioned against aphids (*Toxoptera spp*) by small scale citrus growers in Kenya (Kilalo *et al*., 2009). The Pesticide Action Network (PAN) (2005) in Germany also listed a number of natural pesticides which included soap as one of the ingredients against insect pests of mango. As well, Mkize (2003) reported the use of soapy water to manage aphids on cabbage in the Eastern Cape. Cranshaw (2008) warned against the use of dishwashing and laundry soaps since they may be harmful to plants and might not even possess insecticidal properties. Though there are registered insecticidal soaps in many countries, Ubl and Munnerlyn (2009) discourages farmers from making-up their own insecticidal soap mixtures as these mixtures could negatively affect the same plant which the farmers seek to protect.

Petroleum products such as paraffin are also used to control maize pests. The use of petroleum oils was also mentioned in KwaZulu Natal Province by Sibiya et al. (2013). The participants in the current study use two types of petroleum oils i.e. paraffin and diesel. Paraffin is used as it is (Table 8), while diesel is mixed with a carbaryl/permethrin insecticide (Table 9). According to The Organic Farmer (2010), petroleum-based products are highly toxic to the soil such that even small amounts of these chemicals make the soil loose its natural fertility and its biological activity may not recover for many years. Of interest though, is the fact that refined petroleum paraffinic oils similar to those used in the household or automotive industry are used in agriculture to manage pests and diseases of plants. According to Bográn et al. (2006), modern petroleum-based horticultural oils are refined to standard specifications. Since they are highly refined, they have low residual activity and must be sprayed directly on the insect.

Respondents also use table salt to make the plant taste bitter to target insect pests. The use of table salt to control insects in the study areas corresponds with the use of inert dusts of common salt, wood ash and lime by entomologists so as to control insect pests of stored grain at rates of more than 10 grams per kilogram of grain (Banks & Fields 1995; Golob, 1997). Also, it relates with the use of a saturated solution of salt to preserve, repel insects and mites and inhibit development of bacteria and fungi on meat and fish cited by Hill (2002). Though, all the scenarios mentioned above were not on field insects, they give insight on the interactions of sodium chloride with insects. Sodium chloride kills arthropods by removing or absorbing the epicuticular lipid layers causing excessive water loss through the cuticle (Ebelling *et al*., 1961). Insects exposed to it are subjected to desiccating and other physiological stresses (Mahdi & Khaleguzzaman, 2006).

Similar to reports by participants, small-scale farmers in KwaZulu-Natal province and in Uganda manipulate time of planting to prevent stalk borer attacks (Sibiya *et al*., 2013; Richards, 1985). This is one of the cultural methods indicated by Kfir et al. (2002) & Abate et al. (2000) for maize stalk borer control. In this study respondents only referred to planting earlier. However, planting earlier does not always produce the desired effect. For example, in Tanzania, Swaine (1957) found that maize planted early in the season was more infested by *B. fusca* than maize sown later, while in the Highveld region of

South Africa, the second-generation population *B. fusca* is larger and can cause more damage than the first generation (Van Rensburg *et al*., 1988).

Hand picking of insects, removal of infested plants, burning of vegetation and consultation of traditional healers are some of the practices indicated by participants in this study. Similarly, they were also report by authors such as Odeyemi et al. (2006); Kfir et al. (2002); Abate et al. (2000) & Altieri (1993) from studies conducted in different regions of Africa. There were also reports of making fire in the field in order to fumigate against pests. It is believed that smoke from fire repells insects. Respondents also mentioned the use of cattle bones, meat gravy, pork fat and cooking oil. These substances, according to respondents, attract predator ants which prey on the pest as it appears on maize. Predator ants (*D. helvous*) have been recorded against stalk borers in South Africa (Hoekstra & Kfir, 1997). It must be noted though that these authors never mentioned that the ants were attracted to fat or cooking oil.

Joe Gqabi participants mentioned the rock hyrax. The people collect soil from which the hyraxes urinate and mix it with *E. panculutus* leaves in water. Use of fermented cattle and goat urine to control pests is prevalent in developing countries especially in instances where farmers cannot afford conventional methods (Tesfaye & Gautam, 2003).

The methods used for the preparation of substances for the control of maize insect pests

The 74 respondents, who cited alternative non-plant methods, mentioned 40 preparation methods (Table 8). These methods were further classified into 8 groupings. These included substances prepared through soaking, boiling, mixing, use of substances as they are etc. The most prevalent methods were prepared through mixing, followed by use of substances as they are.

Out of the 40 preparation methods, only 7 revealed quantities of mixtures applied per plant. Similar to the plant product users, most of these respondents did not measure how much of these substances are applied on the plant or soil. Different to insecticidal plant users, majority of the people who mentioned alternative methods use bare hand as a mode of application. This information reveals that though respondents were eager to control insect pests from their maize stands, they were not knowledgeable on insecticide handling. Some of the substances were mixed with insecticides; others mixed together, or used as they are. Certainly some mixtures are poisonous to be handled with bare hands.

Twenty three (23) of all preparation methods were specified against stalk borers, with 21 against cutworms, 2 against beetles and 1 against the African bollworm. Six (6) methods were reported to control more than one plant. Of these, five were stated to control stalk borers and cutworms, with one able to control cutworms, spotted beetles and stalk borers.

Again, even with alternative methods, there were inconsistences with regards to intervals at which the methods could be applied against the pests. The intervals stated included once, 7 days, 14 days and whenever one sees the insect on his maize crop. The most mentioned interval was once during a growing season.

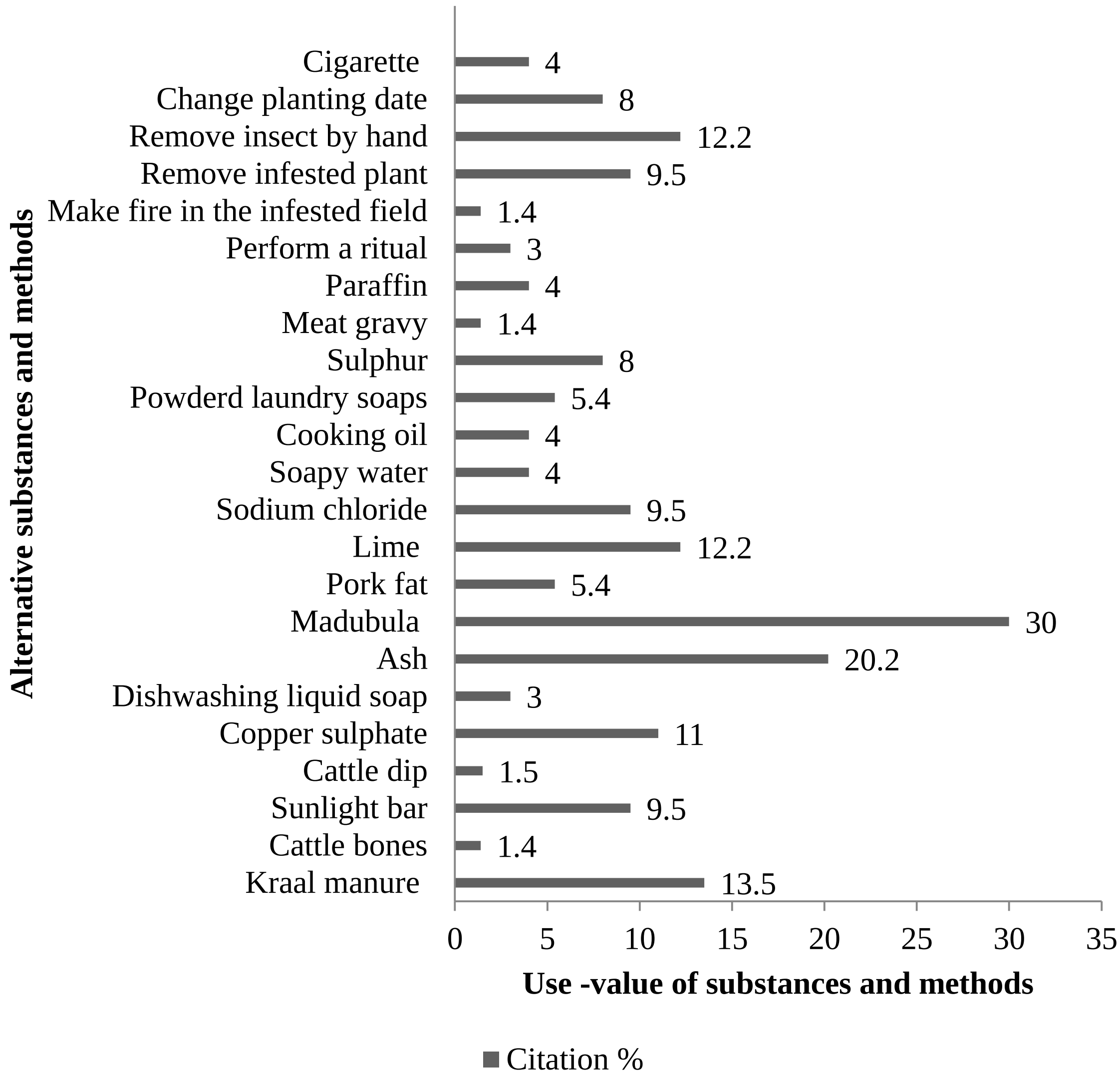

Figure 3 : Alternative substances and cultural methods used by respondents to control maize pests

Table 8: Preparation methods for alternative substance

Preparation methods	Target insect	Citation (N = 74)
Kraal manure is soaked in water for three days and the formulation is applied on the whole plant using a small container at 7 day intervals until insects are controlled.	Stalk borer	3 (4 %)
Cattle bones are boiled in water and placed the soil around the plants. These will attract predator ants which will in	Cutworm	1(1.4 %)

turn prey on cutworms. This is done once during the growing season.		
A sunlight bar soap is boiled in water until pasty and thereafter when the paste has cooled down, cigarette leftovers are added to it. This is then applied on the whole plant using a small container once during a growing season.	Stalk borer	3 (4 %)
One litre of cattle dip is mixed with 1.5 L water. The mixture is then applied on the whorl once during the growing season. Only a cup size is applied per plant.	Stalk borer	1(1.4 %)
Ten drops of cattle dip are mixed with water and then applied on the whorl using a grass broom once during the growing season.	Beetles	1(1.4 %)
Copper sulphide is mixed with water and then applied on the soil in the infested field using a grass broom on a 7 day interval until insects are controlled.	Cutworm	2 (2.7 %)
250 ml of dishwashing liquid soap is mixed with water and the applied on the soil in the infested field using a watering can on intervals of 3 days until insects are fully controlled.	Cutworm	2 (2.7 %)
One cup of ash is mixed with 10 L of water and then applied on the whole plant using a small container on intervals of 7 days until insects are controlled.	Cutworm	3 (4 %)
Three litres (3L) of Madubula are mixed with 10 L of water and then applied on the whole plant using a watering can once during a growing season.	Stalk borer	3 (4 %)
One litre (1 L) of Madubula is mixed with with 10 L of water and then applied on the whole plant using a small container once during a growing season.	Stalk borer	4 (5.4 %)
Two (2) tablespoons of Madubula are mixed with 10 L of water and then applied on the infested plant once during a growing season. Only one broom sprinkle per plant.	Stalk borer	2 (2.7 %)
Ash, pork fat, and lime are mixed with water and then applied on the whole plant by hand once during the growing season.	Stalk borer	1 (1.4 %)

Slaked lime is mixed with pork fat and then applied on the leaves and stalk of the plant by hand once during the growing season.	Cutworm	2 (2.7 %)
One (1) coke cap of cattle dip is mixed with with 25 L of water and then applied on the whole plant using a watering can once during a growing season.	Stalk borer	1 (1.4 %)
One (1) coke cap of cattle dip is mixed with 5 L of water and then applied on the whole plant using a watering can once during a growing season.	Stalk borer	1 (1.4 %)
Small amounts of Madubula are mixed with water and then applied on the whole plant and soil around it using a watering can once during a growing season	Stalk borer/ Cutworm	3 (4 %)
Ash is mixed with lime and then applied by hand on the whorl of the plant once during a growing season.	Stalk borer/ Cutworm	2 (2.7 %)
One (1) cup of sodium chloride (table salt) is mixed with 10 L of water and then applied on the whole plant and soil around it using a watering can once during a growing season.	Stalk borer/ Cutworm	2 (2.7 %)
Small amounts of cattle dip are mixed with water and then applied on the whole plant using a grass broom once during the growing season.	Stalk borer	6 (8.1 %)
Soapy water are mixed with drops of cooking oil and then applied on the whole plant and soil around on intervals of 7 days until the insect is controlled. Only one watering can sprinkle per plant.	Cutworm	3 (4%)
Ash is mixed with kraal manure and then applied by hand on the whole plant and soil and around it once during the growing season.	Cutworm	5 (6.8 %)
One litre (1 L) of Madubula is mixed with 20 L of water and then applied on the leaves of the maize plant using a small container once during a growing season.	Stalk borer	2 (2.7 %)
50 g of Surf powdered laundry soap are mixed with 50 L of water and then applied on the whole maize plant and soil around it using a small container once during a growing season. Only 20 ml of the mixture is applied per plant.	Cutworm	1 (1.4 %)

One (1) tablespoon of lime is mixed with water and then applied on the soil in the infested field using a small container on a 7 day interval until insects are controlled.	Cutworm	2 (2.7 %)
Copper sulphide is mixed with Sulphur and then applied on the whole plant by hand once during a growing season.	African bollworm	6 (8.1 %)
Meat gravy is used as is. Small amounts of it are applied on the soil in the infested field at 7 day intervals. This will attract predator ants which will in turn prey on the insects.	Cutworm	1 (1.4 %)
Pork fat is used as is. It is applied on the soil by hand once during a growing season. This will attract predator ants which will in turn prey on the insects.	Cutworm	2 (2.7 %)
Omo laundry powder soap is used as is. A handful of the soap is applied on the whole plant once during the growing season.	Stalk borer	3 (4%)
Sodium chloride is used as is. A handful of the salt is applied on the soil in the infested field whenever the insect is noticed.	Cutworm	5 (6.8 %)
Ash is used as is. A small amount of ash is applied on the maize plant and soil around the plant. For stalk borers this is applied once, while applications are on 14 day intervals until insects are controlled in the instance of cutworms.	Stalk borer/ Cutworm	4 (5.4 %)
Slaked lime is used as is. It is applied by hand on the entire field once, on 7 day or 14 day intervals until insects are controlled.	Cutworm	4 (5.4 %)
Kraal manure is used as is. It is applied on the whole plant using a small container once during a growing season.	Cutworm	2 (2.7 %)
Paraffin is used as is. A coke cap size of the substance is applied on the whorl once during a growing season.	Stalk borer	3 (4 %)
Madubula is used as is. It is applied on the whole plant using a small container once during a growing season.	Stalk borer	8 (10.8 %)
A traditional healer to perform a ritual in the field. This is done once during a growing season.	Stalk borer	2 (2.7 %)

One sunlight bar is added to irrigation water. The water with the soap inside is used to water infested plants.	Cutworm	4 (5.4 %)
Make fire in the field. The fumes will repel insects away. This is done once during a growing season.	Stalk borer	1(1.4 %)
Infested maize plants are removed from the field. The plants are removed either by hand or dugout using a spade. It depends on the age of the plant.	Stalk borer/ Cutworm	7 (9.5 %)
Infesting insects are removed by hand.	Beetles/Stalk borer/cutworm	9 (12.2 %)
Planting date of maize is changed from summer to spring.	Stalk borer	6 (8.1 %)

% was calculated as follows: Total no. of citations per preparation method X 100
Total no. of respondents citing preparation methods

3.3.3 Insecticides

List of insecticides used

Respondents mentioned 10 insecticides using their trade names and also cited an unknown chemical. For the purposes of the study, the insecticides were further classified according to their active ingredients and families (Table 9). Insecticides were further ranked according to the World Health Organisation classification of hazardous chemicals (WHO, 2010a). Two (2) were rated highly hazardous, 8 moderately hazardous and other 2 as slightly hazardous. The most frequently cited chemical ingredient was carbaryl from the carbamate family.

Four insecticides (i.e carbaryl, carbaryl/permethrin, mercaptothion and cypermethrin) mentioned in the study areas were also reported by Sibiya et al. (2013) in a study conducted in KwaZulu-Natal, as chemical insecticides used by small-scale farmers of maize to control diseases and insect pests. Similarly participants in that study also listed an unknown chemical. What was found thought-provoking in the current study was the use of DDT by participants. DDT, according to van Rensburg et al. (1978) was withdrawn from the South African market during 1973. It has only been reintroduced into

South Africa for the control of mosquitoes; however it is still banned for agricultural use (Gudorf & Huchinson, 2010). The use of a banned product by small-scale farmers was also reported by Plianbangchang et al. (2009) in Thailand, where farmers were using an endosulfan which had been banned by the Thai government since 2004.

Table 9: List of insecticides and frequency of citation

Product name	**Active ingredients**	**Chemical family**	**WHO hazard class**	**Citation (N = 79)**
Methamidophos	Methamidophos	Organophosphate	Ib[1]	4 (5 %)
Cutworm bait	Sodium flurosilicate	Fluoride	II[2]	5 (6.3 %)
Stalk borer bait	Carbaryl	Carbamate	II	17 (21. 5 %)
Blue death	Carbaryl/Permethrin	Carbamate/Pyrethroid	II/II	26 (32.9 %)
Bulalazonke	Mercaptothion	Organophosphate	III[3]	11 (13. 9 %)
Unknown	-	-	-	6 (7.6 %)
Kabardust	Carbaryl	Carbamate	II	7 (8.9 %)
Karate	Lambda-cyhalothrin	Pyrethroid	II	1 (1.3 %)
Kemprin 200 EC	Cypermethrin	Pyrethroid	Ib	3 (3. 8 %)
DDT	Dichlorodiphenyltrichloroethane	Organochloride	II	15 (19 %)
Kombat				
Á *Cutworm bait*	Sodium Fluosilicate	Fluoride	II	1 (1.3 %)
Malathion	Mercaptothion	Organophosphate	III	7 (8.9 %)
Stalk borer granules	Carbaryl	Carbamate	II	13 (16. 5 %)

[1]*Highly hazardous*, [2] *Moderately hazardous*, [3]*Highly hazardous.*

% was calculated as follows: *Total no. of citations per insecticide X 100*
Total no. respondents citing insecticides

The methods used to prepare chemical insecticides for the control of maize insect pests

Respondents mentioned 24 preparation methods which were divided into 5 preparation practices, namely: insecticides prepared through mixing of ingredients, insecticide used as it is, respondents assisted by extension officers, preparations done according to instructions on the container label and also one prepared through soaking (Table 9). Majority (14) of preparations were done through mixing. The most cited methods were the use of stalk borer bait as it is and also the use of blue death by extension officers.

Out of the 24 methods, 17 were prepared against stalk borers. Two insecticides were reported to kill more than one insect. One was stated to control both stalk borers and cutworms, with the other effective against the spotted and black maize beetles. All the insecticides mentioned by respondents were specified to be used only once per season due to lack of resources.

The handling of insecticides in the study areas was of great concern since some respondents mentioned mixing of insecticides with other insecticides or sometimes with plants or other substances. This may alter the chemical composition of the insecticide and affect its efficacy against the pest. It may even have adverse effects on human health and the environment. In some instances participants were not able to state the amount of insecticide used and in cases where measurements were done respondents used scales such as small amount or tablespoon. Only 7.7 % of the respondents indicated to read the leaflet and prepare the chemical accordingly. Most of the insecticides were prepared and applied without proper protective clothing as most people were using bare hands as insecticide applicators.

These findings are similar to reports by Plianbangchang et al. (2009), who stated that small-scale farmers in Thailand did not wear suitable personal protection, apply pesticides in an appropriate manner, or discard the waste safely. In another study conducted by Jørs et al. (2006) in Bolivia, poor knowledge on how to handle pesticides and lack of protective measures by small-scale farmers was cited. The mishandling of insecticide by the people may have a negative effect on their health. Depending on the type of insecticide, mis-use of insecticides may lead to exposure to carcinogens and suspected endocrine disrupters (Ngowi *et al*., 2007). Hayes & Laws (1991) argue that it is not enough for a farmer to use the right insecticide for the control of pests. Equally important is the correct application of the insecticide at the right time with appropriate precautions in terms of storage, preparation and application, and the cleaning of equipment.

With regards to the part of plant where the insecticide is applied, respondents mentioned mostly the whole plant, followed by whole plant and soil and then whorl. Most insecticides used against maize stalk borers are applied on the whorl due to the fact that neonate larvae of these pests spend more or less 10 days on the whorl before they start boring the stem. Farmers are generally advised to mind the time of application, since once the stalk borers get into the stalk it is hard to control them. Insecticide applications on the whole plant (which includes whorl) may be effective in controlling stalk borers; however timing of application is crucial. This needs a farmer who understands the lifecycle and biology of the pest. It however would be a wasteful expenditure to apply an insecticide meant for the whorl on the whole plant.

The once off application of insecticides makes it difficult for the farmer to have full protection of crop during the growing season. For example, in the Eastern Cape, there are three stalk borer species recorded against maize. They have different peak times and also a number of generations during the maize growing season. These generations may overlap, such that the three borer species complex can be available in the field at the same time. The farmer should be aware of these factors before deciding what to spray and when. Most probably, this is one of the reasons why some respondents reported to use more than one control method or mixed different chemicals together.

Table 10: Preparation methods for insecticides

Preparation methods	**Target insect**	**Citation (N= 79)**
DDT is mixed with cattle dip in 20 L of water and then applied on the whole plant using a watering can.	Stalk borer	2 (2.5 %)
Two litres (2 L) of Blue death is mixed with 20 L of water and then applied on the whole plant using a knapsack sprayer.	Stalk borer	2 (2.5 %)
Ten millimetres (10 ml) of Kemprin is mixed with 20 L of water and then applied on the whole plant using a knapsack sprayer.	Stalk borer	3 (4 %)
DDT is mixed with Kombat (Á Cutworm bait) and then applied on the soil in the infested field by hand.	Cutworm	2 (2.5 %)
DDT is mixed with ash and then applied on the whole plant by hand.	Stalk borer	2 (2.5 %)
Blue death is mixed with ash and then a small amount of the chemical is applied on the whole plant and soil by hand.	Cutworm	2 (2.5 %)
DDT is mixed with lime and then applied on the whole plant by hand.	Stalk borer	2 (2.5 %)
Methamidophos is mixed with water and then a small amount of it is applied on the whole plant using either a knapsack sprayer or hand.	Stalk borer	4 (5 %)
DDT and OMO are mixed with water and then applied on the whole plant using a small container.	Stalk borer	2 (2.5 %)
Small amounts of Diesel and Blue death are mixed in 20 L of water and then a small amount of the insecticide is applied on the whole plant using a watering can.	Spotted maize beetle	2 (2.5 %)
An unknown chemical is mixed with 7 L of water and then applied on the whorl using a watering can.	Stalk borer	4 (5 %)

One litre (1L) of the unknown chemical is mixed with 2L of water and then applied on the whole plant using a broom.	Stalk borer	2 (2.5 %)
Bulalazonke is mixed with water and then applied on the whole plant and soil around it by hand.	Cutworm	10 (13 %)
Stalk borer bait is used as is. A tablespoon size of the insecticide is applied on the whorl.	Stalk borer	11 (14 %)
DDTis used as is. It is appliedon the whole plant by hand.	Stalk borer	7 (8.9 %)
Kombat (Stalk borer granules) is used as is. It is applied on the whorl by hand.	Stalk borer	8 (10 %)
Kaberdust is used as is. A teaspoon size of the insecticide is applied on the leaves and soil around the plant by hand or with a teaspoon.	Stalk borer/ Cutworm	7 (9 %)
Extension officers apply blue death on the plants. We do not know how much of the insecticide is used and where it is applied on the plant.	Black maize beetle/Spotted maize beetle	11 (14 %)
Extension officers apply stalk borer bait on the plants. We do not know how much of the insecticide is used and where it is applied on the plant.	Stalk borer	6 (7.6 %)
Extension officers apply Kombat (Malathion) on the plants. We do not know how much of the insecticide is applied and where it is applied on the plant.	Earwig	8 (9 %)
Karate is prepared as per instructions on the label and then applied on the whole plant using a watering can.	Stalk borer	1 (1.3 %)
Kombat (Stalk borer granules) is prepared as per instructions on the label and then applied on the whole plant using a knapsack sprayer.	Stalk borer	3 (4 %)
Cutworm bait is prepared as per instructions on the label and then applied on the whole plant and soil around it using a knapsack sprayer.	Cutworm	5 (6.3 %)
A mixture of Kombat (Stalk borer granules) and kraal manure is soaked in water for few days and then applied on the whole plant and soil using a watering can.	Stalk borer	1 (1.3 %)

% was calculated as follows: $\frac{\textit{Total no. of citations per preparation method X 100}}{\textit{Total no. respondents citing preparation methods}}$

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

Majority of participants in the study areas were females who had attended primary education and were unemployed and/or pensioners. Very few of the respondents regarded themselves as farmers. Maize in these areas was grown for subsistence purposes and it was the most important crop. The main insect pests of maize were stalk borers, followed by cutworms as it is with the rest of the country. Participants were knowledgeable of the major pests affecting their maize and their feeding patterns. The lesser known insects were those whose occurrence was minimal on the crop.

Three types of control methods were used against the pests. These were insecticides, plant extract and alternative substances. Although majority of respondents were using insecticides, it is clear that some were supplementing insecticides with other methods as multiple responses were experienced when respondents were stating method of control. Some people were not controlling pests at all though their crop was attacked. Studying the demography of respondents, one can conclude that the lack of control was due to the fact that a) Some participants were elderly people who perhaps due to their state of health could not participate fully in crop production b) Some could not afford the high costs of insecticides as there was a large number of unemployed people in this study c) Since they could not afford insecticides, they also were not aware of other control methods d) The laborious work associated with the collection of plants and preparation of formulations may have deterred others from using plant products, e) The laborious work associated with other alternative methods, e.g. collection of kraal manure, ash etc and also the expenses associated with other substances such as diesel, cooking oil, Madubula, paraffin etc may also have been a limit to others.

Generally few respondents had knowledge on the use of plants that are used to control insect pests. Out of the 217 participants interviewed, only 25 were aware and were using them. Twenty one plants were mentioned by those respondents. Most of these plants are already listed in literature as plants with insecticidal properties, while some are recorded as medicinal plants. Majority are from the families Solanaceae and Asteraceae. Although, the most widely used plant was *C. ambrosioides*, a perennial herbaceous from family Chenopodiceae. From the findings of this study, it can be safely concluded that there is information on insecticidal plants in the rural areas of the Eastern Cape, even though it may reside with few individuals. This confirms assertions by Odeyemi et al. (2006), who stated that indigenous knowledge on plants that can be used to control insect pests is available in the Eastern Cape but is getting eroded. Continual documentation of such information can assist greatly in developing integrated pest management strategies that are specific to the farmers in these particular areas.

It may be possible that not all the plants mentioned by participants can control stalk borers or the preparation methods stated may be compromising the efficacy of the plants. For example, in a study conducted by Delohel & Malonga (1987) in Congo, it was found that out of five plants used by farmers for the control of bean and ground nut pests only one was effective. Farmers in that particular study stated the strong smell of the plants as their reason to use them as a control agent. The lack of proper measurements of ingredients and standard procedure of preparing formulations, handling and application of these plant extracts mean that research needs to be done to evaluate efficacy of plants and establish standard preparation procedures for the formulations. Once documented and researched, insecticidal plants may attract use by young people. Again, extension officers may also be able to advise farmers regarding their use.

The use of disinfectants, unrefined petroleum oils and livestock dip amongst other things, could be an indication that the people are looking for other methods other than insecticides or, they seek to supplement insecticides. However, there is little or no information on efficacy, human and environmental health effects or withholding periods of most of the substances. With some, literature already indicates that they are harmful to the environmental e.g unrefined petroleum oils such as diesel. While, there are also those substances which are already known in the scientific world to be able to control or limit stalk borer numbers on maize crops. For example the application of kraal manure, as discussed in this study and also the application of substances such as ash on the whorl to deter oviposition by female stalk borer can also be encouraged when proper research has been done.

The mis-handling of chemical insecticides by respondents gives an indication that they are not well cognisant about the effect which these chemicals may have on their health and that of the environment. This is apparently not unique to the Eastern Cape Province, since reports by other authors indicate the same in other regions of Africa. People in the study areas need training on handling of insecticides, use of protective clothing and proper ways of mixing and administering pesticides.

It is recommended that research institution with the mandate of rural and agriculture development be involved in the documentation and validation of plant based insecticides and alternative substances used by farmers to control pests of maize. According to Van Melle et al. (2001), continuous documentation of indigenous methods and validation thereof, is especially useful to set a research agenda, for developing messages for communication, planning campaign strategies and for the basis of constructive collaboration between researchers and farmers. The documentation of these methods will take them out of the local village box, and put them in the global arena where everybody can benefit from them.

Awareness campaigns in the matter of insecticide handling, protective clothing and application need to be conducted by relevant stakeholders such as government institutions mandated with such and Non – governmental organisations practising in the field of agriculture. Mishandling of chemicals and lack of protection when using them may endanger the health of the users and the extent depends on the type of chemical used. For example, organophosphates and carbamites affect the nervous system, while pyrethroids irritate the skin or eyes. Other insecticides may affect the hormone and endocrine system in the body, while some may be carcinogens (Addo-Bediako & Thanguane, 2012). Chemical mishandling does not only affect humans, it also affects the environment. The residuals left on the soil, may affect the microbial activity in the soil as a result alter soil fertility. It may even affect ground water (Moyo & Masika, 2013).

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LIST OF APPENDICES

APPENDIX 1: QUESTIONNAIRE

Indigenous knowledge questionnaire for farmers

Enumerator's name..

Personal information

Name of respondent.. Age (years)..	Date of interview... Gender………...
Occupation…………………………………………..	District………………………………………………… ……..
Village...	Sub-location...
Division………………………………………………	Ward …………………………………………………..

1. Demographic information

1.1 What is the size of the household?

Age group	**Males**	**Females**
Children (<18 years)		
Adults (>18 years)		

1.2 What is the level of education for person responsible for crop production?

1. Grade 1-4☐ 2. Grade 5-7☐ 3.Grade 8-10☐ 4.Grade 11-12☐ 5.Other (specify)☐.............

1.3 What is his/her marital status?

1. Single☐ 2.Married☐ 3.Divorced☐ 4.Widowed☐ 5.Other (specify)☐.............

1.4 How much income do you derive from the following sources?

Source	**Salaries**	**Pension**	**Child maintenance**	**Disability grant**	**Child support grant**	**Crops**
Rand per month						

1.5 Who does the farming activities within your household?

1. Father ☐ 2.Mother☐ 3. Son ☐ 4. Daughter☐ 5.Other (Specify)☐...............

2 Crop production

2.1 Which crops do you plant in your field? And what benefits do these different types of crops provide to your household?

	Type of crop	**Tick appropriate response**	**Hectares**	**Rank crops according to importance**	**Benefits**
1	Maize				
2	Cabbage				
3	Spinach				
4	Potatoes				
5	Pumpkins				
6	beans				
7	Beetroot				
8	Others (specify)				

2.2 When do you plant these crops?

	Type of crop	**Season of the year**	**Month**
1	Maize		
2	Cabbage		
3	Spinach		
4	Potatoes		
5	Pumpkins		
6	Beans		
7	Beetroot		
8	Others (specify)		

2.4 Who owns the field?

1. Father ☐ 2. Mother ☐ 3. Children ☐ 4. Other (specify)..........................

3. **Insect pest status, prevention and control**

3.1. What insect pests do you observe from the following crops?

	Crop	**Insect pest**	**To what level of infestation/%**
1	Maize		

2	Cabbage		
3	Spinach		
4	Potatoes		
5	Pumpkins		
6	beans		
7	Beetroot		
8	Others (specify)		

3.2. How do you identify insect pests?

3.3. What control measures do you use to deal with insect pest infestations?

3.3.1 If different from insect to insect, please specify and describe the control methods used for each pest?

	Crop	**Insect pest**	**Name of Plant/plants /method**	**Preparation including ratios**	**Amount used on plant**	**How is it applied on the plant**	**Where is it applied on the plant**
1	Maize						
2	Cabbage						
3	Spinach						
4	Potatoes						
5	Pumpkins						
6	Beans						
7	Beetroot						
8	Others (specify)						

3. 4 How many times after the first application is the medicine applied, at what intervals?

3. 5. Does it reduce insect population/eradicate pests on plants?

1. Yes ☐ 2. No ☐