# DIVERSITY AND INFESTATION LEVELS OF ARTHROPOD PESTS ATTACKING *Dolichos lablab (L.)*, GROWN IN MERU CENTRAL AND YATTA SUB-COUNTIES, KENYA



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## DECLARATION

This thesis is my original work and has not been presented for a degree in any other University or any other award.

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## DEDICATION

To my wife, Elizabeth, children; Pauline, Brian and Edwin, my mum Pauline and my brothers and sisters and my close friends; Stanley Ngei and Stephen Mbunzi

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## ABSTRACT

*Dolichos lablab (L.)* is one of the many crop species that are neglected and undercultivated in Kenya. This crop is different from the other grain legume crops due to the fact that its economic potential has been poorly exploited. These economic values of *D. lablab* may not be realized, due to; poor planting materials, limited genetic diversity, poor agronomic practices and arthropod pests and disease. Arthropod pests are probably the main factors limiting *D .lablab* production in Kenya. However, there is dearth of information on arthropod pests attacking *D. lablab* in Kenya. This study therefore, aimed at assesing the diversity and infestation levels of key arthropod pests infesting *D. lablab*. It was conducted Yatta and Meru Central sub-counties. In each sub-county, four irrigated and four rainfed *D. lablab* farms were randomly selected for sampling of arthropod pests. Sampling was done by using five 0.09m² (30cm by 30cm) quadrat which was randomly placed in five stations per sampling session. Arthropod pest species composition, diversity, infestation levels were analysed from each sub-county and compared between wet and dry seasons, irrigated and rain fed conditions, phenological stages of the crop and intercropping patterns. Results revealed that *D. lablab* was infestated by thirteen insect pest species and mites, dominated by *Megalurothrips sjostedti* and *Clavigralla* spp. in the both sub-counties; however diversity index was 4.5. The infestation levels of arthropod pests varied significantly between sites, seasons and irrigated and rain fed systems. The diversity index was 3.8 in both Meru and yatta in dry and wet seasons. Mean numbers of Eggs and larvae of *M. testulalis* were significantly higher (t-test) in Yatta (1.9 ± 0.3 and 5.9 ± 0.6) than Meru (0.9 ± 0.2 and 2.4 ± 0.4); the rest of the species did not vary between sites. *M. sjostedti* infestation levels in dry season (152.2 ± 20.0) was significantly higher (t-test) than wet season (73.3 ± 13.3) in Meru. *Clavigralla* spp. infestation level of nymphs and adults was significantly (t - test) higher in wet season (33.3 ± 7.8) than in dry season (6.7 ± 2.0) in Yatta. In Meru central infestation rates of *Liriomyza* spp., *Bemisia* spp. and *Aphis* spp. in wet season had medians of 2.0, 2.0 and 1.0 respectively and were significantly (Mann-whitney test) higher than dry season. In wet season infestation level of larvae of *H. amigera* was significantly higher in rain fed *D. lablab* (20.7 ± 1.4) than irrigated *D. lablab* (6.0 ± 1.2) in Meru. *M. sjostedti* infestation level in irrigated (176.2 ± 11.0) was significantly (ANOVA) higher than rain fed (117.1 ± 3.0) in Meru. Most of the arthropod pests started infestation at the vegetative and flower budding and levels increased in flowering and podding stages. In dry season, *Bemisia* spp. and *Liriomyza* spp. infestation levels were significantly (ANOVA) higher in irrigated *D. lablab* grown alone compared to the rest of the cropping patterns in both Meru and Yatta. *M. sjostedti* infestation level in irrigated *D. lablab* grown with bananas (176.2 ± 11.1) was significantly (ANOVA) higher than rest of the intercropping patterns in dry season. *Clavigralla* spp. nymphs and adults infestation level in rain fed *D. lablab* grown with bananas (54.2 ± 6.1) was significantly (ANOVA) higher the rest of the intercropping patterns in wet season. From the study it can be concluded that location, seasonality, irrigation and rain fed conditions and phenology of the crop significantly affects, infestation level of arthropod pests species, though not all species are affected by these factors.The results of this study provides basic information on arthropod pests attacking *D. lablab* during wet and dry seasons, in irrigated (vegetable type) and rain fed (grain type), at different phenological stages and different cropping patterns. The information obtained will form an important basis for further research work in trying to look for appropriate control measures of these arthropod pests of *D. lablab*.

# CHAPTER ONE
# INTRODUCTION

## 1.1 Background information

*Dolichos lablab* (L.) is also known as *Lablab purpureus* (L.). It is in the family leguminoseae and sub family papilionodeae. *Dolichos lablab* (L.) is commonly known as black bean or hyacinth bean. In Africa, *D. lablab* is grown in Egypt, Sudan, and both East and West Africa. Outside Africa, it is widely grown in South Asia, Southeast Asia, Central America and tropical zones of South America. It is a neglected and undercultivated legume crop in Kenya and other parts of the world (Williams and Haq, 2002). Neglected and undercultivated crops are those species grown in local production systems, where they are highly adapted to a range of ecological niches and are highly underdeveloped due to lack of formal research input (Padulosi *et al.*, 2006). This neglect places these undercultivated crops in a danger of continued genetic erosion, and restricted development options by the rural poor (Williams and Haq, 2002). It should be noted that the Kenyan population is now over 40 million people; many are starving, malnourished and shackled by poverty especially those in semi arid parts of the country (Ministry of Finance and planning Kenya, 2007).

The inability to secure sufficient and quality food in these areas has led to deaths and other consequences of poor nutrition. *Dolichos lablab* is a drought resistant and highly nutritious plant and can therefore be used to solve some of the malnutrition related problems in these areas. Besides it has multiple uses which include; provision of food to both human beings and livestock, and improves soil fertility (Anonymous, 2006). It supplies considerable proportions of proteins, carbohydrates and macro-nutrients (Schaffhausen, 1963). Comparing the crude protein content of *D. lablab* and dried seeds of other common legumes, *Dolichos lablab* is

exceptionally nutritious with 20 – 28 percent crude protein (Anonymous, 2006). This makes it potentially a very promising crop to solve the problem of malnutrition prevailing in most parts of Kenya.

As food, *D. lablab* can be utilized in different ways; in India, the young pods are popular vegetables used like green beans or snow peas (Idowu, 2008). In Kenya, the grains are cooked just like any of the common legumes. The grains are boiled together with maize or better still fresh or dry grains may be boiled alone and made to stew and used as accompaniment for starchy foods, such as *Ugali* (Adeka *et al.*, 2008). In Asia the leaves are used as vegetables though they are said to be less palatable and less popular compared to cowpea leaves (Idowu, 2008). In many countries in the world, for instance, India, Malaysia, Indonesia, Philipines, Egypt and Bostwana, *D. lablab* is promoted as forage crop (Andrea *et al.*, 1999). The crop is fast growing that grazing or haymaking can begin 7 – 10 weeks after sowing and as forage; its nutritional value is comparable to alfalfa (Thomas and Samberg, 1995). *Dolichos lablab* can also be used for improving soil fertility as green manure and/or as intercrop with cereal crops (Anonymous, 2006). As a cover crop, its dense cover during dry season can protect the soils against the action of sunrays, and decreases erosion by wind and rain and can reduce weed population (Schaffhausen, 1963).

The constraints of its development and widespread cultivation like other undercultivated crops includes; lack of available knowledge on their potential to contribute to sustainable food sufficiency and food security in arid and semi-arid areas, Lack of quality seeds and arthropod pests affecting *D. lablab* (Hughes, 2008). The yield potential of locally grown

varieties is unknown while very few seed companies in Kenya are involved in research and development of *D. lablab* seeds (Kamau *et al.*, 2010). In Kenya, there is scanty information regarding the arthropod pests that are associated with *D. lablab* (Kinyua *et al.*, 2008). However, in India, production is limited by a wide range of arthropod pests, which include thrips, sucking bugs, pod borers and aphids (Thejaswi *et al.*, 2007). The information obtained from the study will form an important basis for further research work in trying to look for appropriate control measures of these arthropod pests. The ultimate goal is to reduce pest damage caused to this crop, and achieve its full economic potential in Kenya.

### 1.2 Problem statement

In Kenya, *D. lablab* is predominantly grown by small scale farmers (Ministry of Agriculture - Kenya, 2005). The main *D. lablab* producing areas are Eastern, Central and Coast regions where it's grown either as a pure stand or as an intercrop especially with maize. The grain yield of *D. lablab* on farmers' fields in Kenya is low, (range between 800 and 900kg Ha-1) compared to the yield potential of 2700-3000 Kg ha-1 (Kamau *et al.*, 2010). The low yield is attributed to use of unimproved varieties and influx of arthropod pests into the *D. lablab* crop (Kinyua *et al.*, 2008). The major constraint to development and widespread production of *Dolichos lablab* in Kenya is paucity of knowledge regarding its arthropod pests, its potential as human and livestock food, soil improvement and contribution to agro-biodiversity (Kinyua *et al.*, 2008). This is a common problem with all undercultivated crops (Williams and Haq, 2002). The apparent importance of *D. lablab* is low due to perceived low economic importance among communities growing it and therefore it has been often neglected in research and development priorities. The few farmers growing this crop have had decreasing

levels of attainable yields due to arthropod pests which may not be well known to farmers. As a result of this, there is tendency to replace *D. lablab* with other species of legume crops like common beans and French beans which may not be able to withstand the harsh environmental conditions (semi arid production conditions) where *D. lablab* would do well (Ministry of Agriculture – Kenya, 2005). These legume crops which tend to replace *D. lablab* are given to farmers with important information regarding arthropod pests and diseases during their production (Adeka *et al.*, 2008).

### 1.3 Justification

*Dolichos lablab* can easily adapt to harsh environments brought about by degradation of arable land and scarce water resources. This crop can therefore be grown under poor soil conditions in marginal areas of Kenya, such as; hilly, drought prone or saline areas (Anonymous, 2006). It has multiple uses which include; provision of food to both human beings and livestock, and improves soil fertility (Anonymous, 2006). It supplies considerable proportions of proteins, carbohydrates and macro-nutrients (Schaffhausen, 1963). The most serious threat to the environment is climate change, particularly reduced rainfall which impact negatively on agriculture production and consequently affects the world food supply. Increased erratic rainfall patterns and unpredictably high and low temperature spells will consequently reduce crop productivity (Hughes, 2008). Therefore food security in Kenya like any other country affected by climate change will be at risk unless measures are undertaken to mitigate or adapt to the effects of climate change. These variations in the environmental and geographical conditions (dry and wet seasons) can be considered as main factors in the incidence and infestation levels of arthropod pests and diseases (Zahid and Muhammed,

2005). It is therefore important to embark on study and information dissemination of arthropod pests of crops like *D. lablab* which can withstand this kind of climate change. This study provides basic information on arthropod pests affecting *D. lablab* production. The information obtained will form an important basis for further research work in trying to look for appropriate control measures of these arthropod pests to reduce damage caused to this crop, and achieve its economic potential in Kenya.

### 1.4 Research questions

(i) Which arthropod pest species are associated with *D. lablab* in Yatta and Meru central Sub-counties?

(ii) What are the differences in infestation levels of arthropod pest species attacking *D. lablab* in Meru central and Yatta sub-counties?

(iii) What is the effect of dry and wet seasons on diversity and infestation levels of arthropod pest species attacking *D. lablab* in Meru central and Yatta sub-counties?

(iv) What is the effect of irrigated (vegetable type) and rain fed (grain type) *D. lablab* on the levels of infestation of arthropod pest species in Meru central and Yatta sub-counties?

(v) What is the effect of different phenological stages on infestation levels of arthropod pest species attacking rain fed *D. lablab* in Meru central and Yatta sub-counties?

(vi) What effect do cropping patterns have on infestation levels of arthropod pest species attacking rain fed *D. lablab* in Meru central and Yatta sub-counties?

## 1.5 Hypotheses

(i) There are no differences in the species of arthropod pests associated with *D. lablab* in Meru central and Yatta sub- counties

(ii) There are no differences in the infestation levels of arthropod pest species attacking *D. lablab* in Meru central and Yatta sub-counties.

(iii) There are no differences in the diversity and infestation levels of arthropod pest species attacking *D. lablab* in dry and wet seasons.

(iv) There are no differences in the infestation levels of arthropod pest species irrigated (vegetable type) and rain fed (grain type) *D. lablab* Meru central and Yatta sub-counties.

(v) There are no differences in infestation levels of arthropod pest species attacking rain fed *D. lablab* in the different phenological stages in Meru central and Yatta sub-counties.

(vi) There are no differences in infestation levels of arthropod pest species attacking *D. lablab* in monocrop and in different cropping patterns in Meru central and Yatta sub-counties.

## 1.6 Objectives

### 1.6.1 General objective

To assess the species composition of different arthropod pest species attacking *D. lablab* and the infestation levels in Yatta and Meru central Sub-counties of Kenya.

### 1.6.2 Specific objectives

(i) To determine the species composition of different arthropod pest species infesting *D. lablab* in Meru and Yatta sub-counties.

(ii) To compare diversity and infestation levels of arthropod pest species attacking *D. lablab* in Meru central and Yatta sub-counties.

(iii) To compare diversity and infestation levels of different arthropod pest species attacking *D. lablab* during the dry and wet seasons in Meru central and Yatta sub-counties.

(iv) To investigate the effects of irrigation (vegetable type) and rain fed (grain type) conditions on infestation levels of different arthropod pest species attacking *D. lablab* in Meru and Yatta sub-counties.

(v) To assess the differences in the infestation levels of different arthropod pest species attacking rain fed *D. lablab* at different phenological stages in Meru central and Yatta sub-counties.

(vi) To compare infestation levels of different arthropod pest species attacking *D. lablab* monocrop and in different cropping patterns in Meru central and Yatta sub-counties.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Description of *Dolichos lablab*

*Dolichos lablab* (L.) (*Lablab purpureus* (L.) commonly known as hyacinth bean and pig bean belongs to the family leguminoseae. It is a vigorous trailing and herbaceous plant. The trailing varieties when trellised can climb on the stakes up to three meters high before it starts trailing horizontally over the stakes used (Aganga and Tshwenyane, 2003). The leaves are large trifoliate with the leaflets measuring 7.5- 15cm long. The dorsal side of the leaf is smooth with the underside being hairy. The petioles are long and slender (Shivanshankar, 2007).

There are over 200 genotypes that are recognized in the world, but despite the wealth of available germplasm, only a handful of registered commercial varieties are known in the countries that now cultivate the *D. lablab* (Rekhas, 2005). These are irrigated and non-irrigated (rain fed) types (Anonymous, 2006). In Kenya there are two cultivars namely; Rongai Cultivar which originally came from Kenya as CPI 16883 and much earlier-flowering cultivar, Highworth, which was introduced to Australia as CPI 20212 from southern India (Adeka *et al.*, 2008). Highworth has purple flowers and black seeds, while those of 'Rongai' are white and light brown seeds. These *D. lablab* cultivars are not well known to the farmers (Adeka *et al.*, 2008). *Dolichos lablab* is especially adapted to drought and has been reported to have better drought tolerance than common beans (*Phaseolus vulgaris*) or cowpea (*Vigna unguiculata*) (Maundu *et al.*, 1999).

## 2.2 Origin and distribution of *Dolichos lablab*

The wild forms of *D. lablab* are believed to have originated from India and were introduced into Africa from south East Asia during the eighteenth century (Andrea *et al.*, 1999). The cultivated one is known in Egypt, Sudan and both eastern and western Africa. It is also claimed that *D. lablab* originated from Africa where the only true wild materials have been collected so far (Angesa, 2006). Today this crop is grown widely in Tanzania, but has been neglected and undercultivated in Kenya (Angesa, 2006).

## 2.3 Ecological requirements of *Dolichos lablab*

*Dolichos lablab* grows in a wide range of ecological conditions. It grows in a wide range of soils, from deep sandy loams to heavy clay provided the drainage is good. It does well in soil with a pH ranging between 4.5 - 7.5, and an average rainfall of 600 – 900mm per year (Andrea *et al.*, 1999). It is a drought tolerant crop when established and can grow where rainfall is below 400mm per year. For well established lablab plant, the root system penetrate in the soil more than two meters deep, permitting growth to continue long after the rains have ended and other crops have dried (Anonymous, 2006). It is for this reason, that the crop has a long production season, providing food, fodder and soil protection long after other herbaceous plants have dried. *Dolichos lablab* can tolerate high temperatures, with average temperature ranges between $18^0$C – $30^0$C, but does not withstand frost (Andrea *et al.*, 1999). This crop is therefore suitable for arid areas and especially where global climate change has brought about long drought with high temperatures.

## 2.4 Uses of *Dolichos lablab*

The *D. lablab* plant looks somewhat like cowpea and although in the tropics the plant can persists for two to three years; it mostly acts as an annual. When grown for food, *D. lablab* is usually sown in rows either alone or mixed with crops such as maize, sorghum, potatoes and bananas (Anonymous, 2006). The growth period can vary from approximately 75 – 300 days. In India, *D. lablab* begins to bear pods approximately 60 - 65 days after sowing and continues for 90 - 100 days (Anonymous, 2006). The mature seeds are normally harvested 150 - 210 days after sowing depending on the cultivar and the season of sowing. In the same tropical climates and with good management, the plant can yield continuously for two to three years if desired (Andrea *et al.*, 1999).

The young fresh pods are popular vegetables in India, Indonesia, and the Philippines and elsewhere in the Asian tropics, where they are eaten like green beans or snow peas (Anonymous, 2006). The pods in most cases retain their tenderness until they attain full size; therefore, the seeds alone can be utilized (Adeka *et al.*, 2008). Green pods are gathered at all stages of development and tender seeds are eaten fried or cooked, and salted in the same manner as green pea. In India the dried seeds are split like lentils and used in making dhal, the major source of protein for millions of the populace (Anonymous, 2006). In Kenya it is a major source of proteins especially for the malnutritioned people in arid and semi arid areas (Adeka *et al.*, 2008). *Dolichos lablab* is valued more for the seeds than the pods. Ripe and dried seeds are consumed as split pulse, while seeds are sometimes soaked in water overnight and when germination starts, they are sun dried and stored for future use or fried with spices and used as an accompaniment with starchy foods (Shivanshankar, 2007). In Kenya the seeds

are included in the traditional kikuyu dish called *Mukimo*, a mixture of maize, beans, bananas, potatoes and green vegetables all boiled and mashed (Anonymous, 2006). The leaves are occasionally used as a vegetable, although they are said to be less palatable and less popular than those of cowpeas (Anonymous, 2006). When *D. lablab* is grown as a forage crop, it can produce high seed and biomass yields. In northern Australia trials of the variety Highworth consistently yielded over 1.5 tonnes/ha of seed as well as 5-11 tonnes/ha of forage (dry weight) with a protein content up to 22 percent (Anonymous, 2006). *Dolichos lablab* crop is also used for land restoration, as green manure, cover crop and can be incooperated into cereal cropping systems as legume leys to address soil fertility decline (Rekha and Mallapur, 2009).

**2.5 Arthropod pests of *Dolichos lablab***

*Dolichos lablab* is infested by a number of phytophagous arthropod pests, which include; pod borers, pod sucking bugs, mites and thrips (Thejaswi *et al.*, 2007). Pod borers include; *Helicoverva amigera* Hubner (Lepidoptera: Noctuidae), *Maruca testulalis* Geyer (Lepidoptera: Pyralidae) and *Adisura atkinsoni* Moore (Lepidoptera: Noctuidae). According to Thejaswi *et al.* (2007) and Shivanshankar (2007), *H. amigera* and *A. atkinsoni* bore clean circular holes on the flower buds and pods, while *M. testulalis* bore one small irregular circular hole on pods and made silk web on the flowers.

Among the common sucking bugs attacking *D. lablab* in include, *Nezara viridula* Linneus (Hemiptera: Pentatomidae) and *Clavigralla gibbosa* Spinola (Hemiptera: Coreidae) (Ahamed *et al.*, 2004; Thejaswi *et al.*, 2007; Shivanshankar, 2007). These sucking bugs are mainly

found sucking sap from the young shoots and pods, making the pods to shrink and failure of the seeds to develop. Thrips of the genus *Frankliniella* and *Megalurothrips* have also been reported to infest *D. lablab* (Rekhas, 2005). These genera are found on young leaves, flower buds, flowers and young pods. Thrips cause streaking on the shoots and pods. Severe infestation is characterized by flower and pod malformation, distortion and discoloration, while flower buds do not open but abort prematurely (Thejaswi *et al.*, 2007). Tetranychus uticae Koch has also been reported to infest *D. lablab* in Bangladesh by Najmoon *et al.* (2008). Mallikarjunappa (1989) recorded ten pod borers throughout cropping season *viz.*, *A. atkinsoni, H. armigera, Sphaenarches caffer, E. zinkenella, M. testulalis, L. boeticus, C. ptychora, M. obtusa* and *Callosobruchus theobromae*. In Uganda, during a screening of the resistance of pulse legumes to arthropod pests, *D. lablab* was found to be severely damaged by a wide range of arthropod pests which include; *Helicoverva amigera* Hubner, *Clavigralla gibbosa* Spinola and *Aphis craccivora* Koch (Kikafunda *et al.*, 2001).

In eastern and central regions of Kenya, the cowpea aphid (*Aphis craccivora*) (Homoptera: Aphididae) is one of the major economic sucking pests that attacks and damages *D. lablab* either directly and indirectly. They are usually found in the inflorescences, on tender pods and the terminal twig resulting to twisting of young pods and young shoots (Kamau *et al.*, 2010). A heavy attack on young seedlings can cause death, whereas the growth of older plants is stunted, leaves are distorted and there is delay in flowering (Rekha and Mallapur, 2007). There is paucity of information on the arthropod pests of *D. lablab* in Kenya (Kinyua *et al.*, 2008). In the African tropics, Cowpea *(Vigna unguiculata)* and pegion pea (*Cajanus cajan)* are legume crops related to *D. lablab* and are infested by such arthropod pests like;

aphids, red spider mites, whiteflies, pod and bud sucking bugs, thrips, blister beetles, pod borers, and bruchids (Reed *et al.*, 1989).

## 2.6 Seasonality of arthropod pests attacking *Dolichos lablab*

The variations in the environment and geographical conditions are the main factors in the incidence and infestation level of arthropod pests and diseases (Zahid and Muhammed, 2005). In the studies of status and seasonal dynamics of arthropod pests attacking *D. lablab*, Rekha (2005) found that the total number of thrips trapped in the wet season was higher compared with the first dry season. The seasonal abundance of *H. armigera* on *D. lablab* was studied for three seasons at Anand (Gujarat). The peak period of *H. armigera* infestation was observed from December to February and declined as the summer advanced and the pest become almost inactive during May, when high temperature prevailed (Mallikarjunappa, 1989). Lalasangi (1984) studied the seasonal incidence of *M. testulalis* and found that the insect pest peaked during the month of July, August and October. In the studies of the incidence of heteropteran bugs on *D. lablab* in Karnata, Thippeswamy and Rajagopal (1998) found that the total number of *Clavigralla* spp. in the wet season was higher compared with the dry season.

## 2.7 Effects of irrigated and rain fed conditions on arthropod pests attacking *Dolichos lablab*

*Dolichos lablab* is grown under irrigation and rain fed conditions. The vegetable type grows under irrigation while the grain type relies on rains (Anonymous, 2006). In eastern region of Kenya, the vegetative type *D. lablab* (Plate 2.1) is grown under irrigation while the grain type

relies on rains (Plate 2.2). The vegetable type is locally known as *Varole* (plate 2.1) and is a perennial type grown mainly for its young fresh pods. The vegetable type remains ever green throughout the production period as long as there is water for irrigation. The grain type is annual and mainly grown for its fresh or dry grains. It is drought resistant and remains ever green during the dry season long after other crops dried (Maundu *et al.*, 1999).

Conditions are more favorable for the proliferation of arthropod pests in warmer climates (Anonymous, 2006). In these warmer climates, irrigation is a factor in development of crop arthropod pests, and the populations levels are related to the start of irrigation (Kannan and Mohammed, 2001). The weather conditions affect the buildup of insects and the most independent mortality factors are effective regulatory mechanisms of insect numbers (Anonymous, 2006). In *D. lablab*, irrigation brings about longer growing seasons which enables arthropod pests to complete a greater number of reproductive cycles during the growing season (Kannan and Mohammed, 2001). The increase in pest infestations brings about greater use of chemical pesticides in irrigated *D. lablab*, a situation that requires further development and application of integrated pest management techniques.

Plate 2.1(a) "*Varole*" [vegetable] type of *D. lablab*

Plate 2.1(b) Vegetable type young pods

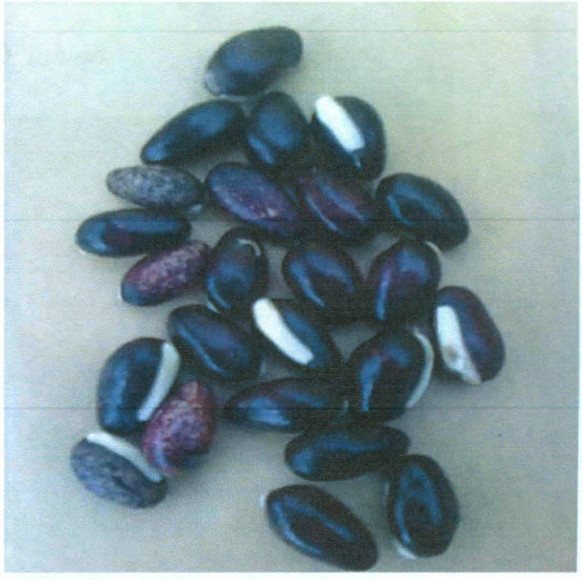

Plate 2.1(c) seeds of vegetable type

Plate 2.2(a) Grain type *D. lablab*

Plate 2.2(b) Grain type fresh pods

Plate 2.2(c) Grain type dry grains

## 2.8 Effects of cropping patterns on infestation levels of arthropod pests attacking *Dolichos lablab*

Many legumes are grown in intercrops with cereals, notably maize and sorghum (Nampala *et al.*, 2002). In India, *D. lablab* is largely grown as a mixed crop with finger millet and sorghum mainly in Kolar, Bangalore, Mandya, Mysore, Tumkur, Shimoga, Haveri, Belgaum and Hassan districts (Rekhas, 2005). However, it is also grown as pure crop under rainfed as well as irrigated conditions (Rekhas, 2005). In Kenya, *D. lablab* is sown in rows, either alone or intercropped with crops such as maize, pegion peas or bananas (Kamau *et al.*, 2010).

It has been argued that intercropping can reduce pest loads. This is not necessarily the case and depends on the intercropping species and pest complex since the micro-climate created can actually increase pest and disease problems for legumes (Jackai and Adalla, 1997). Jackai and Adalla (1997) suggest that many studies underestimate the impact of pests and diseases in intercrops because they focus on the constraints associated with only one of the two crops when overall damage levels may be comparable to mono-crops. Crops grown simultaneously enhance the infestation level of predators and parasites, which in turn prevent the build-up of arthropod pests, thus minimizing the need of using expensive and dangerous chemical insecticides (Nampala *et al.*, 2002).

It is apparent from the foregoing review that there is very scanty information in available literature on the arthropod pests associated with *D. lablab* in Kenya. Furthermore, the socio economic significance of the crop on rural livelihood in Kenya is lacking.

# CHAPTER THREE

# MATERIALS AND METHODS

## 3.1Geographical location of study sites

The study was conducted in Kithimani and Matuu locations of Yatta Sub-county ($37^{o} - 53^{1}$ E and $1^{o} - 56^{1}$ S) and Mitunguu and Makandune locations of Meru central Sub-county ($37^{o} - 30^{1}$ E and $2^{o} - 50^{1}$ S), in Eastern Province Kenya (Figure 3.1). The study was conducted under farmers' field conditions during the dry season (June 2009 to October 2009) and the wet season (November 2009 to February 2010). In these two sub-counties *D. lablab* was grown under irrigation and rain fed production systems (Appendix 1).

### 3.1.1 Yatta sub-county

Yatta sub-county lies within $37^{o} - 53^{1}$ E and $1^{o} - 56^{1}$ S in the semi- arid region of the Eastern province of Kenya. The rainfall pattern of this agro- ecological zone is bimodal with a mean annual rainfall of 600mm. (Wambugu *et al.*, 2010). The long rains occur between March and May but are not reliable. The short rains occur between October and December and are relatively more reliable. In general, the rains have been reported to be erratic and unreliable with annual average ranging between 500mm to 800mm (Wambugu *et al.*, 2010). The soils vary from sandy, sandy loams to black cotton (Kamau *et al.*, 2010).

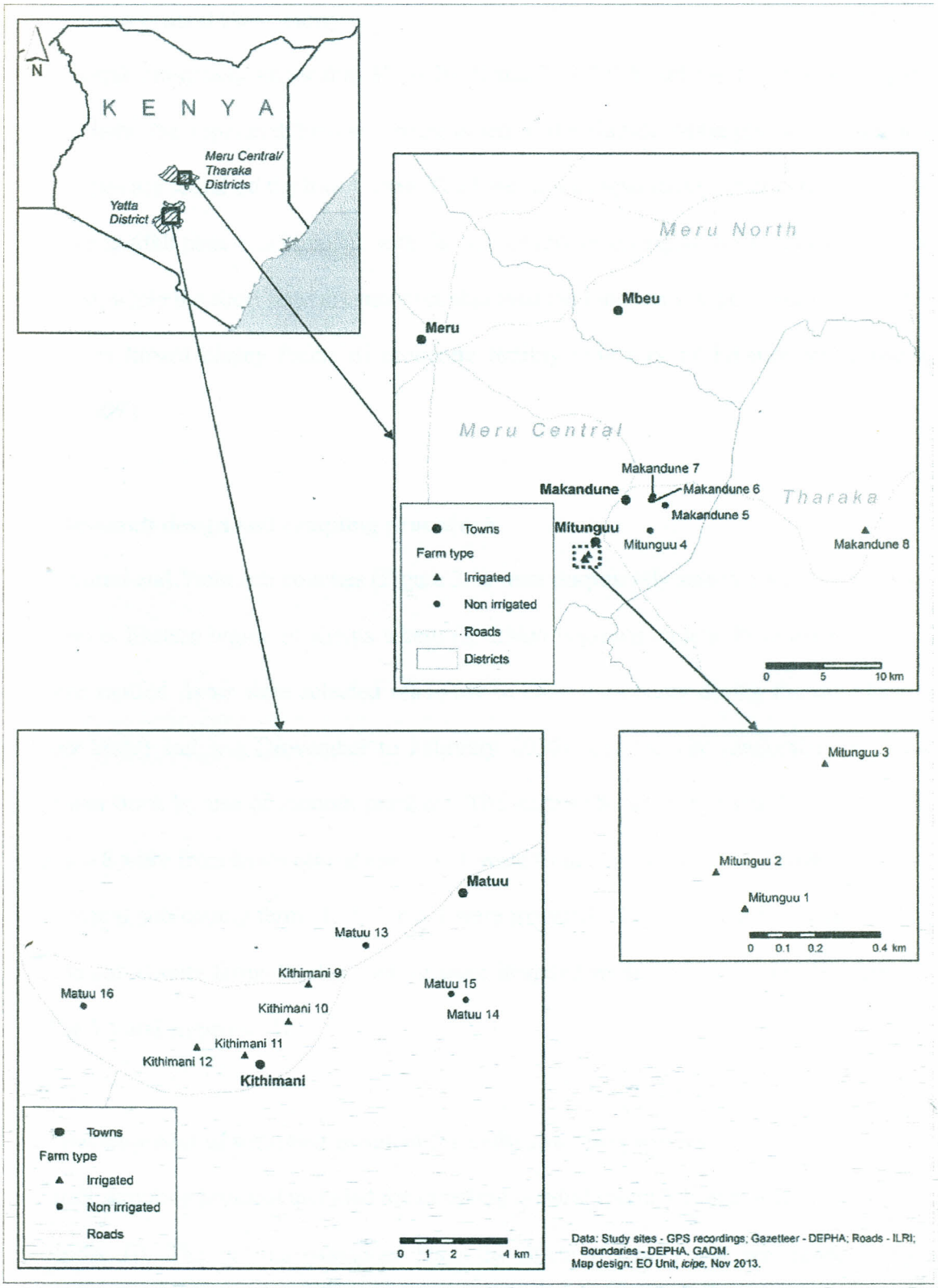


**Figure 3.1** Map of Kenya showing Meru central and Yatta Sub-counties and the study sites Sub-counties

### 3.1.2 Meru central Sub-county

Meru central sub-county lies within 37° – 30$^{1}$ E and 2° – 50$^{1}$ S and has two agro-ecological zones namely; the upper and the lower zones based on the altitude. Mitunguu and Makandune sub-counties are found on the lower zone. The latter is a comparatively drier agro- ecological zone. The rainfall pattern is bimodal, with the sub-county receiving as low rainfall as 500 mm per annum while the short rains are more reliable than the long rains (Oginosaka *et al.*, 2006). The soil is brown clayey loams of moderate fertility (Ministry of Finance and planning Kenya, 2007).

## 3.2 Research design and sampling procedure

Meru central and Yatta sub-counties (Figure 3.1) were purposively selected because these are the areas in Eastern region of Kenya where *D. lablab* is grown widely. Four irrigated farms and four rainfed farms were selected randomly in each sub-county during the dry (June to October 2009) and wet (November to February 2010) seasons. The randomization of the farms was done by use of random numbers. The sixteen farms were named 1 – 16, where farms 1 – 8 were from Meru central and 9 – 16 were from Yatta (Fig 3.1 and Appendix I). In Meru central sub-county farms 1, 2, 3 and 4 were irrigated while 4, 5, 6 and 8 were rain fed. In Yatta sub-county farms 9, 10,11and 12 were irrigated while 13, 14, 15 and 16 were rain fed (Fig 3.1 and Appendix I)

### 3.2.1 Development of sampling protocol for arthropod pest species

The draft sampling protocol included the sampling quadrat (plate 3.1) and a field record sheet (Appendix II). The quadrat measured 30cm by 30cm (0.09m$^{2}$) and was made of light

aluminum material of 1mm thick and 1cm wide in order to minimize damage to the plants when placed on the crop (Plate 3.1). The protocol was pre-tested on both sub-counties and in irrigated and rain fed *D. lablab* farms before it was adopted as indicated under plate 3.1 and appendix II.

### 3.2.2 Sampling procedure for plants and arthropod pest species

During the seedling and vegetative stages, before the twigs intertwined to form a single canopy, arthropod pests infestation levels were assessed per four plants; the four plants were randomly selected from five randomly selected points (also called stations) in each study farm on each sampling date. At the vegetative and podding stages, when the crop twigs intertwined and formed a dense canopy typical of the crop at these stages, sampling was done per unit area using a 30cm x 30cm quadrat. On each farm, five stations were randomly selected using the quadrat. From each sub-county, data on various arthropod pests' developmental stages counts and infestation or damage scores was collected. The sampling of arthropod pests was done after every two weeks, giving a total of seven sampling dates. During sampling, the crop phenology and the intercrop were recorded.

Plate 3.1 30cm by 30cm quadrat used in sampling of *D. lablab* plants

### 3.3 Estimation of populations of different arthropod pest species

Infestation levels of arthropod pests were determined by making actual counts and scoring the rate of infestation.

#### 3.3.1 Pod borers, Pod sucking bugs, flower beetles, leaf beetles and grasshoppers

The plants or plant parts of the randomly selected stations were examined for various developmental stages of pod borers. These included; eggs, small larvae (1-3 instars) and large larvae (4-6 instars). In addition the number of damaged pods was also assesed. The population of the various developmental stages of pod borers and pods damaged were

determined by making actual counts. From the same plants or plant parts were also examined for various developmental stages of sucking bugs. These included; egg masses, nymphs and adults. In addition the number of damaged pods by sucking bugs, numbers of; flower beetles, leaf beetles and grasshoppers were also assessed and their populations estimated by making actual counts. All the counts were recorded on the field record sheet (Appendix II).

### 3.3.2 Thrips

Populations of thrips was estimated by randomly selecting and picking three young leaves from the tip of a shoot, a shoot bearing two to three flowers and flower buds from the randomly selected plants within various stations. The young leaves, flowers and flower buds were placed in 30ml vials and transfered to laboratories within *icipe* in Nairobi. In the laboratory, the young leaves, flowers and the flower buds were opened and washed in 70% alcohol to extract adults and nymphs. All the thrips were then sorted out according to their characteristics, identified, counted and recorded. The thrips were then preserved in 70% alcohol for further taxonomic use e.g. molecular studies. The thrips overall damage rating was done on the farm at every randomly selected plants and stations by use of infestation scale of 1-2 (Table 3.1). The number of damaged pods by thrips through scarification and bending were counted and recorded.

### 3.3.3 Thrips, Aphids, leaf miners, spider mites and whiteflies

The assessment of populations of thrips, aphids, leaf miners, whiteflies and spider mites was carried out by use of non destructive sampling method that involved use of an infestation rating scale. Leaf miners, whiteflies and spider mites had an infestation rating scale of 1-2,

while that of aphids was 1-3 (Saika and Muniyappa, 1989) (Table 3.1). The lower surfaces of leaves of the randomly selected plants or plant parts were examined for whiteflies and spider mites and rated accordingly (Table 3.1). The inflorescence, terminal twigs and tender pods were examined for aphids and thrips and the infestation level was rated accordingly (Table 3.1). The upper surface of the leaves were examined for leave miners' feeding and oviposition punctures and the larvae feeding mines and also rated according to the scale (Table 3.1). All the ratings were recorded in the record sheet (Appendix II).

### 3.4 Determining the arthropod pest species composition attacking *Dolichos lablab*

During the sampling protocol pre-test on both sub-counties and in irrigated and rain fed *D. lablab* farms, the arthropod pest species found infesting *D. lablab* were identified on the field by the help of *icipe* taxonomists. The developmental stages of arthropod pest species which could not be identified on the field from both sites were taken to *icipe* Nairobi where they were reared on their natural diets until the adult stages emerged and identified by biosystematics department. The identification of thrips was carried out by the help of taxonomist using characteristics such as; color, the rows of setae along the veins of the fore wings, the number of antennal segments and the positioning of the pair of setae III on the imaginary triangle of the occelli (Ralph, 1998; Stiller, 2001). The frequency of occurrence of the arthropod pest species was also rated in all the sampled farms and in dry and wet seasons. The frequency of occurrence was rated at a scale of 1-5. (1- Very high frequency of occurrence; 2- High frequency of occurrence; 3- medium frequency of occurrence; 4- low frequency of occurrence and 5-No occurrence).

**Table 3.1** Infestation rating scale of thips, aphids, leaf miners, spider mites and whiteflies

| Thrips | Aphids. | Spider mites. | Leaf miners. | White flies. |
|---|---|---|---|---|
| • 0- clean<br>• 1- indicated few silvery streaks on the young shoots<br>• 2- Indicated heavy streaking on young shoots, flower buds, flowers and pods and presence of feeding nymphs and adults. | • 0- clean<br>• 1- one or two adults available on the crop<br>• 2-Many adults and nymphs but not covering the plant part.<br>• 3- Very many adults and nymphs covering the plant part. | • 0- clean<br>• 1- Few adult mites on the lower leaf surface.<br>• 2- Mottling of the leaves and presence of many adults, nymphs and eggs. | • 0- clean<br>• 1- Few feeding and oviposition punctures.<br>• 2- Many punctures and mines on leaves. | • 0- clean<br>• 1- One or two adults.<br>• 2- Many adults, nymphs, eggs and honey dew on the upper leave surface. |

### 3.5 Comparing diversity and infestation levels of arthropod pest species attacking *Dolichos lablab* in Meru central and Yatta sub-counties

Meru central and Yatta sub-counties were purposively selected because these are the areas in Eastern region of Kenya where *D. lablab* is grown widely. Eight farms were randomly sampled from each sub-county. From the sixteen randomly selected farms as described in section 3.2, the infestation levels of the arthropod pest species were estimated as described in section 3.3 in two cropping seasons (dry and wet seasons). The infestation levels of arthropod pest species were used to determine the diversity index.

### 3.6 Comparing diversity and infestation levels of arthropod pest species attacking *Dolichos lablab* during the dry and wet seasons

Sampling of the arthropod pests was done during the dry (June to October 2009) and wet (November to February 2010) seasons. From the sixteen randomly selected farms as described in section 3.2, the infestation levels were estimated as described in section 3.3 and recorded on the record sheet (Appendix II). The infestation levels of arthropod pest species were used to determine the diversity index.

### 3.7 Investigating the effects of irrigation (vegetable type) and rain fed (grain type) conditions on infestation levels of arthropod pest species attacking *Dolichos lablab*

There were two types of *D. lablab* grown in the two sub-counties. These were the vegetable type (a perennial form) and the grain type (an annual form). As regards the irrigated *D. lablab* (vegetable type), insecticides were used to control the arthropod pests but for the grain type, farmers did not use insecticides. Four irrigated farms and four rainfed farms were selected

randomly in each sub-county during the dry (June to October 2009) and wet (November to February 2010) seasons. The randomization of the farms was done by use of random numbers. From these farms, sampling of the plants or the plant parts and various arthropod pests was done as described in section 3.2.2. The infestation levels and rates of the arthropod pests were estimated as described in section 3.3 and recorded on the record sheet (Appendix II).

### 3.8 Assessing the differences in the infestation levels of arthropod pest species attacking rain fed *D. lablab* at different phenological stages

*Dolichos lablab* crop was sown on the randomly sampled rain fed farms by the farmers in the wet season (November to February 2010). Sampling of the plants and arthropod pests started fifteen days after sowing. Sampling of the plants or the plant parts and various arthropod pests was done as described in section 3.2.2. The infestation levels of various arthropod pests were estimated at four phenological stages. These phenological stages were; seedling, vegetative, flower budding and flowering and podding. The infestation levels and rates of the arthropod pests were estimated as described in section 3.3 and recorded on the record sheet (Appendix II). Sampling of the arthropod pests was done biweekly until the harvesting of the crop.

### 3.9 Comparing infestation levels of arthropod pest species attacking *D. lablab* in different cropping patterns

The sixteen farms randomly sampled from the two sub-counties as described in section 3.2.2, had four cropping patterns. These included; *D. lablab* monocrop, *D. lablab* intercropped

with maize, *D. lablab* intercropped with bananas and *D. lablab* intercropped with pigeon peas and sorghum. The infestation levels and rates of the arthropod pest species from these cropping patterns were estimated as described in section 3.3 and recorded on the record sheet (Appendix II). Sampling of the arthropod pests was done biweekly until the harvesting of the crop.

**3.10 Data analysis**

Data were analysed using Genstat Statistical Software, version 14. Log transformation was done on the parametric data (count data). Diversity was assessed by calculating Shannon diversity index using the infestation levels of arthropod pest species in Yatta and Meru central sub-counties and in dry and wet seasons. Data on arthropod pest species composition was analysed descriptively.

Data on comparison of diversity and infestation levels of arthropod pests attacking *D. lablab* in Meru central and Yatta sub-counties was analysed by subjecting the transformed data of the two sub-counties to t-test, while the infestation score data was subjected to Mann-Whitney-U-test.

Data on comparison of diversity and infestation levels of arthropod pest species in dry and wet seasons was analysed by subjecting the transformed data to t-test, while the infestation score data was subjected to Mann-Whitney-U-test. To investigate the effects of irrigated and rain fed conditions, the data was analysed by performing analysis of variance on the transformed count data, while Kruskal Wallis test was performed on the score rates data.

To assess the differences in the infestation levels of arthropod pest species at phenological stages, the data was analysed by performing analysis of variance on the transformed count data, while Kruskal Wallis test was performed on the score rates data. To compare the differences in the infestation levels of arthropod pests in different cropping partterns, the data was analysed by performing analysis of variance on the transformed count data, while Kruskal Wallis test was performed on the score rates. Post ANOVA test was done using the Student-Neuman-Keuls test.

# CHAPTER FOUR

# RESULTS

## 4.1 Arthropod pest species composition in Meru central and Yatta sub-counties

A total of thirteen (13) species of insects and one species of mite belonging to nine and one order respectively were found infesting and damaging *D. lablab* in Meru central and Yatta sub-counties (Table 4.1). The infestation levels of these arthropod pests varied between study sites, seasons and farming types (irrigated and rain fed). The order Lepidoptera included; *Helicoverpa amigera* (Hubner) and *Maruca testulalis* (Fabricius). *Helicoverpa amigera* had a higher frequency of occurrence of 3 in rain fed *D. lablab* during the wet season compared to the other *D. lablab* types which had a frequency of occurrence of 4 in both seasons and sub-counties. *Maruca testulalis* had a frequency of occurrence of 4 in all *D. lablab* types in both seasons and sub-counties (Table 4.1). The order Hemiptera had *Clavigralla* spp. (pod sucking bugs) which had a higher frequency of occurrence in rain fed *D. lablab* rated 1 compared to irrigated *D. lablab* which was rated 3 in both seasons and sub-counties (Table 4.1).

The order Coleoptera included *Mylabris* spp. (Flower beetles) and *Apion* spp. (leaf beetles). *Mylabris* spp. occurred in all *D. lablab* types in both seasons and sub-counties with a low frequency of occurrence rated 4. *Apion* spp. occurred only during the wet season in both sub-counties with the frequency of occurrence rated 4 (Table 4.1). Similarly, *Melanoplus spp.* in the order Orthoptera occurred only during the wet season in both sub-counties with the frequency of occurrence rated 4 (Table 4.1). The order Thysanoptera included; (*Megalurothrips sjostedti* (Trybom), *Frankliniella occidentallis* (Pergande), *Frankliniella schultzei* (Pergande), *Hydatothrips* spp.) in family thripidae. *Megalurothrips sjostedti* had a

very high frequency of occurrence rated 1 in all *D. lablab* types except rain fed *D. lablab* during the wet season in Meru in both seasons and sub-counties (Table 4.1).

The order Homoptera had two species, namely; *Bemisia* spp. (white flies) and *Aphis* spp. During the dry season, *Aphis* spp. occurred during dry and wet seasons in both sub-counties with the frequency of occurrence rated 3 (Table 4.1). *Bemisia* spp. had a medium frequency of occurrence rated 3 in all the *D. lablab* types in both seasons and sub-counties (Table 4.1). *Liriomyza* spp. (Leaf miners) in the order Diptera had a higher frequency of occurrence rated 2 in irrigated *D. lablab* in dry season in both sub counties compared to rain fed *D. lablab* in both counties which had a frequency of occurrence of 3 (Table 4.1). During the dry season, had *Tetranychus* spp. (spider mites) in the order Acarina had a higher frequency of occurrence rated 3 in irrigated *D. lablab* compared to rain fed *D. lablab* which had frequency of occurrence of 4 in both counties. During the wet season, *Tetranychus* spp. had a higher frequency of occurrence rated 3 in rain fed *D. lablab* compared to irrigated *D. lablab* which had frequency of occurrence of 4 in Yatta (Table 4.1).

**Table 4.1** Arthropod pest species found infesting *D. lablab* in Yatta and Meru central sub-county, 2009/2010

| Common names | Order | species | Ranks of frequency of occurrence | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Meru | | | | Yatta | | | |
| | | | Dry season | | Wet season | | Dry season | | Wet season | |
| | | | Irrigated *varole* | Rain fed | Irrigated *varole* | Rain fed | Irrigated *varole* | Rain fed | Irrigated *varole* | Rain fed |
| Pod borers | Lepidoptera | *Helicoverpa amigera* | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 3 |
| | | *Maruca testulalis* | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Pod sucking bugs | Hemiptera | *Clavigralla* spp. | 4 | 2 | 3 | 1 | 4 | 3 | 3 | 2 |
| Flower beetles | Coleoptera | *Mylabris* spp. | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Leaf beetles | Coleoptera | *Apion* spp. | 5 | 5 | 3 | 3 | 5 | 5 | 4 | 4 |
| Grass hoppers | Orthoptera | *Melanoplus* spp. | 5 | 5 | 4 | 4 | 5 | 5 | 4 | 4 |
| Thrips | Thysanoptera | *Megalurothrips sjosedti* | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 1 |
| | | *Frankliniella occidentallis* | 4 | 4 | 3 | 3 | 4 | 4 | 4 | 4 |
| | | *Frankliniella schultzei* | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | | *Hydatothrips* spp. | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Leaf miners | Diptera | *Liriomyza* spp. | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| White flies | Homoptera | *Bemisia* spp. | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Aphids | Homoptera | *Aphis* spp. | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 3 |
| Spider mites | Acarina | *Tetranychus* spp. | 3 | 4 | 4 | 4 | 3 | 4 | 3 | 4 |

Key: 1- Very high frequency of occurrence; 2- High frequency of occurrence; 3- medium frequency of occurrence; 4- low frequency of occurence 5-No occurrence

4.3(a) *D. lablab* grain type pod infested by *H. amigera*

4.3(b) *D. lablab* vegetable type pod damaged due to *H. amigera* feeding

4.4 (a) *M. testulalis* larva on a *D. lablab* leaf

Plate 4.4(b) *D. lablab* vegetable type pods infested and damaged due to *M. testulalis* feeding

Plate 4.5(a) Adult *Clavigralla* spp. on a *D. Lablab* leave.

Plate 4.5(b) Pods of grain type *D. lablab* damaged due to feeding by pod sucking bugs

Plate 4.6 *Mylabris* spp feeding on *D. lablab* flower.

Plate 4.7 *D. lablab* leaves infested by *Bemisia* spp.

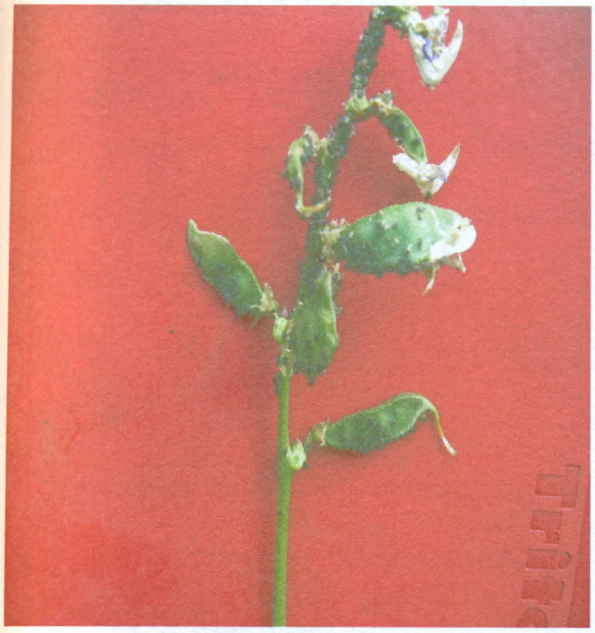

Plate 4.8(a) Young pods of grain type *D. lablab* deformed due to feedig by *Aphis* spp.

Plate 4.8(b) Flower buds and young pods of vegetable type *D. lablab* deformed due to feeding by *Aphis* spp.

Plate 4.9 *D. lablab* leaves infested by *Melanoplus* spp.

Plate 4.10 *D. lablab* leaves with mines of *Liriomyza* spp.

**4.2 Differences in diversity and infestation levels of arthropod pest species in Meru central and Yatta sub-counties**

The arthropod pest species distribution within the two sub-counties was high with a diversity index of 4.5 (Table 4.2). The mean numbers of eggs of *H. amigera* in Yatta (7.3 ± 0.6) and Meru central (6.2 ± 0.6), were not significantly different ($t_{(134)}$=1.06; P>0.05). Similarly, the mean numbers of larvae of *H. amigera* in Yatta (8.6 ± 0.7) and Meru central (7.1 ± 0.7) were not significantly different from each other ($t_{(134)}$=0.78; P>0.05). Mean numbers of eggs of *M. testulalis* in Yatta (1.9 ± 0.3) was significantly higher ($t_{(125)}$ =2.16; P<0.05) than in Meru central (0.9 ± 0.2). Similarly, the mean numbers of larvae of *M. testulalis* in Yatta (5.9 ± 06) was significantly higher ($t_{(115)}$=3.16; P<0.05) than Meru central (2.4 ± 0.4) (Table 4.2).

The mean numbers of egg masses of *Clavigralla* spp. in Meru central (4.9 ± 0.56) was not significantly different ($t_{(134)}$ =0.24; P>0.05) from Yatta (4.8 ± 0.6), similarly, the mean numbers of nymphs and adults of *Clavigralla* spp in Meru (28.9 ± 3.0) and Yatta (22.1 ± 2.6) did not differ significantly ($t_{(134)}$=1.01; P>0.05) (Table 4.2).

*Mylabris* spp. occurred in both Meru and Yatta but the mean numbers of the adults in Yatta (8.0 ± 0.6) and Meru (7.8 ± 0.7) were not significantly different ($t_{(134)}$=0.97; P>0.05). *Apion* spp. occurred in both Meru and Yatta but the mean numbers of adults in Yatta (3.6 ± 0.4) and Meru central (3.4 ± 0.4) were not significantly different ($t_{(134)}$ =0.35; P>0.05). The mean numbers of adults of *Melanoplus* spp. was significantly higher ($t_{(134)}$=1.73; P<0.05) in Yatta (5.8 ± 0.6) than Meru central (4.3 ± 0.6) (Table 4.2).

The species of thrips infesting *D. lablab* in Yatta were also the same species found in Meru. *Megalurothrips sjostedti* dominated in both Meru and Yatta, but the mean numbers of adults in Meru central (113.9 ± 6.7) and Yatta (107.8 ± 6.2) were not significantly different ($t_{(134)}$ =0.27; P>0.05). The other commonly occurring thrip species in both Meru and Yatta was *F. occidentallis*, whose mean numbers of its adults was significantly higher ($t_{(122.88)}$ =1.67; P<0.05) in Meru (17.2 ± 2.4) than Yatta (7.9 ± 1.2) (Table 4.2). The mean numbers of adults of *F. schultzei* was significantly higher in Meru (8.9 ± 1.3) ($t_{(95.84)}$ =1.83; P<0.05) than Yatta (4.4 ± 0.8). *Hydatothrips* spp. occurred in Meru and Yatta averaging 6.0 ± 0.9 and 5.8 ± 1.4 respectively but these means were not significantly different ($t_{(134)}$ =0.81; P>0.05) from each other (Table 4.2).

**Table 4.2** Mean numbers (± SE) of developmental stages of various arthropod pest species found infesting *D. lablab* in Yatta and Meru sub-counties; 2009/2010

| Arthropod pest species | Developmental stages | Mean numbers (± SE) developmental stages of various arthropod pests per $m^2$ | | | | | Shannon diversity index – H - value |
|---|---|---|---|---|---|---|---|
| | | Meru | Yatta | d.f | t - value | P – value ($p<0.05$) | |
| *H. amigera* | Eggs | 6.2 ± 0.6 | 7.3 ± 0.6 | 134 | 1.06 | 0.291 | |
| | Larvae | 7.1 ± 0.7 | 8.6 ± 0.7 | 134 | 0.78 | 0.438 | |
| *M. testulallis* | Eggs | 0.9 ± 0.2 | 1.9 ± 0.3 | 125 | 2.16 | 0.032 | |
| | Larvae | 2.4 ± 0.4 | 5.9 ± 0.6 | 115 | 3.16 | 0.002 | |
| *Clavigralla* spp. | Egg masses | 4.9 ± 0.6 | 4.8 ± 0.6 | 134 | 0.24 | 0.814 | |
| | Nymphs & adults | 28.9 ± 3.0 | 22.1 ± 2.6 | 134 | 1.01 | 0.315 | |
| *Mylabris* spp. | Adults | 7.8 ± 0.7 | 8.0 ± 0.6 | 134 | 0.97 | 0.332 | |
| *Apion* spp. | Adults | 3.4 ± 0.4 | 3.6 ± 0.4 | 134 | 0.35 | 0.729 | |
| *Melanoplus* spp. | Adults | 4.3 ± 0.6 | 5.8 ± 0.6 | 134 | 1.73 | 0.086 | |
| *M. sjostedti* | Adults | 113.9 ± 6.7 | 107.8 ± 6.2 | 134 | 0.27 | 0.788 | |
| *F. occidentallis* | Adults | 17.2 ± 2.4 | 7.9 ± 1.2 | 122.88 | 1.67 | 0.048 | |
| *F. schultzei* | Adults | 8.9 ± 1.3 | 4.4 ± 0.8 | 95.84 | 1.83 | 0.030 | |
| *Hydatothrips* spp. | Adults | 6.0 ± 0.9 | 5.8 ± 1.4 | 134 | 0.81 | 0.422 | |
| | | | | | | | Total H- value = 4.5 |

### 4.2.1 Differences in infestation rates of arthropod pest species in Meru central and Yatta

Infestation levels of thrips, spider mites, white flies, leaf miners and aphids were determined by infestation score rates (Table 3.1).

**Table 4.3** Medians of infestation scores of arthropod pest species of *D. lablab* in Yatta and Meru central sub-counties.

| Arthropod pest species | | Medians of Infestation scores | | | | |
|---|---|---|---|---|---|---|
| Common names | Scientific names | Meru | Yatta | U - value | Z - value | P – value |
| Thrips | Thrips species | 2.00 | 2.00 | 56693.5 | 0.77 | 0.534 |
| Spider mites | *Tetranychus* spp. | 0 | 0 | 57780.0 | 0.23 | 0.841 |
| Leaf miners | *Liriomyza* spp. | 1.00 | 2.00 | 51704.0 | 2.72 | 0.011 |
| White flies | *Bemisia* spp. | 0 | 1.00 | 49518.0 | 3.70 | 0.001 |
| Aphids | *Aphis* spp. | 0 | 1.00 | 47474.0 | 4.20 | 0.001 |

The infestation levels of thrips in Meru and Yatta was not significantly different ($U=56693.5$; $Z=0.77$; $P>0.05$) with a median score of 2.00 in each sub-county (Table 4.3). The infestation levels of *Tetranychus* spp. in Meru central and Yatta were not significantly different ($U=57780.0$; $Z=0.23$; $P>0.05$) with the median score being zero in each sub-county (Table 4.3). Infestation levels of *Liriomyza* spp. in Yatta was significantly higher ($U=51704.0$; $Z=2.72$; $P<0.05$) with a median score of 2.00 compared to Meru which had a median of 1.00 (Table 4.3). Infestation levels *Bemisia* spp. in Yatta was significantly higher ($U=49518.0$; $Z=3.70$; $P<0.05$) with a median score of 1.00, than Meru which had a median score of zero (Table 4.3). Infestation levels of *Aphis* spp. in Yatta was significantly higher ($U=47474.0$;

Z=4.20; P<0.05) than Meru with a median score of 1.00, while Meru had a median score of zero (Table 4.3).

### 4.3 Comparison of diversity and infestation levels of arthropod pest species attacking *D. lablab* in Meru central and Yatta sub-counties during the dry and wet seasons

The arthropod pests infesting *D. lablab* in both dry and wet seasons were similar except *Apion* spp. and *Melanoplus* spp. which were observed only during the wet season both in Meru central and Yatta sub-counties. The arthropod pest species were more abundant in wet season than the dry season. The arthropod pest species diversity index in both seasons in Meru sub-county was 4.0 (Table 4.4), while in Yatta sub-county, the diversity index was 3.9 (Table 4.5).

*Helicoverpa amigera* occurred in both wet and dry seasons in Meru central sub-county. However in the wet season the mean numbers of eggs of *H. amigera* was 10.0 ± 1.1 and was significantly higher ($t_{(67.0)}$=4.50; P<0.05) than dry season which had 3.3 ± 1.1. In wet season, the mean numbers of eggs of *H. amigera* in Yatta was 9.7 ± 0.8 and was significantly higher ($t_{(67.0)}$=2.06; P<0.05) than dry season which had 5.2 ± 0.9. In Meru, infestation of larvae of *H. amigera* in wet season was significantly higher ($t_{(67.0)}$=5.25; P<0.05) with mean numbers of was 12.0 ± 0.8 compared to dry season which had 2.4 ± 0.9. In Yatta, infestation of larvae of *H. amigera* in wet season was significantly higher ($t_{(48.13)}$=8.01; P<0.05) with mean numbers of 13.7 ± 0.8 compared to dry season which had 0.9 ± 0.6 (Table 4.6). *Maruca testulalis* occurred in both wet and dry seasons in Yatta sub-county. However, the mean numbers of eggs of *M. testulalis* in wet season (2.2 ± 1.1) in Yatta was significantly higher (t

$_{(65.0)}$=3.65; P<0.05) than dry season (1.2 ± 0.9) (Table 4.5). In Yatta, mean numbers of larvae of *M. testulalis* in wet season (7.2 ± 0.6) was significantly higher ($t_{(65.0)}$=2.05; P<0.05) than in dry season (3.8 ± 0.8) (Table 4.4).

Pod sucking bugs, *Clavigralla* spp., were found infesting *D. lablab* in both seasons, but in Meru, the mean numbers of egg masses of *Clavigralla* spp. was significantly higher ($t_{(57.24)}$ =2.87; P<0.05) in wet season (7.2 ± 0.8) than dry season (2.7 ± 0.8). Similarly, in Meru, the mean numbers of nymphs and adults of *Clavigralla* spp. was significantly higher in wet season (41.0 ± 3.9) ($t_{(67.0)}$=2.27; P<0.05) than dry season (17.1 ± 3.7) (Table 4.4). In Yatta, mean numbers of egg masses of *Clavigralla* spp. in dry season (7.2 ± 0.7) was significantly higher ($t_{(52.72)}$ =4.12; P<0.05) than wet season which had mean numbers of 0.9 ± 0.9. In Yatta, mean numbers of nymphs and adults of *Clavigralla* spp. in wet season was 32.0 ± 3.6 and was significantly higher ($t_{(64.48)}$=2.85; P<0.05) than dry season whose mean numbers of nymphs and adults of *Clavigralla* spp. was 6.3 ± 4.4 (Table 4.4).

The flower beetles, (*Mylabris* spp.), were found occurring in both dry and wet seasons. In wet season, the mean numbers of adults of *Mylabris* spp. was 10.6 ± 0.9 and was significantly higher ($t_{(67.0)}$=2.27; P<0.05) than dry season with mean numbers of 5.0 ± 0.8 (Table 4.4). In Yatta, the mean numbers of adults of *Mylabris* spp. in wet season (9.6 ± 0.8) was significantly higher ($t_{(65.0)}$=2.36; P<0.05) than dry season which had 5.4 ± 1.0 (Table 4.5). *Apion* spp. and *Melanoplus* spp. were only found infesting the crop in the wet season.

**Table 4.4** Mean numbers (±SE) of developmental stages of various arthropod pest species during dry and wet seasons in Meru central sub-county between June 2009 and February 2010

| Arthropod pests species and their developmental stages | Mean numbers (±SE) of developmental stages of various of insect pest species per m² | | | | | Shannon Weiner Diversity index H- value |
|---|---|---|---|---|---|---|
| | Dry season | Wet season | d.f | t – value | P –value | |
| *H. amigera.* Eggs | 3.3 ± 1.1 | 10.0 ± 1.1 | 67.0 | 4.50 | 0.001 | |
| *H. amigera.* Larvae | 2.2 ± 1.1 | 12.2 ± 2.2 | 53.6 | 5.25 | 0.001 | |
| *M. testulalis* eggs | 2.2 ± 1.1 | 2.2 ± 1.1 | 54.7 | 1.85 | 0.070 | |
| *M. testulalis* larvae | 2.2 ± 1.1 | 3.3 ± 1.1 | 67.0 | 1.50 | 0.138 | |
| *Clavigralla* spp. eggs | 2.2 ± 0.9 | 7.8 ± 1.0 | 57.2 | 2.87 | 0.006 | |
| *Clavigralla* spp. nymphs & adults | 17.78 ± 5.6 | 42.2 ± 12.2 | 67.0 | 2.27 | 0.026 | |
| *Mylabris* spp.adults | 4.5 ± 1.0 | 10.0 ± 2.1 | 67.0 | 2.27 | 0.008 | |
| *Apion* spp. adults | 0 | 6.7 ± 1.2 | 67.0 | 5.67 | 0.001 | |
| *Melanoplus* spp. adults | 0 | 8.9 ± 2.3 | 67.0 | 6.11 | 0.001 | |
| *M. sjostedti* | 152.2 ± 20.0 | 73.3 ± 13.3 | 67.0 | 3.35 | 0.001 | |
| *F. occidentalls* | 6.7 ± 3.2 | 28.9 ± 7.9 | 50.33 | 2.83 | 0.978 | |
| *F.schultzei* | 8.9 ± 3.2 | 8.9 ± 3.2 | 67.0 | 0.16 | 0.876 | |
| *Hydatothrips* spp. | 6.7 ± 2.1 | 5.6 ± 1.1 | 67.0 | 0.01 | 0.992 | |
| Immature thrips stages | 30.0 ± 7.8 | 11.1 ± 6.7 | 61.90 | 2.66 | 0.010 | H- value = 4.0 |

**Table 4.5** Mean numbers (±SE) of developmental stages of various arthropod pest species during dry and wet seasons in Yatta sub-county between June 2009 and February 2010

| Arthropod pests species and their developmental stages | Mean numbers (±SE) of developmental stages of various insect pest species per m² | | | | | Shannon Weiner Diversity index H - value |
|---|---|---|---|---|---|---|
| | Dry season | Wet season | d.f | t - value | P - value | |
| *H. amigera.* Eggs | 5.6 ± 1.1 | 9.8 ± 1.1 | 65.0 | 2.06 | 0.043 | |
| *H. amigera.* Larvae | 1.2 ± 0.9 | 13.3 ± 2.2 | 48.13 | 8.01 | 0.001 | |
| *M. testulalis* eggs | 1.2 ± 1.0 | 2.2 ± 1.1 | 65.0 | 3.65 | 0.001 | |
| *M. testulalis* larvae | 4.4 ± 1.1 | 6.7 ± 1.0 | 65.0 | 2.05 | 0.044 | |
| *Clavigralla* spp. eggs | 1.2 ± 0.9 | 7.8 ± 1.0 | 52.7 | 4.12 | 0.001 | |
| *Clavigralla spp.* nymphs & adults | 6.7 ± 2.0 | 33.3 ± 7.8 | 64.5 | 2.85 | 0.006 | |
| *Mylabris* spp.adults | 5.6 ± 1.0 | 10.0 ± 1.0 | 65.0 | 2.36 | 0.021 | |
| *Apion* spp. adults | 0 | 5.6 ± 1.0 | 65.0 | 4.68 | 0.001 | |
| *Melanoplus* spp. adults | 0 | 8.9 ± 1.1 | 65.0 | 8.10 | 0.001 | |
| *M. sjostedti* | 80.0 ± 13.3 | 127.8 ± 17.8 | 65.0 | 1.21 | 0.229 | |
| *F. occidentallis* | 1.2 ± 0.8 | 12.2 ± 3.3 | 56.2 | 3.99 | 0.001 | |
| *F.schultzei* | 4.5 ± 2.1 | 4.5 ± 1.1 | 65.0 | 0.18 | 0.855 | |
| *Hydatothrips* spp. | 3.3 ± 0.9 | 7.8 ± 2.0 | 65.0 | 1.58 | 0.120 | |
| Immature thrips stages | 16.7 ± 5.6 | 11.1 ± 2.2 | 37.81 | 1.24 | 0.810 | Total H- value = 3.9 |

Thrips infesting *D. lablab* in dry season and wet season in both Meru and Yatta sub-counties were of similar species, but their infestation levels varied between seasons (Table 4.4). The four thrips species were dominated by *M. sjostedti* in both seasons and su-conties, however, in Meru, the mean numbers of adults of *M. sjostedti* in dry season (153.9 ± 8.7) was significantly higher ($t_{(67.0)}$ =3.35; P<0.05) than wet season (72.4 ± 8.8) (Table 4.5). In Yatta, the situation was different with *M. sjostedti* infestation levels being significantly higher ($t_{(65.0)}$ =1.21; P<0.05) in wet season (126.8 ± 1.3) than dry season (77.2 ± 10.1). In Meru sub-county, infestation level of *F. occidentallis* was significantly higher in wet season with mean numbers of 27.7 ± 2.7 compared to dry season which had 7.2 ± 0.2 (Table 4.4). In Yatta sub-county infestation level of *F. occidentallis* was significantly higher in wet season with mean numbers of 12.1 ± 2.4 compared to dry season which had 1.2 ± 0.3 (Table 4.5).

*F. schultzei* infestation occurred in both wet and dry seasons, with a higher infestation level in Meru central. The mean numbers of adults of this thrip species did not differ significantly in Meru ($t_{(67.0)}$ =2.27; P>0.05) and in Yatta ($t_{(65.0)}$ =0.18; P>0.05) between seasons (Table 4.5). In Meru, infestation of *Hydatothrips* spp. in dry season was higher with mean numbers of 6.3 ± 1.7 of adults compared to wet season which had mean numbers of 5.7 ± 1.7, but these two means were not significantly different ($t_{(67.0)}$ =0.01; P>0.05) (Table 4.4). In Yatta the infestation of adults of *Hydatothrips* spp. was significantly ($t_{(65.0)}$ =1.58; P<0.05) higher in wet season with mean numbers of 7.2 ± 1.6 compared to dry season which had mean numbers of 2.9 ± 0.2 (Table 4.5).

### 4.3.1 Comparison of infestation rates of arthropod pest species in dry and wet seasons

Dry season had a significantly higher (U=11585.0; Z=3.63; P<0.05) infestation level of thrips in Meru with a median of 2.0 compared to wet season which had a median of 1.0 (Table 4.6). In Yatta infestation levels of thrips did not differ significantly (U=9692.0; Z=1.90; P>0.05) between dry and wet seasons (Table 4.7). In Meru, the infestation of *Liriomyza* spp. during the wet season was significantly higher (U=4988.5; Z=11.37; P<0.05) with a median of 2.0 compared to the dry season which had a median of 0 (Table 4.6). Similary in Yatta, wet season had a significantly higher (U=4512.0; Z=9.51; P<0.05) infestation of *Liriomyza* spp. with a median of 2.0 compared to the dry season which had a median of 1.0 (Table 4.7).

**Table 4.6** Medians of infestation scores of insect pest species in dry season and wet season in Meru central sub-county between June 2009 and February 2010

| Arthropod pests | Medians of infestation scores | | | | |
|---|---|---|---|---|---|
| | Dry season | Wet season | U - value | Z - value | P- value |
| Thrips | 2 | 1 | 11585.0 | 3.36 | 0.001 |
| *Tetranychus* spp. | 0 | 0 | 14409.5 | 0.59 | 0.556 |
| *Liriomyza* spp | 0 | 2 | 4988.5 | 11.37 | 0.001 |
| *Bemisia* spp. | 0 | 2 | 6988.0 | 9.64 | 0.001 |
| *Aphis* spp. | 0 | 1 | 11665.5 | 4.25 | 0.001 |

In Meru, *Bemisia* spp infestation was significantly higher (U=6988.0; Z=9.64; P<0.05) in wet season with a median of 2.0 compared to the dry season which had a median of 0 (Table 4.6). Similarly in Yatta, infestation of *Bemisia* spp. was significantly higher (U=5586.0; Z=7.88;

P<0.05) in wet season with a median of 2.0 compared to the dry season which had a median of 0 (Table 4.7).

**Table 4.7** Medians of score rates of arthropod pests' species in dry season and wet season in Yatta sub-county between June 2009 and February 2010

| Arthropod pests | Medians infestation scores | | | | |
|---|---|---|---|---|---|
| | Dry season | Wet season | U - value | Z - value | P- value |
| Thrips | 2 | 2 | 9692.0 | 1.90 | 0.057 |
| *Tetranychus* spp. | 0 | 0 | 10902.5 | 0.33 | 0.744 |
| *Liriomyza* spp | 1 | 2 | 4512.0 | 9.51 | 0.001 |
| *Bemisia* spp. | 0 | 2 | 5586.0 | 7.88 | 0.001 |
| *Aphis* spp. | 0 | 1 | 6933.5 | 6.07 | 0.001 |

In Meru, the *Aphis* spp. infestation was significantly higher (U=11665.5; Z=4.25; P<0.05) in wet season with a median of 1.0, compared to the dry season which had a median of 0 (Table 4.6). In Yatta, *Aphis* spp. infestation was significantly higher (U=5586.0; Z=7.88; P<0.05) in wet season with a median of 1.0, compared to the dry season which had a median of 0 (Table 4.7).

## 4.4 Effects of irrigation and rain fed conditions on infestation levels of arthropod pest species attacking *D. lablab* in Meru central and Yatta sub-counties

During the wet season the arthropod pests had a higher diversity index of 4.1 compared to the dry season which had a diversity index of 3.8.

In dry, the mean numbers of eggs of *H. amigera* in Meru and Yatta were not significantly different ($F_{(3,57)}$=19.02; p>0.05) (Table 4.8). In wet season, the infestation of eggs of *H. amigera* in irrigated *D. lablab* was significantly higher ($F_{(3,57)}$=19.02; p>0.05) than the other *D. lablab* types with mean numbers of 6.0 ± 1.0 (Table 4.9). In dry season, the infestation level of larvae of *H. amigera* was significantly higher ($F_{(3,57)}$=19.02; p<0.05) in the rain fed (grain type) farms with mean numbers of 6.4 ± 0.7, compared to irrigated farms which did not record any infestation of larvae of *H. amigera* in dry season (Table 4.8). This infestation was evident by the pods damaged by larvae of *H. amigera* in rain fed *D. lablab* being significantly higher ($F_{(3,57)}$=19.02; p<0.05) with mean numbers of 6.8 ± 1.4 compared to irrigated (0.7 ± 0.2) in the dry season (Table 4.8).

During the wet season, infestation levels of larvae of *H. amigera* in rain fed (grain type) *D. lablab* had mean numbers of 20.7 ± 1.4 and 19.4 ± 1.1 in Meru and Yatta respectively. These means were significantly ($F_{(3,71)}$=6.98; p<0.05) higher than irrigated (vegetable type) *D. lablab* in Meru and Yatta (6.0 ± 1.2 and 7.1 ± 1.2) in the wet season (Table 4.9). There was no significance difference ($F_{(3,71)}$=0.08; p>0.05) within the mean numbers of pods damaged by *H. amigera* in the wet season (Table 4.9).

The mean numbers of eggs of *M. testulalis* were significantly ($F_{(3,57)}$=0.37; p>0.05) higher in irrigated *D. lablab* with mean numbers of 11.8 ± 0.3 in both sub-counties in the dry season, while rain fed *D. lablab* recoded 0 infestation (Table 4.8). The mean numbers of larvae of *M. testulalis* did not differ significantly ($F_{(3,57)}$=0.69; p>0.05) within the *D. lablab* types in both sub-counties in the dry season. The mean numbers of the damaged pods by *M. testulalis* did

not differ significantly ($F_{(3,57)}$=0.28; p>0.05) between the *D. lablab* types in both sub-counties (Table 4.9).

**Table 4.8** Mean numbers (±SE) of developmental stages of pod borers in irrigated and rain fed *D. lablab* in Yatta and Meru central sub-counties between June and October 2009 (Dry season).

| | Mean numbers (± SE) of developmental stages of pod borers per m² | | | |
|---|---|---|---|---|
| Arthropod pests | Meru central | | Yatta | |
| | Irrigated (vegetable type) | Rainfed (grain type) | Irrigated (vegetable type) | Rainfed (grain type) |
| *H. amigera.* eggs | 2.6 ± 0.9a | 3.7 ± 1.2a | 6.0 ± 1.0b | 3.3 ± 1.6a |
| *H. amigera.* larvae | 0a | 6.4 ± 0.7b | 3.7 ± 0.6a | 1.1 ± 0.9a |
| *H. amigera.* damaged pods | 0.7 ± 0.2a | 6.8 ± 1.4c | 0.4 ± 0.1a | 8.3 ± 1.8b |
| *M. testulalis* eggs | 11.8 ± 0.3b | 0a | 11.8 ± 0.3b | 0a |
| *M. testulalis* larvae | 1.7 ± 0.8a | 2.0 ± 0.9a | 5.6 ± 0.8a | 2.6 ± 1.2a |
| *M. testulalis* damaged pods | 2. 7 ± 0.9a | 2.3 ± 1.1a | 4.4 ± 1.0a | 2.6 ± 1.2a |

Means with the same letter within the same row are not significantly different at p=0.05. Means separated using SNK test.

In wet season, the larval populations of *M. testulalis* in irrigated (3.7 ± 0.9) and rain fed (2.6 ± 1.1) *D. lablab* were not significantly different ($F_{(3,71)}$=3.04; p>0.05) from each other in Meru. InYatta, infestation levels of larvae of *M. testulalis* in irrigated *D. lablab* (7.7 ± 0.9) and rain fed *D. lablab* (6.8 ± 0.9) were not significantly different ($F_{(3,71)}$=3.04; p>0.05) from each other. In wet season, the mean numbers of pods damaged by larvae of *M. testulalis* in irrigated *D. lablab* in Yatta (6.1 ± 0.8) was significantly higher ($F_{(3,71)}$=3.04; p<0.05) than the rest of the types of *D. lablab* in both sub-counties (Table 4.9).

**Table 4.9** Mean numbers (± SE) of developmental stages of pod borers in irrigated and rain fed *D. lablab* in Yatta and Meru central sub-counties between November 2009 and February 2010 (Wet season).

| Arthropod pests | Mean numbers (± SE) of developmental stages per $m^2$ | | | |
|---|---|---|---|---|
| | Meru central | | Yatta | |
| | Irrigated (vegetable type) | Rain fed (grain type) | Irrigated (vegetable type) | Rain fed (grain type) |
| *H. amigera* eggs | 8.3 ± 1.0a | 11.4 ± 1.2a | 8.1 ± 1.1a | 9.1 ± 1.0a |
| *H. amigera.* Larvae | 6.0 ± 1.2a | 20.7 ± 1.4b | 7.1 ± 1.2a | 19.4 ± 1.1b |
| *H. amigera.* damaged pods | 5.6 ± 1.3a | 8.8 ± 1.6a | 6.3 ± 1.3a | 8.8 ± 1.2a |
| *M. testulalis* eggs | 1.3 ± 0.6a | 1.4 ± 0.7a | 2.7 ± 0.6a | 2.9 ± 0.6a |
| *M. testulalis* larvae | 3.7 ± 0.9a | 2.6 ± 1.1a | 7.7 ± 0.9b | 6.8 ± 0.9b |
| *M. testulalis* damaged pods | 3.6 ± 0.8a | 1.4 ± 0.9a | 6.1 ± 0.8b | 2.8 ± 0.8a |

Means with the same letter within the same row are not significantly different at p=0.05. Means separated using SNK test.

In the infestation thrips, the most dominant species was *M. sjostedti* in irrigated and rain fed *D. lablab* in both sub-counties and seasons. In dry season, the mean numbers of *M. sjostedti* adults in irrigated *D. lablab* was 176.2 ± 11.0 and was significantly higher ($F_{(3,57)}$=4.73; $p<0.05$) than in rain fed *D. lablab* with mean numbers of 117.1 ± 3.0 in Meru (Table 4.10). In Yatta, unlike Meru, the rain fed *D. lablab* had a significantly higher ($F_{(3,57)}$=4.73; $p<0.05$) mean numbers of adults of *M. sjostedti* (117.2 ± 18.3) compared to the irrigated *D. lablab* which had 59.6 ± 12.2 in dry season (Table 4.10). In Meru, irrigated *D. lablab* had mean numbers of 109.4 ± 10.8 of adults of *M. sjostedti* . This infestation level was significantly higher ($F_{(3,71)}$=8.41; $p<0.05$) than rain fed *D. lablab* which had mean numbers of 19.6 ± 7.9

(Table 4.11). In Yatta, *M. sjostedti* adults infestation level was significantly higher ($F_{(3,71)}$=8.41; $p<0.05$) in irrigated *D. lablab* with mean numbers of 141.7 ± 11.0 compared to rain fed *D. lablab* whose mean numbers of adults was 114.3 ± 10.2 (Table 4.11).

In dry season, irrigated *D. lablab* in Meru had the highest infestation level of *F. occidentallis* compared to the rest of the *D. lablab* types in both Meru and Yatta (Table 4.10). The mean numbers of *F. occidentallis* adults was 10.7 ± 2.0 in irrigated *D. lablab* in Meru and was significantly higher ($F_{(3,57)}$=3.15; $p<0.05$) than the rest of the *D. lablab* types (Table 4.10). In wet season, irrigated *D. lablab* in Meru had the highest infestation levels of *F. occidentallis* with mean numbers of adults being 30.6 ± 4.3 (Table 4.10). During the dry season, *Hydatothrips* spp. infestation level was significantly higher ($F_{(3,54)}$=0.88; $p<0.05$) in rain fed *D. lablab* in Meru, with adults mean numbers of 9.0 ± 2.0 compared to the rest of types of *D. lablab* in both sub-counties (Table 4.10). In wet season, the highest infestation of *Hydatothrips* spp. was in rain fed *D. lablab* in both Meru and Yatta with mean numbers of *Hydatothrips* spp. adults being 9.7 ± 3.0 and 10.9 ± 2.3 respectively. These means were not significantly different ($F_{(3,71)}$=1.75; $p>0.05$) from each other, but both were significantly higher ($F_{(3,71)}$=1.75; $p<0.05$) than irrigated *D. lablab* in both Meru and Yatta (2.9 ± 2.4 and 3.8 ± 2.6) (Table 4.11).

**Table 4.10** Mean numbers (±SE) of adults of various species of thrips in irrigated and rain fed *D. lablab* in Meru central and Yatta sub-counties between June and September 2009 (Dry season).

| Thrip species | Mean numbers (±SE) of various species of thrips per $m^2$ | | | |
|---|---|---|---|---|
| | Meru | | Yatta | |
| | Irrigated (vegetable type) | Rainfed (grain type) | Irrigated (vegetable type) | Rainfed (grain type) |
| *M. sjostedti* | 176.2 ± 11.0c | 117.1 ± 3.0b | 59.6 ± 12.2a | 117.2 ± 18.3c |
| *F.occidentallis* | 10.7 ± 2.0b | 1.4 ± 2.6a | 1.3 ± 1.1a | 3.7 ± 3.2ab |
| *F. schultzei* | 10.0 ± 2.0b | 7.4 ± 2.6ab | 4.1 ± 2.2a | 5.6 ± 3.3ab |
| *Hydatothrips* spp. | 4.7 ± 1.6a | 9.0 ± 2.0b | 3.3 ± 1.8a | 2.7 ± 2.0a |
| Immature stages | 36.1 ± 5.9b | 21.6 ± 7.7b | 11.8 ± 6.7a | 25.0 ± 9.9ab |

Means with the same letter within the same row are not significantly different at p=0.05. Means separated using SNK test.

*Clavigralla* spp. was another common insect pest in both irrigated (vegetable type) and rain fed (grain type). In dry season, the mean numbers of egg masses of *Clavigralla* spp. in rain fed *D. lablab* in Meru was 7.1 ± 0.9 and was significantly higher ($F_{(3,57)}$=12.07; p<0.05) than irrigated (0.7 ± 0.4) and rain fed (1.4 ± 0.1) *D. lablab* in Yatta. However, these two mean numbers were not significantly different ($F_{(3,57)}$=12.07; p>0.05) from each other (Table 4.12). In wet season, the mean numbers of egg masses of *Clavigralla* spp. in the *D. lablab* types did not show significant difference ($F_{(3,71)}$=0.35; p>0.05) in both sub-counties (Table 4.13)

**Table 4.11** Mean numbers (±SE) of adults of various species of thrips in irrigated and rain fed *D. lablab* in Meru central and sub-counties Yatta between October 2009 and February 2010 (Wet season).

| Species of thrips | Mean numbers (±SE) of various species of thrips per $m^2$ | | | |
|---|---|---|---|---|
| | Meru | | Yatta | |
| | Irrigated (vegetable type) | Rain fed (grain type) | Irrigated (vegetable type) | Rain fed (grain type) |
| *M. sjostedti* | 109.4 ± 10.8b | 19.6 ± 7.9a | 141.7 ± 11.0d | 114.3 ± 10.2c |
| *F. occidentallis* | 30.6 ± 4.3b | 23.7 ± 5.1ab | 15.9 ± 4.3ab | 8.9 ± 4.1a |
| *F. schultzei* | 7.8 ± 2.0a | 10.0 ± 2.3a | 5.7 ± 2.0a | 3.1 ± 1.9a |
| *Hydatothrips* spp. | 2.9 ± 2.4a | 9.7 ± 3.0b | 3.8 ± 2.6a | 10.9 ± 2.3b |
| Immature stages | 13.7 ± 3.4a | 7.9 ± 4.1a | 11.0 ± 3.4a | 10.4 ± 3.2a |
| Damaged pods | 18.3 ± 1.6c | 6.8 ± 1.9a | 21.6 ± 1.7c | 13.6 ± 1.6b |

Means with the same letter within the same row are not significantly different at p=0.05. Means separated using SNK test.

In dry season, rain fed *D. lablab* had the highest infestation of nymphs and adults of *Clavigralla* spp. with mean numbers of 44.0 ± 3.6. This infestation level was significantly higher ($F_{(3,57)}$=25.37; p<0.05) than irrigated *D. lablab* in Meru (2.8 ± 0.8). Similarly in dry season, rain fed *D. lablab* had significantly higher ($F_{(3,57)}$=25.37; p<0.05) infestation of nymphs and adults of *Clavigralla* spp. with mean numbers of 16.1 ± 4.7 compared to irrigated *D. lablab* which had mean numbers of 3.1 ± 2.0 in Yatta (Table 4.12). In dry season, the highest number of pods damaged by *Clavigralla* spp. in Meru was found in rain fed *D. lablab* farms with mean numbers of 56.7 ± 3.0 and was significantly higher ($F_{(3,57)}$=51.00; p<0.05) than the rest of the *D. lablab* types in both Meru and Yatta (Table 4.12). Rain fed *D.*

*lablab* in Meru had the highest infestation (65.9 ± 7.2) of nymphs and adults of *Clavigralla* spp. and was significantly higher than the rest of *D. lablab* types (Table 4.13). In wet season, the highest number of pods damaged by *Clavigralla spp.* in Yatta was found in rain fed *D. lablab* farms with mean numbers of 13.9 ± 2.1, though this damage was not significantly different ($F_{(3,71)}$=0.16; p>0.05) from the rest of the means of pods damaged by *Clavigralla* spp. in all the *D. lablab* types in both Meru and Yatta (Table 4.13).

In dry season, the infestation level of *Mylabris* spp. adults in rain fed *D. lablab* (1.2 ± 0.6) and irrigated *D. lablab* (1.0 ± 0.9) in Meru did not differ significantly ($F_{(3,57)}$=5.53; p>0.05) from each other (Table 4.12). Similarly, in Yatta, the infestation level of *Mylabris* spp. adults did not differ significantly ($F_{(3,57)}$=5.53; p>0.05) between irrigated (5.1 ± 1.0) and rain fed (6.1 ± 1.6) *D. lablab* in dry season (Table 4.12).

In wet season, *Mylabris* spp. was also a common insect pest in both irrigated and rain fed *D. lablab*, and the highest infestation was found in rain fed *D. lablab* in Meru, with mean numbers of *Mylabris* spp. adults being 14.1 ± 1.3. This infestation level was significantly ($F_{(3,71)}$=2.41; p<0.05) higher than irrigated *D. lablab* which had mean numbers of 8.0 ± 2.2 (Table 4.13). In wet season, irrigated *D. lablab* in Yatta had a significantly ($F_{(3,71)}$=2.41; p<0.05) higher infestation of adults of *Mylabris* spp. with mean numbers of 12.7 ± 1.1 compared to rain fed *D. lablab* which had mean numbers of 10.2 ± 7.0 (Table 4.13). *Apion* spp.were only found infesting the crop in the wet season and in both irrigated and rain fed *D. lablab*. In Meru, Irrigated *D. lablab* had the highest infestation level of *Apion* adults with mean numbers of 30.6 ± 4.3, compared to rain fed *D. lablab* which had mean numbers of

23.7 ± 5.1, but these means were not significantly ($F_{(3,71)}$=0.16; p>0.05) different from each other (Table 4.13).

**Table 4.12** Mean numbers (±SE) of developmental stages of various arthropod pest species in irrigated and rain fed *D. lablab* in Yatta and Meru central sub-counties between June and September 2009 (Dry season).

| | Mean numbers (±SE) per m² | | | |
|---|---|---|---|---|
| Arthropod pest species | Meru central | | Yatta | |
| | Irrigated (vegetable type) | Rainfed (grain type) | Irrigated (vegetable type) | Rainfed (grain type) |
| *Clavigralla* spp. egg masses | 0a | 7.1 ± 0.9b | 0.7 ± 0.4a | 1.4 ± 0.1a |
| *Clavigralla* spp. nymphs plus adults | 2.8 ± 0.8a | 44.0 ± 3.6c | 3.1 ± 2.0a | 16.1 ± 4.7b |
| *Clavigralla* spp. damaged pods | 2.3 ± 0.3a | 56.7 ± 3.0c | 2.6 ± 1.3a | 20.0 ± 3.8ab |
| *Mylabris* spp. | 1.0 ± 0.9a | 1.2 ± 0.6a | 5.1 ± 1.0b | 6.1 ± 1.6b |

Means with the same letter within the same row are not significantly different at p=0.05. Means separated using SNK test.

In Yatta, infestation of *Apion* spp. adults was significantly higher ($F_{(3,71)}$=56.19; p<0.05) in irrigated *D. lablab* (15.9 ± 4.3) compared to rain fed *D. lablab* which had mean numbers of 8.9 ± 4.1 (Table 4.13). *Melanoplus* spp. was also a common insect pest in both types of *D. lablab*, but was only found infesting the crop in the wet season. There was no significant difference ($F_{(3,71)}$=18.05; p>0.05) between the means of the adults of *Melanoplus* spp. in the *D. lablab* types in both Meru and Yatta (Table 4.13).

**Table 4.13** Mean numbers (±SE) of developmental stages of various arthropod pests for irrigated and rain fed *D. lablab* in Meru central and Yatta sub-counties between November 2009 and February 2010 (Wet season).

| | Mean numbers (±SE) per m² | | | |
|---|---|---|---|---|
| Arthropod pest species | Meru central | | Yatta | |
| | Irrigated (Vegetable type) | Rainfed (Grain type) | Irrigated (Vegetable type) | Rainfed (Grain type) |
| *Clavigralla* spp. egg masses | 6.3 ± 1.1a | 8.6 ± 1.3 a | 5.3 ± 1.1a | 8.9 ± 1.0a |
| *Clavigralla* spp. nymphs plus adults | 23.7 ± 6.0a | 65.9 ± 7.2b | 25.9 ± 6.1a | 37.3 ± 5.7a |
| *Clavigralla* spp. damaged pods | 10.7 ± 2.2a | 11.9 ± 2.7a | 13.8 ± 2.2a | 13.9 ± 2.1a |
| *Mylabris* spp. | 8.0 ± 2.2b | 14.1 ± 1.3c | 12.7 ± 1.1c | 10.2 ± 7.0a |
| *Apion* spp. | 30.6 ± 4.3b | 23.7 ± 5.1ab | 15.9 ± 4.3ab | 8.9 ± 4.1a |
| *Melanoplus* spp. | 7.8 ± 2.0a | 10.0 ± 2.3a | 5.7 ± 2.0a | 3.1 ± 1.9a |

Means with the same letter within the same row are not significantly different at p=0.05. Means separated using SNK test.

### 4.4.1 Effects of irrigation and rain fed conditions on infestation rates of arthropod pest species in *Dolichos lablab*

During June 2009 to October 2009 (dry season), generally the infestation of thrips in irrigated *D. lablab* in both Meru and Yatta was significantly different ($H_{(3)}$ =27.16; $p<0.05$) (Table 4.14). In dry season, rain fed *D. lablab* in Yatta had a higher infestation with a mean rank of thrips of 179.96 compared with rain fed *D. lablab*, with a mean rank of 113.17 (Table 4.14). In wet season, like in the dry season, the infestation of thrips in irrigated *D. lablab* in both Meru and Yatta was significantly different ($H_{(3)}$ =78.34; $p<0.05$) (Table 4.14). In the wet season, irrigated *D. lablab* in Meru had a higher infestation of thrips with a mean rank of 222.49 compared to rain fed *D. lablab* which had a mean rank of 101.14. In Yatta, irrigated

*D. lablab* had a higher infestation of thrips with a mean rank of 238.21 compared to rain fed *D. lablab* which had a mean rank of 169.80 (Table 4.15).

In dry season, *Tetranychus* spp. was found infesting the crop in both irrigated and rain fed *D. lablab* in Meru and Yatta, but the infestation was higher in irrigated *D. lablab* than rain fed *D. lablab*. In dry season, irrigated *D. lablab* in Meru had a higher infestation of *Tetranychus* spp. with a mean rank of 189.33 compared to rain fed *D. lablab* which had an infestation mean rank of 103.79 (Table 4.14). In dry season, irrigated *D. lablab* in Yatta had an infestation mean rank of 161.09 and was higher than rain fed *D. lablab* in Yatta which had an infestation mean rank of 125.00 (Table 4.14). In wet season, like in the dry season, infestation of *Tetranychus* spp. was significantly ($H_{(3)}=66.74$; $p<0.05$) higher in irrigated *D. lablab* than rain fed *D. lablab* in both Meru and Yatta (Table 4.15). In wet season, irrigated *D. lablab* in Meru had a higher infestation with a mean rank of 227.25 compared to rain fed *D. lablab* with an infestation mean rank of 127.11(Table 4.15). Similarly, in Yatta, irrigated *D. lablab* had an infestation mean rank of 236.14 and was significantly ($H_{(3)}=66.74$; $p<0.05$) higher than rain fed *D. lablab* with an infestation mean rank of 150.77 (Table 4.15).

In the dry season, infestation of *Liriomyza* spp. was found in both irrigated and rain fed *D. lablab* though the infestation was significantly ($H_{(3)}=48.13$; $p<0.05$) higher in irrigated farms than rainfed farms in Meru, while in Yatta rain fed *D. lablab* farms had higher infestation of *Liriomyza* spp. than irrigated *D. lablab* farms in Meru (Table 4.14).

**Table 4.14** Mean - ranks of scores of arthropod pests in irrigated and rain fed systems of Yatta and Meru central sub-counties between June and September 2009 (dry season).

| | Mean - ranks of score rates per $m^2$ | | | | | |
|---|---|---|---|---|---|---|
| | Meru | | Yatta | | | |
| Arthropod pest species | Irrigated (vegetable type) | Rain fed (grain type) | Irrigated (vegetable type) | Rain fed (grain type) | H- Value | Chi-square probability |
| Thrips | 169.55 | 169.60 | 113.17 | 179.96 | 27.16 | 0.001 |
| *Tetranychus* spp. | 189.33 | 103.79 | 161.09 | 125.00 | 43.70 | 0.001 |
| *Liriomyza* spp. | 166.51 | 109.19 | 193.12 | 106.62 | 48.13 | 0.001 |
| *Bemisia* spp. | 161.31 | 116.38 | 174.24 | 151.36 | 17.50 | 0.001 |
| *Aphis* spp. | 149.48 | 147.44 | 136.63 | 216.49 | 23.93 | 0.001 |

In dry season, irrigated *D. lablab* in Meru had an infestation mean rank of 166.51 and was significantly higher ($H_{(3)}$ =48.13; $p<0.05$) than rain fed *D. lablab* which had an infestation mean rank of 109.19, while in Yatta, irrigated *D. lablab* had an infestation mean rank of 193.12 compared to rain fed *D. lablab* which had an infestation mean rank of 106.62 (Table 4.14). In wet season, irrigated *D. lablab* in Yatta had the highest infestation of *Liriomyza* spp. compared to the other production systems in both Meru and Yatta (Table 4.15). In wet season, *Liriomyza* spp. infestation in irrigated *D. lablab* in Meru was higher with a mean rank of 205.59 compared to rain fed *D. lablab* which had a mean rank of damage score of 172.66 (Table 4.15). similary, irrigated *D. lablab* in Yatta had a higher infestation of *Liriomyza* spp. with a mean rank of 226.07 compared to rain fed *D. lablab* which had a mean rank of 150.26 (Table 4.15).

**Table 4.15** Mean - ranks of scores of arthropod pest species in irrigated and rain fed systems of Yatta and Meru central sub-counties between November 2009 and February 2010 (wet season).

| | Mean - ranks of scores per $m^2$ | | | | | |
|---|---|---|---|---|---|---|
| | Meru | | Yatta | | | |
| Arthropod pest species | Irrigated (vegetable type) | Rain fed (grain type) | Irrigated (vegetable type) | Rain fed (grain type) | H- Value | Chi-square probability |
| Thrips | 222.49 | 101.14 | 238.21 | 169.80 | 78.34 | 0.001 |
| *Tetranychus* spp. | 227.25 | 127.11 | 236.14 | 150.77 | 66.74 | 0.001 |
| *Liriomyza* spp. | 205.59 | 172.66 | 226.07 | 150.26 | 29.05 | 0.001 |
| *Bemisia* spp. | 147.07 | 238.64 | 170.14 | 210.27 | 36.58 | 0.001 |
| *Aphis* spp. | 129.50 | 221.88 | 183.14 | 225.58 | 49.11 | 0.001 |

*Bemisia* spp. was a common insect pest in both irrigated and rain fed *D. lablab* in Meru and Yatta. The infestation of *Bemisia* spp. differed significantly ($H_{(3)}$ =17.50; $p<0.05$) within the *D. lablab* types. In dry season, irrigated *D. lablab* had a higher infestation level with a mean rank of 161.31 compared to irrigated *D. lablab* which had a mean rank of 116.38 in Yatta, while in Meru irrigated *D. lablab* had a higher infestation level with a mean rank of 174.24 compared to rain fed *D. lablab* which had a mean rank of 151.36 (Table 4.14). In wet season, the infestation levels of *Bemisia* spp.were higher in rain fed *D. lablab* compared to irrigated *D. lablab* in both Meru and Yatta (Table 4.15). In wet season, *Bemisia* spp. infestation was higher in rain fed *D. lablab* in Meru with a mean rank of 238.64 compared to irrigated *D. lablab* which had a mean rank of 147.07, while in Yatta, rain fed *D. lablab* had a higher infestation with a mean rank of 210.27 compared to irrigated *D. lablab* which had a mean rank of 170.14 (Table 4.15).

In dry season, *Aphis* spp. infestation levels in all the *D. lablab* types in both Meru and Yatta were significantly different ($H_{(3)}$ =17.50; $p<0.05$) (Table 4.14). In dry season, rain fed and irrigated *D. lablab* in Meru had almost equal *Aphis* spp. infestation level with a mean ranks of 147.48 and 149.48 respectively (Table 4.14). In dry season, rain fed *D. lablab* had a higher infestation levels with a mean rank of 216.49 compared to irrigated *D. lablab* which had a mean rank of 136.63 in Meru (Table 4.14). In wet season, infestation of *Aphis* spp. differed significantly in rain fed *D. lablab* and irrigated *D. lablab* in both Meru and Yatta was ($H_{(3)}$=49.11; $p<0.05$) higher than irrigated *D. lablab* (Table 4.15). In wet season, *Aphis* spp. infestation was higher in rain fed *D. lablab* in Meru with a mean rank of 221.88 compared to irrigated *D. lablab* which had a mean rank of 129.50, while in Yatta, rain fed *D. lablab* had a higher infestation with a mean rank of 225.58 compared to irrigated *D. lablab* which had a mean rank of 183.14 (Table 4.15).

### 4.5 Differences in arthropod pest species infestation levels at different phenological stages of rain fed *D. lablab*

Vegetative and flower budding in rain fed *D. lablab* had the highest infestation of eggs of *H. amigera* with mean numbers of 11.1 ± 2.1 and 11.1 ± 4.2 respectively, but these means of numbers were not significantly different ($F_{(3,66)}$=11.90; $p>0.05$) from flowering and podding which had mean numbers of 8.1 ± 1.0 in Meru (Table 4.16). The seedling stage in rain fed *D. lablab* in Meru had the lowest mean numbers of 2.2 ± 1.1. Flower budding and, flowering and podding phenological stages in rain fed *D. lablab* in Yatta, had a significantly higher ($F_{(3,106)}$=27.69; $p<0.05$) infestation of eggs of *H. amigera* with mean numbers of 13.3 ± 1.0 and 14.9 ± 1.3 respectively, compared to vegetative stage which had mean numbers of 2.8 ±

1.2 (Table 4.17). In wet season in Meru, infestation level of larvae of *H. amigera* in flowering and podding growth stage had mean numbers of 29.8 ± 2.1. This infestation level was significantly higher ($F_{(3,66)}$ =8.74; $p<0.05$) than the seedling stage which had mean numbers of 11.7 ± 2.3 ( Table 4.16). In wet season, the infestation of larvae of *H. amigera* in rain fed *D. lablab* in Yatta started at the seedling stage with mean numbers of 2.1 ± 0.9 and increased significantly ($F_{(3,106)}$ =46.84; $p<0.05$) to the highest infestation in the flower budding stage with mean numbers of 33.3 ± 2.7 ( Table 4.17).

Vegetative stage in rain fed *D. lablab* in Meru had the highest infestation levels of eggs of *M. testulalis* with mean numbers of 2.8 ± 1.1, this was closely followed by flowering and podding with mean numbers of 1.8 ± 0.8, but these means were not significantly different ($F_{(3, 66)}$ =1.26; $p>0.05$) (Table 4.16). In Meru, flower budding in rain fed *D. lablab* had the highest infestation of larvae of *M. testulalis* with mean numbers of 13.3 ± 3.7 (Table 4.17). This infestation was significantly higher ($F_{(3, 66)}$ =11.03; $p<0.05$) than vegetative stage (3.9 ± 1.8) and flowering and podding (3.7 ± 1.3), while seedling stage was not attacked by the larvae of *M. testulalis* (Table 4.17).

Flowering and podding phenological stage in rain fed *D. lablab* in Meru had the highest infestation of egg masses of *Clavigralla* spp. with mean numbers of 21.8 ± 1.7. This mean was significantly higher ($F_{(3, 66)}$ =106.50; $p<0.05$) than the rest of the phenological stages (Table 4.16). Vegetative and flower budding in rain fed *D. lablab* had mean numbers of 2.0 ± 0.9 and 5.4 ± 4.0 respectively, but these means were not significantly different ($F_{(3, 66)}$

=106.50; p>0.05) from each other (Table 4.16). The seedling stage did not record any infestation of eggs of *Clavigralla* spp. in rain fed *D. lablab* in Meru (Table 4.16).

Flowering and podding phenological stage in rain fed *D. lablab* in Yatta had the highest infestation of egg masses of *Clavigralla* spp. with mean numbers of 18.4 ± 6.4. This infestation was significantly ($F_{(3, 106)}$ =33.59; p<0.05) higher than flower budding which had mean numbers of 2.2 ± 0.7(Table 4.17). Flowering and podding in rain fed *D. lablab* in Meru had the highest infestation of nymphs and adults of *Clavigralla* spp. with mean numbers of 167.6 ± 9.1 and was significantly higher ($F_{(3, 66)}$ =110.06; p<0.05) than vegetative and flower budding which had mean numbers of 15.0 ± 8.2 and 24.4 ± 12.3 respectively (Table 4.16). The seedling phenological stage in rain fed *D. lablab* in Meru was not infested by nymphs and adults of *Clavigralla* spp. (Table 4.16). The flowering and podding phenological stage in rain fed *D. lablab* in Yatta had the highest infestation of nymphs and adults of *Clavigralla* spp. with mean numbers 80.4 ± 6.4. This mean was significantly higher ($F_{(3, 106)}$ =46.41; p<0.05) than vegetative and flower budding which had means of 5.8 ± 1.0 and 4.0 ± 0.7 respectively (Table 4.17). The seedling stage in rain fed *D. lablab* did not record infestation of nymphs and adults of *Clavigralla* spp. in Yatta during the wet season (Table 4.17).

*Mylabris* spp. was found in all the stages of development in rain fed *D. lablab* in Meru (Table 4.16). Flowering and podding had the highest infestation of adults of *Mylabris* spp. with mean numbers of adults of 28.0 ± 1.9. This infestation was significantly higher ($F_{(3, 66)}$ =17.06; p<0.05) than vegetative and flower budding phenological stages which had mean numbers of 9.4 ± 2.1 and 6.7 ± 3.3 respectively in Meru (Table 4.16). Seedling phenological

stage had the lowest infestation of *Mylabris* spp. with mean numbers of 3.3 ± 1.2 of adults (Table 4.16). Infestation of adults of *Mylabris* spp. in Yatta was observed in the flower budding and, flowering and podding with mean numbers of 11.9 ± 1.4 and 11.8 ± 1.3 respectively. These means were not significantly different ($F_{(3, 106)}$=32.92; p>0.05) from each other. The seedling and vegetative phenological stages were not attacked by adults of *Mylabris* spp. in Yatta sub-county (Table 4.17).

**Table 4.16** Mean numbers of developmental stages of various arthropod pests at phenological stages in rain fed (grain type) *D. lablab* in Meru between Nov. 2009 and Feb. 2010 (wet season).

| Arthropod pest species | Mean numbers (±SE) per m² | | | |
|---|---|---|---|---|
| | Seedling | Vegetative | Flower budding | Flowering and podding |
| *H. amigera* eggs | 2.2 ±1.1 a | 11.1 ± 2.1 b | 11.1 ± 4.2 b | 8.1 ± 1.0 b |
| *H. amigera* larvae | 11.7 ± 2.3 a | 20.0 ± 2.3 b | 13.3 ± 4.5 ab | 29.8 ± 2.1 b |
| *M. testulalis* eggs | 0 a | 2.8 ± 1.1 b | 0 a | 1.8 ± 0.8 b |
| *M. testulalis* larvae | 0 a | 3.9 ± 1.8 b | 13.3 ± 3.7 c | 3.7 ± 1.3 b |
| *Clavigralla* spp. eggs | 0 a | 2.0 ± 1.0 b | 5.4 ± 4.0 c | 21.8 ± 1.7 d |
| *Clavigralla* nymphs & adults | 0 a | 15.0 ± 5.1 b | 24.4 ± 12.3 c | 167.6 ± 9.1d |
| *Mylabris* spp. | 3.3 ± 1.2 a | 9.4 ± 2.1 b | 6.7 ± 3.3 ab | 28.0 ± 1.9 c |
| *Apion* spp. | 15.0 ± 1.9 a | 12.8 ± 1.4 b | 15.6 ± 1.8 a | 19.1 ± 1.3 a |
| *Melanoplus* spp. | 15.6 ± 1.9 a | 22.2 ± 1.9 b | 13.3 ± 3.7 a | 12.3 ± 1.7 a |

Means with the same letter within the same row are not significantly different at p=0.05. Means separated using SNK test.

**Table 4.17** Mean numbers of developmental stages of various arthropod pests at phenological stages in rain fed (grain type) *D. lablab* in Yatta between Nov. 2009 and Feb. 2010 (wet season).

| | Mean numbers (±SE) per m² | | | |
|---|---|---|---|---|
| Arthropod pest species | Seedling | Vegetative | Flower budding | Flowering and podding |
| *H. amigera* eggs | 0 a | 2.8 ± 1.8 b | 13.3 ± 1.0 c | 14. 4 ± 1.4 b |
| *H. amigera* larvae | 2.1 ± 0.9 a | 17.2 ± 2.3 b | 33.3 ± 2.7 c | 24.4 ± 2.1 b |
| *M. testulalis* eggs | 0 a | 0 a | 7.8 ± 1.3 b | 4.4 ± 1.1 b |
| *M. testulalis* larvae | 0 a | 0 a | 17.0 ± 2.1 c | 10.0 ± 1.1 b |
| *Clavigralla* spp. eggs | 1.8 ± 0.4 a | 2.0 ± 0.6 a | 2.2 ± 0.8 a | 18.9 ± 1.1 b |
| *Clavigralla* nymphs & adults | 0 a | 5.8 ± 1.7 b | 4.0 ± 0.7 b | 80.0 ± 7.8 c |
| *Mylabris* spp. | 0 a | 0 a | 11.9 ± 2.4 b | 12.2 ± 2.2 b |
| *Apion* spp. | 8.0 ± 0.7 a | 9.4 ± 1.4 a | 15.6 ± 1.8 a | 12.2 ± 1.1 a |
| *Melanoplus* spp. | 11.1 ± 1.7 a | 13.3 ± 1.9 b | 19.2 ± 2.1 a | 14.4 ± 1.1 a |

Means with the same letter within the same row are not significantly different at p=0.05. Means separated using SNK test.

Flowering and podding phenological stage in rain fed *D. lablab* in Meru had the highest infestation of adults of *Apion* spp. with mean numbers of 19.1 ± 1.3 compared to; seedling (15.0 ± 1.4), vegetative (12.8 ± 1.4) and flower budding (15.6 ± 1.8), but these means were not significantly different ($F_{(3, 66)}$=0.71; p>0.05) from each other (Table 4.16). Flower budding phenological stage in rain fed *D. lablab* in Yatta had the highest infestation of *Apion* spp. adults with mean numbers of 15.6 ± 1.8 compared to; seedling (8.0 ± 0.7), vegetative (9.4 ± 1.4) and flowering and podding (13.3 ± 1.9), but these means were not significantly different ($F_{(3, 106)}$=1.81; p>0.05) from each other ( Table 4.17).

Vegetative phenological stage in rain fed *D. lablab* in Meru had the highest infestation of *Melanoplus* spp. with a mean numbers of adults of 22.2 ± 1.9, followed by flowering and podding with mean numbers of 20.4 ± 0.2 of adults, while seedling and flower budding had means of adults of 15.6 ± 1.9 and 13.3 ± 3.7 respectively, but all these means were not significantly different ($F_{(3, 66)}$ =1.64; p>0.05) from each other (Table 4.16). Flower budding phenological stage in rain fed *D. lablab* in Yatta had the highest infestation of *Melanoplus* spp. with mean numbers of adults of 19.2 ± 2.1, followed by flowering and podding with mean numbers of 14.4 ± 1.2 of adults of *Melanoplus* spp., while seedling and vegetative had means of numbers of 11.1 ± 1.7 and 13.3 ± 1.9 of adults respectively, but all these means were not significantly different ($F_{(3,106)}$ =1.38; p>0.05) from each other ( Table 4.17).

Flowering and podding in rain fed *D. lablab* in Meru recorded the highest mean numbers of *M. sjostedti* adults of 43.6 ± 10.3. This was significantly higher ($F_{(3,66)}$=14.96; p<0.05) than vegetative stage which had mean numbers of 13.9 ± 9.4, while seedling and flower budding

growth stages were not infested by adults of *M. sjostedti* (Table 4.18). Flowering and podding phenological stage in rain fed *D. lablab* in Yatta had the highest infestation of adults of *M. sjostedti* with mean numbers of 225.1 ± 18.8. This mean was significantly higher ($F_{(3,106)}$=113.48; $p<0.05$) than flower budding which had mean numbers of 83.0 ± 23.7. Vegetative growth stage in rain fed *D. lablab* in Yatta had the lowest infestation of adults of *M. sjostedti* with mean numbers of 9.4 ± 3.3, while seedling stage did not record *M. sjostedti* infestation (Table 4.19).

Flower budding in rainfed *D. lablab* in Meru had the highest infestation of adults of *F. occidentallis* with mean numbers of 31.1 ± 7.8 and was closely followed by flowering and podding with a mean of 24.0 ± 8.4, though these two means were not significantly different ($F_{(3,66)}$=3.85; $p>0.05$) (Table 4.18). Vegetative phenological stage in rainfed *D. lablab* in Meru had the lowest infestation of *F. occidentallis* with mean numbers of adults of 11.6 ± 9.4. Seedling stage was not infestated by adults of *F. occidentallis* (Table 4.18). In Yatta, *F. occidentallis* infestation started at the vegetative stage of growth with mean numbers of 9.4 ± 0.9 and increased to 11.1 ± 8.9 in the flower budding stage. The highest infestation of *F. occidentallis* was in flowering and podding phenological stage with mean numbers of 15.6 ± 6.0. These three means were not significantly different ($F_{(3,106)}$ =6.28; $p>0.05$) (Table 4.19).

Vegetative phenological stage in rain fed *D. lablab* in Meru had the highest infestation of adults of *F. schultzei* with mean numbers of 26.1 ± 4.3 and was significantly higher ($F_{(3,66)}$=2.67; $p>0.05$) than flower budding which had mean numbers of 13.3 ± 5.7 ( Table 4.18). Flowering and podding growth stage of rain fed *D. lablab* in Meru had the lowest

infestation of *F. schultzei* with mean numbers of 4.4 ± 2.8, while the seedling phenological stage was not infestated by *F. schultzei* (Table 4.18). Infestation of *F. schultzei* in rain fed *D. lablab* in Yatta was observed in flower budding, and flowering and podding phenological stages with mean numbers of 5.9 ± 4.6 and 5.1 ± 2.8 respectively, though the means were not significantly different ($F_{(3,106)}$=4.36; p>0.05). Seedling and vegetative phenological stages were not infestated by *F. schultzei* (Table 4.19).

Infestation of *Hydatothrips* spp. was recorded in all the phenological stages. Vegetative phenological stage in rain fed *D. lablab* in Meru had the highest infestation of *Hydatothrips* spp. with mean numbers of 13.9 ± 5.6 of adults. The seedling and flower budding followed with mean numbers of 11.7 ± 5.6 and 11.1 ± 9.8 respectively, but these means were not significantly different ($F_{(3,66)}$=1.71; p>0.05) (Table 4.18). Flowering and podding stage in rain fed *D. lablab* in Meru had the lowest infestation of adults of *Hydatothrips* spp. with mean numbers of 4.4 ± 2.6 (Table 4.18). Flower budding phenological stage in rain fed *D. lablab* in Yatta had the highest infestation of *Hydatothrips* spp. with mean numbers of 15.8 ± 6.3 of adults. This infestation level was significantly ($F_{(3,106)}$ =4.36; p>0.05) higher than vegetative stage with mean numbers of 11.1 ± 4.6, while flowering and podding had the lowest *Hydatothrips* spp. infestation with adults mean numbers of 3.8 ± 1.6 (Table 4.19).

**Table 4.18** Mean numbers (±SE) of adults of various species of thrips at different phenological stages in rain fed (grain type) *D. lablab* in Meru central sub-county between November 2009 and February 2010 (Wet season).

| | Mean numbers (±SE) per m² | | | |
|---|---|---|---|---|
| Species of thrips | Seedling | Vegetative | Flower budding | Flowering and podding |
| *Megalurothrips sjostedti* | 0 a | 13.9 ± 9.4 b | 0 a | 43. 6 ± 8.4 c |
| *Frankliniella occidentallis* | 0 a | 11.6 ± 9.4 b | 31.1 ± 7.8 c | 24.0 ± 8.4 c |
| *Frankliniella schultzei* | 0 a | 26.1 ± 4.3 d | 13.3 ± 5.7 c | 4.4 ± 2.8 b |
| *Hydatothrips* spp. | 11.7 ± 5.6 a | 13.9 ± 5.6 a | 11.1 ± 9.8 a | 4.4 ± 2.6 a |

Means with the same letter within the same row are not significantly different at p=0.05. Means separated using SNK test.

**Table 4.19** Mean numbers (±SE) of adults of various species of thrips at different phenological stages in rain fed (grain type) *D. lablab* in Yatta sub-county between November 2009 and February 2010 (Wet season).

| | Mean numbers (±SE) per m² | | | |
|---|---|---|---|---|
| Species of thrips | Seedling | Vegetative | Flower budding | Flowering and podding |
| *Megalurothrips sjostedti* | 0 a | 9.4 ± 3.3 b | 83.0 ± 23.7 b | 225. 6 ± 18.8 c |
| *Frankliniella occidentallis* | 0 a | 9.4 ± 0.9 c | 11.1 ± 8.9 b | 15.6 ± 6.0 b |
| *Frankliniella schultzei* | 0 a | 0 a | 5.9 ± 4.6 b | 5.1 ± 2.8 b |
| *Hydatothrips* spp. | 0 a | 11.1 ± 4.6 c | 15.8 ± 6.3 d | 3.8 ± 1.6 b |

Means with the same letter within the same row are not significantly different at p=0.05. Means separated using SNK test.

### 4.5.1 Differences in infestation rates of arthropod pests at different phenological stages of rain fed *D. lablab*

Infestation of thrips in rain fed *D. lablab* in Meru started at the seedling stage with a mean rank of 25.10 and increased in the vegetative growth stage with a mean rank of 36.98. The thrips infestation dropped at the flower budding before increasing to the highest levels in flowering and podding phenological stage with a mean rank of 43.66. These infestation levels differed significantly ($H_{(3)}$ =9.66; $p<0.05$) between the phenological stages (Table 4.20). In Yatta the infestation of thrips increased from seedling stage to the highest level at the flowering and podding stage (Table 4.21).

*Tetranychus* spp. infestation in rain fed *D. lablab* in Yatta started at the seedling phenological stage with a mean rank of 37.75 and did not change at the vegetative phenological stage, but the infestation dropped to a mean rank of 32.50 at the flower budding and, flowering and podding (Table 4.20). These infestation levels did not differ significantly ($H_{(3)}$ =4.85; $p>0.05$) between the phenological stages

*Liriomyza* spp. infestation was observed in all the phenological stages in the rain fed *D. lablab* in Meru and the infestation levels did not differ significantly ($H_{(3)}$=4.54; $p>0.05$) within (Table 4.20). Flowering and podding had the highest *Liriomyza* spp. infestation with a mean rank of 38.68, while the lowest was in seedling stage with a mean rank of 28.52 (Table 4.20). Similarly in Yatta, there was no significance difference ($H_{(3)}$ =1.50; $p>0.05$) within the infestation levels at the phenological stages. Vegetative phenological stage in Yatta had the highest infestation of *Liriomyza* spp. with a mean rankof 61.00, this was followed by flower

budding with a mean rank of 57.50, while flowering and podding, and seedling had mean ranks of 55.63 and 49.64 respectively (Table 4.21).

**Table 4.20** Mean - ranks of score of arthropod pest species at phenological stages of rain fed *D. lablab* in Meru central sub-county between June and October 2009 (dry season).

| Arthropod pest species | Mean - ranks of scores per m² | | | | | |
|---|---|---|---|---|---|---|
| | seedling | vegetative | Flower budding | Flowering & podding | H - value | Chi - square p - value |
| Thrips | 25.10 | 36.98 | 30.40 | 43.66 | 9.66 | 0.012 |
| *Tetranychus* spp. | 37.75 | 37.75 | 32.50 | 32.50 | 4.85 | 0.183 |
| *Liriomyza* spp. | 28.52 | 38.73 | 34.60 | 38.68 | 4.53 | 0.209 |
| *Bemisia* spp. | 29.05 | 34.60 | 34.60 | 41.50 | 9.84 | 0.020 |
| *Aphis* spp. | 39.80 | 42.23 | 46.90 | 24.40 | 13.56 | 0.004 |

**Table 4.21** Mean - ranks of score of arthropod pest species at phenological stages of rain fed *D. lablab* in Yatta sub-county between November 2009 and February 2010 (Wet season).

| Arthropod pest species | Mean - ranks of scores per m² | | | | | |
|---|---|---|---|---|---|---|
| | seedling | vegetative | Flower budding | Flowering & podding | H - value | Chi - square p - value |
| Thrips | 21.96 | 36.35 | 72.43 | 74.85 | 57.47 | 0.001 |
| *Tetranychus* spp. | 49.80 | 54.00 | 43.50 | 62.55 | 5.41 | 0.015 |
| *Liriomyza* spp. | 49.64 | 61.00 | 57.50 | 55.63 | 1.50 | 0.555 |
| *Bemisia* spp. | 37.18 | 64.50 | 56.57 | 60.74 | 11.20 | 0.001 |
| *Aphis* spp. | 36.46 | 42.02 | 52.93 | 71.18 | 24.66 | 0.001 |

*Bemisia* spp. infestation started at the seedling phenological stage and was found infesting all the phenological stages of rain fed *D. lablab* in Meru. There was significance difference ($H_{(3)}$

=4.23; $p<0.05$) within the infestation levels at the phenological stages (Table 4.20). Flowering and podding phenological stage in rain fed *D. lablab* in Meru had the highest infestation of *Bemisia* spp. with a mean rank of 41.50, this was followed by flower budding (34.60) and vegetative (34.60), while seedling stage had the lowest with a mean rank of 29.05 (Table 4.16). In Yatta, there was significance difference ($H_{(3)}$ =11.20; $p<0.05$) in the infestation levels at the phenological stages (Table 4.21). Vegetative phenological stage in Yatta had the highest infestation of *Bemisia* spp. with a mean rank of 64.50, this was followed by flowering and podding with a mean rank of 60.74, while flower budding and seedling had mean ranks of 56.57 and 37.18 respectively (Table 4.21).

*Aphis* spp. was found infesting all the phenological stages of rain fed *D. lablab* in Meru. There was significance difference ($H_{(3)}$ =12.08; $p<0.05$) within the infestation levels (Table 4.20). Flower budding phenological stage in rain fed *D. lablab* in Meru had the highest infestation with a mean rank of 46.90, compared to vegetative (42.23) and seedling (39.80), while flowering and podding had the lowest infestation with a mean rank of 24.40 (Table 4.20). Similarly in Yatta, there was significance difference ($H_{(3)}$ =24.66; $p<0.05$) within the infestation levels at the phenological stages (Table 4.21). Flowering and podding phenological stage in rain fed *D. lablab* in Yatta had the highest *Aphis* spp. infestation with a mean rank of 71.18, followed by flower budding with a mean rank of 52.93, while vegetative and seedling had the lowest infestation with a mean ranks of 36.46 and 42.02 respectively (Table 4.21).

**4.6 Comparison of infestation levels of arthropod pest species attacking *D. lablab* in different cropping patterns in Meru central and Yatta sub-counties**

In dry season, the highest infestation of eggs of *H. amigera* was in the farms where irrigated *D. lablab* was grown alone with mean numbers of 6.0 ± 1.0. The lowest infestation of *H. amigera* was in farms where irrigated *D. lablab* was grown with bananas, but there was no significant difference ($F_{(3, 57)} = 1.12$; $p > 0.05$) between the mean numbers of eggs of *H. amigera* in all the cropping patterns (intercrops) in both sub-counties (Table 4.22). In dry season, rain fed *D. lablab* grown with pegion peas and sorghum in Meru had the highest infestation of larvae of *H. amigera* with mean numbers of 6.4 ± 0.7. This mean was significantly higher ($F_{(3, 57)} = 10.44$; $p < 0.05$) than irrigated and rain fed *D. lablab* grown alone in Yatta which had mean numbers of 0.6 ± 0.3 and 1.1 ± 0.9 respectively. Irrigated *D. lablab* grown with bananas in Meru was not infested by larvae of *H. amigera* (Table 4.22).

In wet season, rain fed *D. lablab* grown with pegion peas and sorghum in Meru had the highest infestation of eggs of *H. amigera* with mean numbers of 12.0 ± 1.4. The lowest infestation of eggs of *H. amigera* was in irrigated *D. Lablab* grown with bananas, but there was no significant difference ($F_{(2, 30)} = 0.44$; $p > 0.05$) between the mean numbers of eggs of *H. amigera* (Table 4.23). In wet season, rain fed *D. lablab* grown with bananas in Yatta had the highest infestation of eggs of *H. amigera* with mean numbers of 12.0 ± 2.1, while the lowest was in farms where *D. lablab* was grown with pegion peas and sorghum with mean numbers of 6.3 ± 1.6 (Table 4.24). In wet season, the highest infestation of *H. amigera* larvae was recorded in farms where rain fed *D. lablab* in Meru was grown with pegion peas and sorghum, and rain fed *D. lablab* with bananas with mean numbers of 20.7 ± 1.7 and 20.6 ±

2.7 respectively. These means were not significantly different ($F_{(3, 57)} = 10.44$; $p > 0.05$) from each other (Table 4.23). In wet season, rain fed *D. lablab* grown with bananas and rain fed *D. lablab* grown with maize in Yatta had the highest infestation of larvae of *H. amigera* with means of counts of 23.6 ± 2.3 and 19.3 ± 1.3 respectively. These two means were not significantly different ($F_{(5, 36)} = 2.55$; $p > 0.05$) from each other, but were significantly higher ($F_{(5, 36)} = 2.55$; $p < 0.05$) than rain fed *D. lablab* grown with pegion peas and sorghum (10.7 ± 4.4), irrigated *D. lablab* grown with bananas (7.4 ± 2.0) and irrigated *D. lablab* grown alone (9.2 ± 2.2). Rain fed *D. lablab* grown alone in Yatta was not infested by larvae of *H. amigera* (Table 4.24).

In dry season, infestation levels of eggs and larvae of *M. testulalis* in all the cropping patterns in both sub-counties were not significantly different ($F_{(3, 57)} = 0.69$; $p > 0.05$) (Table 4.22). In wet season, there was no significant difference ($F_{(2, 30)} = 4.51$; $p > 0.05$) in the mean numbers of eggs of *M. testulalis* in all the cropping patterns (intercrops) in Meru (Table 4.23). In wet season, the infestation of eggs of *M. testulalis* in Yatta did not differ significantly ($F_{(5, 36)} = 1.04$; $p > 0.05$) in all the cropping patterns (intercrops) in Yatta (Table 4.24).

In wet season, rain fed *D. lablab* grown with bananas in Meru had highest infestation of levels of *M. testulalis* larvae with mean numbers of 5.6 ± 1.9 compared to irrigated *D. lablab* grown with bananas with mean numbers of 3.7 ± 0.9 but the two means were not significantly different ($F_{(2, 30)} = 1.57$; $p > 0.05$) (Table 4.23). In wet season, irrigated *D. lablab* grown alone and rain fed *D. lablab* grown with bananas in Yatta had the highest infestation levels of larvae of *M. testulalis* with mean numbers of 14.8 ± 1.6 and 12.0 ± 1.7 respectively.

**Table 4.22** Mean numbers (±SE) of developmental stages of various arthropod pest species in *Dolichos lablab* cropping patterns in Yatta and Meru central sub-counties between June and October 2009 (Dry season).

| Location | Means (±SE) of counts per m² | | | |
|---|---|---|---|---|
| | Meru | | Yatta | |
| Arthropod pest species | *D. lablab* with pegion peas and sorghum (rain fed) | *D. lablab* with bananas (irrigated) | *D. lablab* plain (irrigated) | *D. lablab* plain (rain fed) |
| *H. amigera* eggs | 3.7 ± 1.2a | 2.6 ± 1.0a | 6.0 ± 1.0a | 3.3 ± 1.6a |
| *H. amigera* larvae | 6.4 ± 0.7b | 0 a | 0.6 ± 0.3a | 1.1 ± 0.9a |
| *M. testulalis* eggs | 0 a | 0.8 ± 0.6a | 0.7 ± 0.3a | 0 a |
| *M. testulalis* larvae | 0 a | 0.8 ± 0.6a | 0.7 ± 0.3a | 0 a |
| *Clavigralla* spp.eggs | 7.1 ± 0.9b | 0 a | 0.8 ± 0.7a | 1.4 ± 1.1a |
| *Clavigralla* spp. nymphs adults | 44.0 ± 3.6c | 2.8 ± 0.8a | 3.1 ± 2.0a | 16.1 ± 4.7b |
| *Mylabris* spp. | 11.7 ± 1.2c | 1.0 ± 0.8a | 5.1 ± 1.0b | 6.1 ± 1.6b |

Means with the same letter within the same row are not significantly different at p=0.05. Means separated using SNK test.

These two means were not significantly different ($F_{(5,36)}$=1.18; p>0.05), but were significantly higher ($F_{(5, 36)}$ =1.18; p<0.05) than the rest of the cropping patterns in the two sub-counties (Table 4.24). Rain fed *D. lablab* grown alone in Yatta was not infested by *M. testulalis* larvae (Table 4.24).

In dry season, rain fed *D. lablab* grown with pegion peas and sorghum in Meru had an infestation level of egg masses of *Clavigralla* spp. with mean numbers of 7.1 ± 0.9 compared

to irrigated *D. lablab* grown with bananas which was not infested by egg masses of *Clavigralla* spp. (Table 4.22). In wet season, there was no significant difference ($F_{(2, 30)} = 0.20$; $p > 0.05$) between the mean numbers of egg masses of *Clavigralla* spp. in all the cropping patterns in Meru (Table 4.25). In wet season, rain fed *D. lablab* grown with bananas in Yatta had the highest infestation levels of eggs masses of *Clavigralla* spp. with mean numbers of 10.2 ± 2.2, this mean was followed by irrigated *D. lablab* grown alone in Yatta (9.2 ± 2.0) and rain fed *D. lablab* grown with Maize in Yatta (8.9 ± 1.2). The lowest mean numbers of egg masses of *Clavigralla* spp. in Yatta was recorded in farms where rain fed *D. lablab* was grown alone, but there was no significant difference ($F_{(5, 36)} = 0.92$; $p > 0.05$) in the mean numbers of egg masses of *Clavigralla* spp. in all the cropping patterns (Table 4.26).

**Table 4.23** Mean numbers ± (SE) of developmental stages of pod borers in *D. lablab* cropping patterns in in Meru central from November 2009 to February 2010 (wet season).

| | Mean numbers of developmental stages of pod borers per $m^2$ | | |
|---|---|---|---|
| Pod borers species | *D. lablab* with pegion peas and sorghum (Rain fed) | *D. lablab* with bananas (irrigated) | *D. lablab* with bananas (Rain fed) |
| *Helicoverpa amigera* eggs | 12.0 ± 1.4 a | 8.3 ± 1.0 a | 10.0 ± 2.3 a |
| *Helicoverpa amigera* larvae | 20.7 ± 1.7 b | 6.0 ± 1.2 a | 20.6 ± 2.7 b |
| *Maruca testulalis* eggs | 0a | 1.3 ± 0.9 b | 5.0 ± 1.1 b |
| *Maruca testulalis* larvae | 1.3 ± 1.2 a | 3.7 ± 0.9 a | 5.6 ± 1.9 a |

Means with the same letter within the same row are not significantly different at p=0.05. Means separated using SNK test.

**Table 4.24** Mean numbers ± (SE) of developmental stages of pod borers in different cropping patterns in *D. lablab* in Yatta from November 2009 to February 2010 (wet season).

| | Mean numbers of developmental stages of pod borers per $m^2$ | | | | | |
|---|---|---|---|---|---|---|
| Pod borers species | *D. lablab* with pigeon peas and sorghum (rain fed | *D. lablab* with bananas (irrigated) | *D. lablab* with bananas (rain fed) | *D. lablab* with maize (rain fed) | *D. lablab* plain (rain fed) | *D. lablab* plain (irrigated) |
| *H. amigera* eggs | 6.3 ± 1.9 b | 9.2 ± 1.8 b | 12.0 ± 2.1 b | 8.8 ± 1.9 b | 0 a | 8.6 ± 2.2 b |
| *H.* amigera larvae | 10.7 ± 4.4 b | 7.4 ± 2.0 b | 23.6 ± 2.3 c | 19.3 ± 1.3 c | 0 a | 9.2 ± 2.2 b |
| *M. testulalis* eggs | 1.1 ± 0.9 b | 3.1 ± 0.8 b | 4.9 ± 1.0 b | 2.3 ± 0.8 b | 0 a | 3.7 ± 0.9 b |
| *M. testulalis* larvae | 6.3 ± 1.6 b | 4.7 ± 1.4 b | 12.0 ± 1.7 c | 5.6 ± 1.0 b | 0 a | 14.8 ± 1.6 c |

Means with the same letter within the same row are not significantly different at p=0.05. Means separated using SNK test.

In dry season, rain fed *D. lablab* grown with pegion peas and sorghum in Meru had a significantly higher ($F_{(3, 57)}$ =25.37; $p<0.05$) infestation level of nymphs and adults of *Clavigralla* spp. with mean numbers of 44.0 ± 3.6, compared to irrigated *D. lablab* grown with bananas which had mean numbers of 2.8 ± 0.8 (Table 4.22). In dry season, farms where rain fed *D. lablab* was grown alone in Yatta had a significantly ($F_{(3, 57)}$ =25.37; $p<0.05$) higher infestation of nymphs and adults of *Clavigralla* spp. with mean numbers of 16.1 ± 4.7 compared to irrigated *D. lablab* grown alone in Yatta which had mean numbers of 5.1 ± 1.0 (Table 4.22).

In dry season, rain fed *D. lablab* grown with pegion peas and sorghum in Meru had the highest infestation of adults of *Myabris* spp. with mean numbers of 11.7 ± 1.2 and was significantly higher ($F_{(3, 57)}$ =5.53; $p<0.05$) than irrigated *D. lablab* grown with bananas (1.0 ± 0.9). Rain fed *D. lablab* grown alone in Yatta had an infestation of mean numbers of 6.1 ± 1.57 of *Myabris* spp. adults. This was not significantly different ($F_{(3, 57)}$ =5.53; $p>0.05$) from irrigated *D. lablab* grown alone (5.1 ± 1.0) (Table 4.22). In wet season, rain fed *D. lablab* grown with bananas in Meru had the highest infestation of adults of *Myabris* spp. with mean numbers of 14.4 ± 2.4 compared to rain fed *D. lablab* grown with pegion peas and sorghum in Meru (14.0 ± 1.6) and irrigated *D. lablab* grown with bananas in Meru (8.0 ± 1.1), but there was no significant difference ($F_{(2, 30)}$ =0.59; $p>0.05$) in the mean numbers of adults of *Myabris* spp. in the three cropping patterns (Table 4.25). Similarly, in wet season, there was no significant difference ($F_{(5, 36)}$ =1.79; $p>0.05$) in the mean numbers of adult of *Mylabris* spp. in all the cropping patterns in Yatta (Table 4.25).

*Apion* spp. infestation was only found in the wet season. Rain fed *D. lablab* grown with pegion peas and sorghum in Meru had the highest infestation of adults of *Apion* spp. with mean numbers of 16.7 ± 1.0, while rain fed *D. lablab* grown with bananas had mean numbers of 13.9 ± 1.6. These two means were not significantly different ($F_{(2, 30)}$ =130.9; $p>0.05$) from each other, but were both significantly higher ($F_{(2, 30)}$ =130.9; $p<0.05$) than irrigated *D. lablab* grown with bananas in Meru (6.78±0.78) (Table 4.25). In Yatta, rain fed *D. lablab* grown with bananas had the highest infestation of *Apion* spp. adults with mean numbers of 11.1 ± 1.2 compared to rain fed *D. lablab* grown with maize (11.0 ± 0.8). These two means were not significantly different ($F_{(5, 36)}$ =35.06; $p>0.05$) from each other, but were both significantly higher ($F_{(5, 36)}$ =35.06; $p<0.05$) than rain fed *D. lablab* grown alone (6.7 ± 3.1). Rain fed *D. lablab* grown with pegion peas and sorghum, irrigated *D. lablab* grown with bananas and irrigated *D. lablab* grown alone in Yatta, were not infested by adults of *Apion* spp. (Table 4.26).

*Melanoplus* spp. infestation was only found in the wet season. In Meru, rain fed *D. lablab* grown with bananas had the highest infestation of adults *Melanoplus* spp. with mean numbers of 26.1 ± 1.8 and was significantly higher ($F_{(2, 30)}$ =82.85; $p<0.05$) than rain fed *D. lablab* grown with pegion peas and sorghum with mean numbers of 16.2 ± 1.1. The infestation of *Melanoplus* spp. in irrigated *D. lablab* grown with bananas in Meru was negligible (Table 4.25).

**Table 4.25** Mean numbers ± (SE) of developmental stages of various arthropod pest species in *D. lablab* cropping patterns in Meru from November 2009 to February 2010 (wet season).

| | Mean numbers of arthropod pests per $m^2$ | | |
|---|---|---|---|
| Arthropod pests | *D. lablab* with pegion peas and sorghum (Rain fed) | *D. lablab* with bananas (irrigated) | *D. lablab* with bananas (Rain fed) |
| *Clavigralla* spp. eggs | 9.6 ± 1.6 a | 6.3 ± 1.1 a | 6.1 ± 2.3 a |
| *Clavigralla* spp. nymphs & adults | 72.4 ± 8.4 c | 23.7 ± 6.0 a | 49.4 ± 13.3 b |
| *Mylabris* spp. | 14.0 ± 1.6 a | 8.0 ± 1.1a | 14.4 ± 2.4 a |
| *Apion* spp. | 16.7 ± 1.0 a | 6.8 ± 0.8 a | 13.9 ± 1.6 a |
| *Melanoplus* spp. | 16.2 ± 1.1 b | 1.6 ± 0.8 a | 26.1 ± 1.8 c |

Means with the same letter within the same row are not significantly different at p=0.05. Means separated using SNK test.

In wet season, rain fed *D. lablab* grown with bananas and rain fed *D. lablab* grown with maize in Yatta had the highest infestation of adults of *Melanoplus* spp. with mean numbers of 16.9 ± 0.9 and 13.4 ± 0.9 respectively. These means were not significantly different ($F_{(5, 36)}$ =15.81; p>0.05) from each other, but both were significantly higher ($F_{(5, 36)}$ =15.81; p<0.05) than; irrigated *D. lablab* grown with bananas (2.8 ± 1.3) and rain fed and irrigated *D. lablab* grown alone (6.6 ± 1.6) (Table 4.26).

In dry season, rain fed *D. lablab* grown with bananas in Meru had significantly higher ($F_{(3, 57)}$ =4.73; p<0.05) infestation of adults of *M. sjostedti* with mean numbers of 176.2 ± 11.1 compared to rain fed *D. lablab* grown with pegion peas and sorghum in Meru which had mean numbers of 117.3 ± 14.3 (Table 4.27).

**Table 4.26** Mean numbers ± (SE) of developmental stages of various arthropod pest species in *D. lablab* cropping patterns in Yatta sub-county from November 2009 to February 2010 (wet season).

| | Mean numbers of arthropod pests per $m^2$ | | | | | |
|---|---|---|---|---|---|---|
| Arthropod pests | *D. lablab* with pigeon peas and sorghum (rain fed | *D. lablab* with bananas (irrigated) | *D. lablab* with bananas (rain fed) | *D. lablab* with maize (rain fed) | *D. lablab* plain (rain fed) | *D. lablab* plain (irrigated) |
| *Clavigralla* spp. eggs | 2.7 ± 1.8 a | 4.3 ± 1.8 b | 10.2 ± 2.2 c | 8.9 ± 1.2 c | 4.9 ± 2.2 b | 9.2 ± 2.2 c |
| *Clavigralla* spp. nymphs & adults | 10.9 ± 4.4 b | 24.7 ± 9.8 c | 52.9 ± 11.9 e | 34.4 ± 5.5 d | 0 a | 44.4 ± 10.8 e |
| *Mylabris* spp. | 12.6 ± 2.0 b | 12.3 ± 1.9 b | 7.1 ± 2.2 b | 7.8 ± 2.2 b | 0 a | 13.0 ± 2.0 b |
| *Apion* spp. | 0 a | 0 a | 11.1 ± 1.2 c | 11.0 ± 0.8 c | 6.7 ± 3.1 b | 0 a |
| *Melanoplus* spp. | 37.0 ± 16.0 c | 2.8 ± 1.3 a | 16.9 ± 0.9 b | 13.4 ± 0.9 b | 11.1 ± 3.7 b | 6.6 ± 1.6 a |

Means with the same letter within the same row are not significantly different at p=0.05. Means separated using SNK test.

**Table 4.27** Mean numbers (±SE) of various species of thrips in cropping patterns of *Dolichos lablab* in Yatta and Meru central sub-counties between June and October 2009 (Dry season).

| | Mean numbers (±SE) per m² | | | |
|---|---|---|---|---|
| | Meru | | Yatta | |
| Cropping patterns<br><br>Species of thrips | *D. lablab* with pegion peas and sorghum (rain fed) | *D. lablab* with bananas (irrigated) | *D. lablab* plain (irrigated) | *D. lablab* plain (rain fed) |
| *M. sjostedti* | 117.3 ± 14.3b | 176.2 ± 11.1c | 59.6 ± 12.2a | 117.2 ± 18.3bc |
| *F. occidentalis* | 2.6 ± 1.4a | 10.7 ± 2.0b | 2.0 ± 0.1a | 3.7 ± 3.2ab |
| *F. schultzei* | 7.4 ± 2.6b | 10.0 ± 2.0b | 4.1 ± 2.2a | 5.6 ± 3.3ab |
| *Hydatothrips* spp. | 9.0 ± 2.0b | 4.7 ± 1.6a | 3.3 ± 1.8a | 2.7 ± 2.0a |
| Number of damaged pods | 7.7 ± 1.9a | 15.0 ± 1.4b | 9.8 ± 1.6ab | 19.4 ± 2.4c |

Means with the same letter within the same row are not significantly different at p=0.05. Means separated using SNK test.

In dry season, rain fed *D. lablab* grown alone in Yatta had a significantly ($F_{(3, 57)}$=4.73; p<0.05) higher infestation of adults of *M. sjostedti* with mean numbers of 117.2 ± 18.3 compared to irrigated *D. lablab* grown alone in Yatta which had mean numbers of 59.6 ± 12.2 (Table 4.27).

In wet season, irrigated *D. lablab* grown with bananas in Meru had a significantly higher ($F_{(2, 30)}$ =16.93; p<0.05) infestation of adults of *M. sjostedti* with mean numbers of 109.4 ± 10.2 compared to rain fed *D. lablab* grown with pegion peas and sorghum (17.9 ± 14.4) and rain

fed *D. lablab* grown with bananas (22.8 ± 8.6) (Table 4.28). In wet season, rain fed *D. lablab* grown with bananas in Yatta had the highest infestation of adults of *M. sjostedti* with mean numbers of 211.6 ± 20.4, this was followed by; irrigated *D. lablab* grown alone (197.4 ± 16.7), irrigated *D. lablab* grown with bananas (126.2 ± 17.0), and rain fed *D. lablab* grown with pegion peas and sorghum (104.4 ± 18.7). These means were not significantly different ($F_{(5, 36)}$ =1.86; p>0.05) from each other (Table 4.29). Rain fed *D. lablab* grown with maize in Yatta had the lowest infestation of adults of *M. sjostedti* with mean numbers of 91.1 ± 14.4; while rain fed *D. lablab* grown alone was not attacked by *M. sjostedti* (Table 4.29).

In dry season, irrigated *D. lablab* grown with bananas in Meru had significantly higher ($F_{(3, 57)}$ =3.15; p<0.05) infestation levels of adults of *F. occidentallis* with mean numbers of 10.7 ± 2.0 compared to rain fed *D. lablab* grown with pegion peas and sorghum (2.6 ± 1.4) (Table 4.27). In dry season, rain fed *D. lablab* grown alone in Yatta had significantly higher ($F_{(3, 57)}$ =4.73; p<0.05) infestation levels of adults of *F. occidentallis* with mean numbers of 3.7 ± 3.2 compared to irrigated *D. lablab* grown alone with mean numbers of 2.0 ± 0.1 (Table 4.27).

In wet season, rain fed *D. lablab* grown with pegion peas and sorghum in Meru had the highest infestation of adults of *F. occidentallis* with mean numbers of 32.0 ± 6.0 compared to irrigated *D. lablab* grown with bananas (30.6 ± 4.2) though they did not differ significantly ($F_{(2, 30)}$ =1.08; p>0.05) from each other (Table 4.28). In wet season, irrigated *D. lablab* grown alone in Yatta had the highest infestation of adults of *F. occidentallis* with mean numbers of 25.6 ± 7.8. The lowest was irrigated *D. lablab* grown with bananas with mean numbers of 7.1 ± 6.4, but there was no significant difference ($F_{(5, 36)}$ =0.28; p>0.05) within

the means of counts of adults of *F. occidentallis* in all the cropping patterns in Yatta (Table 4.29).

In dry season, *F. schultzei* infestation in Meru was higher in irrigated *D. lablab* grown with bananas with mean numbers of adults of 10.0 ± 2.0 compared to rain fed *D. lablab* grown with pigeon peas and sorghum which had mean numbers of 7.4 ± 2.6. These two means were not significantly different ($F_{(3, 57)}$ =0.88; p>0.05) (Table 4.27) from each other. In dry season, rain fed *D. lablab* grown alone in Yatta had a higher infestation of adults of *F. schultzei* with mean numbers of 5.6 ± 3.3, compared to irrigated *D. lablab* grown alone which had mean numbers of 4.1 ± 2.2. The two means were not significantly ($F_{(3, 57)}$ =0.88; p>0.05) different (Table 4.27). In wet season, rain fed *D. lablab* grown with pigeon peas and sorghum in Meru had higher infestation of *F. schultzei* with mean of 14.0 ± 2.8 compared to irrigated *D. lablab* grown with bananas with mean numbers 7.8 ± 2.0 but the two means did not differ significantly ($F_{(2, 30)}$ =0.92; p>0.05). Rain fed *D. lablab* grown with bananas in Meru was not infested by adults of *F. schultzei* in wet season (Table 4.28). In wet season, irrigated *D. lablab* grown alone in Yatta had the highest infestation level of adults of *F. schultzei* with mean numbers of 8.9 ± 3.6, while rain fed *D. lablab* grown alone was not infested by *F. schultzei*, but there was no significant difference ($F_{(5, 36)}$ =0.39; p>0.05) in the means in all cropping patterns (Table 4.29).

In dry season, rain fed *D. lablab* grown with pigeon peas and sorghum had significantly higher ($F_{(3, 57)}$=2.77; p<0.05) infestation of *Hydatothrips* spp. with mean numbers of 9.0 ± 2.0 of adults compared to rain fed *D. lablab* grown alone which had mean numbers of 4.7 ±

1.6 of adults in Meru (Table 4.27). In Yatta, during the dry season, irrigated *D. lablab* grown alone had higher infestation of adults of *Hydatothrips* spp. with mean numbers of 3.3 ± 1.8 compared to rain fed *D. lablab* grown alone with mean numbers of adults of 2.7 ± 2.0, though the two means did not differ significantly ($F_{(3, 57)}$ =2.77; p>0.05) (Table 4.27). In wet season, rain fed *D. lablab* grown with bananas in Meru had the highest infestation of *Hydatothrips* spp. with mean numbers of adults of 14.4 ± 5.4 and was not significantly different ($F_{(2, 30)}$ =1.67; p>0.05) from irrigated *D. lablab* grown with bananas (2.9 ± 2.4) and rain fed *D. lablab* grown with pegion peas and sorghum (7.8 ± 3.0) (Table 4.28). In wet season, rain fed *D. lablab* grown with bananas in Yatta had the highest infestation of *Hydatothrips* spp. with mean numbers of 28.0 ± 4.9 of adults, but did not differ significantly ($F_{(5, 36)}$ =1.67; p>0.05) from the rest of the cropping patterns in this sub-county (Table 4.29).

**Table 4.28** Mean numbers ± (SE) of adults of various species of thrips in cropping patterns of *D. lablab* in Meru sub-county from November 2009 to February 2010 (wet season).

| | Mean numbers (±SE) per m² | | |
|---|---|---|---|
| Species of thrips | *D. lablab* with pegion peas and sorghum (Rain fed) | *D. lablab* with bananas (irrigated) | *D. lablab* with bananas (Rain fed) |
| *M. sjostedti* | 17.9 ± 4.4 a | 109.4 ± 10.2 b | 22.8 ± 8.6 a |
| *F. occidentalis* | 36.0 ± 6.0 b | 30.6 ± 4.2 b | 9.8 ± 2.8 a |
| *F. schultzei* | 14.0 ± 2.8 b | 7.8 ± 2.0 b | 0 a |
| *Hydatothrips* spp. | 7.8 ± 3.4 b | 2.9 ± 1.4 a | 14.4 ± 5.4 c |

Means with the same letter within the same row are not significantly different at p=0.05. Means separated using SNK test.

**Table 4.29** Mean numbers ± (SE) of adults of various species of thrips in different cropping patterns of *D. lablab* in Yatta sub-county from November 2009 to February 2010 (wet season).

| | Mean numbers (±SE) per m² | | | | | |
|---|---|---|---|---|---|---|
| Species of thrips | *D. lablab* with pigeon peas and sorghum (rain fed | *D. lablab* with bananas (irrigated) | *D. lablab* with bananas (rain fed) | *D. lablab* with maize (rain fed) | *D. lablab* plain (rain fed) | *D. lablab* plain (irrigated) |
| *M. sjostedti* | 104.9 ± 1.8 b | 126.2 ± 1.7 c | 211.6 ± 20.4 e | 91.1 ± 14.4 b | 0 a | 197.4 ± 16.7 d |
| *F. occidentalis* | 17.4 ± 4.4 c | 7.1 ± 4.4b | 8.4 ± 2.9 b | 10.0 ± 3.3 b | 0 a | 25.6 ± 7.8 c |
| *F. schultzei* | 7.0 ± 3.6 c | 3.3 ± 1.4 b | 3.9 ± 2.2 b | 3.3 ± 1.1 b | 0 a | 8.9 ± 3.6 c |
| *Hydatothrips* spp. | 2.6 ± 1.1 b | 4.0 ± 0.9 b | 28.0 ± 4.9 d | 6.7 ± 2.2 c | 0 a | 8.6 ± 4.4 c |

Means with the same letter within the same row are not significantly different at p=0.05. Means separated using SNK test.

### 4.6.1 Comparison of infestation rates of arthropod pest species different cropping patterns of *D. lablab*

In dry season, *Tetranychus* spp. infestation in the cropping patterns in Meru and Yatta had significance difference ($H_{(3)}$ =43.70; $p<0.05$) within the mean ranks (Table 4.30). Rain fed *D. lablab* grown with bananas in Meru had a higher infestation of *Tetranychus* spp. with a mean rank of 189.33 compared to rain fed *D. lablab* grown with pegion peas and sorghum (Table 4.30).

**Table 4.30** Mean - ranks of scores of insect pest in cropping patterns of *D. lablab* in Yatta and Meru central sub-counties between June and October 2009 (Dry season).

| | Mean - ranks of scores per $m^2$ | | | | | |
|---|---|---|---|---|---|---|
| location | Meru | | Yatta | | | |
| Cropping patterns<br><br>Arthropod pests | *D. lablab* with pegion peas and sorghum (rain fed) | *D. lablab* with bananas (irrigated) | *D. lablab* plain (irrigated) | *D. lablab* plain (rain fed) | H - value | Chi - square probability |
| Thrips | 169.60 | 169.55 | 113.17 | 176.96 | 48.13 | 0.001 |
| *Tetranychus* spp. | 103.79 | 189.33 | 161.09 | 125.00 | 43.70 | 0.001 |
| *Liriomyza* spp. | 109.19 | 166.51 | 193.12 | 106.62 | 48.13 | 0.001 |
| *Bemisia* spp. | 116.38 | 161.31 | 174.24 | 151.36 | 17.50 | 0.001 |
| *Aphis* spp. | 147.44 | 149.48 | 136.63 | 216.49 | 23.92 | 0.001 |

In dry season, irrigated *D. lablab* grown alone in Yatta had a higher infestation of *Tetranychus* spp. with a mean rank of 161.09 compared to rain fed *D. lablab* grown alone which had a mean rank of 125.00 (Table 4.30).

In wet season, irrigated *D. lablab* grown with bananas in Meru had the highest infestation of *Tetranychus* spp. with a mean rank of 227.25, this was followed by rain fed *D. lablab* grown with bananas with a mean rank of 136.95, while rain fed *D. lablab* grown with pegion peas and sorghum had the lowest mean rank of 123.18 (Table 4.31). In wet season, irrigated *D. lablab* grown alone in Yatta had the highest infestation level *Tetranychus* spp. with a mean rank of 286.47, this mean rank was followed by rain fed *D. lablab* grown with pegion peas and sorghum with a mean rank of 245.95, while *D. lablab* grown alone had the lowest infestation of *Tetranychus* spp. with a mean rank of 114.00 (Table 4.31).

In dry season, *Liriomyza* spp. infestation in the cropping patterns in Meru and Yatta had significance difference ($H_{(3)} = 43.13$; $p<0.05$) within the mean ranks (Table 4.30). In Meru, during the dry season, rain fed *D. lablab* grown with pegion peas and sorghum had higher infestation with a mean rank of 166.51 compared to irrigated *D. lablab* grown with bananas which had a mean rank of 109.79. During the dry season in Yatta, irrigated *D. lablab* grown alone had a higher infestation of *Liriomyza* spp. with a mean rank of 193.12 compared to rain fed *D. lablab* grown alone which had a mean rank of 106.62 (Table 4.30). In wet season, irrigated *D. lablab* grown with bananas in Meru had the highest infestation of *Liriomyza* spp. with a mean rank of 205.59 and was followed by rain fed *D. lablab* grown with pegion peas and sorghum (180.13). Rain fed *D. lablab* grown with bananas had the lowest *Liriomyza* spp. infestation with a mean rank 153.97 (Table 4.31).

In wet season, the infestation levels differed significantly ($H_{(8)}$ =36.55; p=0.001) within all the cropping patterns (Table 4.31). Irrigated *D. lablab* grown alone in Yatta had the highest infestation with a mean rank of 251.87 compared to; rain fed *D. lablab* grown with pegion peas and sorghum (233.77), rain fed *D. lablab* grown with bananas (198.15), rain fed *D. lablab* grown with bananas in Yatta (160.16) and rain fed *D. lablab* grown with maize (151.71). Rain fed *D. lablab* grown alone had the lowest mean rank of 77.55 (Table 4.31).

In dry season, irrigated *D. lablab* grown with bananas in Meru had a higher infestation of *Bemisia* spp. with a mean rank of 161.31 compared to rain fed *D. lablab* grown with pigeon peas and sorghum which had a mean rank of 116.38 (Table 4.30). In dry season, irrigated *D. lablab* grown alone in Yatta had a higher infestation of *Bemisia* spp. with a mean rank of 174.24 compared to rain fed *D. lablab* grown alone which had a mean rank of 151.36 (Table 4.30). In wet season, rain fed *D. lablab* grown with pegion peas and sorghum in Meru had the highest infestation of *Bemisia* spp. with a mean rank of 248.90 and was followed by rain fed *D. lablab* grown with bananas (235.00), while irrigated *D. lablab* grown with bananas had the lowest *Bemisia* spp. infestation with a mean rank 147.07 (Table 4.31). In the wet season, rain fed *D. lablab* grown with maize in Yatta had the highest infestation level of *Bemisia* spp. with a mean rank of 217.41, followed by rain fed *D. lablab* grown with bananas with a mean rank of 214.90, while rain fed *D. lablab* grown with pigeon peas and sorghum had a mean rank of 208.25. Irrigated and rain fed *D. lablab* grown alone in Yatta had mean ranks of 116.25 and 73.00 respectively (Table 4.31).

**Table 4.31** Mean- ranks of scores of arthropod pests' species in different cropping patterns of *D. lablab* in Meru central and Yatta sub-counties from November 2009 to February 2010 (wet season).

| | Mean - ranks of scores per $m^2$ | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| location | Meru | | | Yatta | | | | | | | |
| Intercrop / Insect species | *D. lablab* with pigeon peas & sorghum (rain fed) | *D. lablab* with bananas (irrigated) | *D. lablab* with bananas (rain fed) | *D. lablab* with pigeon peas & sorghum (rain fed) | *D. lablab* with bananas (irrigated) | *D. lablab* with bananas (rain fed) | *D. lablab* with maize (rainfed) | *D. lablab* Plain (rainfed) | *D. lablab* Plain (irrigated) | H-value | Chi – square probability |
| Thrips | 100.68 | 222.49 | 102.30 | 229.98 | 234.50 | 210.76 | 163.00 | 73.90 | 271.10 | 86.75 | 0.001 |
| *Tetranychus spp.* | 123.18 | 227.25 | 136.95 | 245.95 | 186.03 | 129.22 | 159.80 | 114.00 | 286.47 | 83.40 | 0.001 |
| *Liriomyza spp.* | 180.13 | 205.59 | 153.97 | 233.77 | 198.15 | 160.16 | 151.71 | 77.50 | 251.87 | 36.55 | 0.001 |
| *Bemisia spp.* | 240.10 | 147.07 | 235.00 | 208.25 | 183.29 | 214.90 | 217.41 | 73.00 | 116.25 | 56.57 | 0.001 |
| *Aphis spp.* | 218.55 | 125.50 | 230.20 | 143.22 | 212.19 | 248.90 | 220.16 | 195.60 | 188.20 | 57.69 | 0.001 |

In dry season, irrigated *D. lablab* grown with bananas in Meru had a higher infestation of *Aphis* spp. with a mean rank of 149.48 compared to rain fed *D. lablab* grown with pigeon peas and sorghum which had a mean rank of 147.44 (Table 4.31). In the dry season, rain fed *D. lablab* grown alone in Yatta had a higher infestation of *Aphis* spp. with a mean rank of 216.49 compared to irrigated *D. lablab* grown alone which had a mean rank of 136.63 (Table 4.30).

In wet season, rain fed *D. lablab* grown with bananas in Meru had the highest infestation of *Aphis* spp. with a mean rank of 230.20 and was followed by rain fed *D. lablab* grown with pegion peas and sorghum (218.55). Irrigated *D. lablab* grown with bananas in Meru had the lowest *Aphis* spp. infestation with a mean rank 125.50 (Table 4.31). In wet season, rain fed *D. lablab* grown with bananas in Yatta had the highest infestation level of *Aphis* spp. with a mean rank of 248.90, followed by rain fed *D. lablab* grown with maize rain fed with a mean rank of 220.16, while irrigated *D. lablab* grown with bananas had a mean rank of 212.19 (Table 4.31). Rain fed and irrigated *D. lablab* grown alone in Yatta had mean ranks of 195.60 and 188.20 respectively, while rain fed *D. lablab* grown with pigeon peas and sorghum had a mean rank of 143.22 (Table 4.31).

# CHAPTER FIVE

# DISCUSSION, CONLUSIONS AND RECOMMENDATIONS

## 5.1 Arthropod pest species composition in Meru central and Yatta sub-counties

Results revealed that a complex of thirteen species of arthropod pests and mites were found infesting and damaging the crop in Meru central and Yatta sub-counties, during the dry and wet seasons and in irrigated (vegetable type) and rain fed (grain type) *D. lablab*. Sucking arthropod pests had high frequency of occurrence (rated 1) compared to the pod borers and defoliators. The sucking arthropod pests recorded included; pod sucking bugs (*Clavigralla* spp) in the order hemiptera, thrips (*Megalurothrips sjostedti* (Trybom), *Frankliniella occidentallis* (Pergande), *Frankliniella schultzei* (Pergande), *Hydatothrips* spp.) in the order thysanoptera and family thripidae, white flies (*Bemisia* spp.), aphids (*Aphis* spp.) and spider mites (*Tetranychus* spp.). These were followed by pod borers, which included; *Helicoverpa amigera* (Hubner) and *Maruca testulalis* (Fabricius) which had medium frequency of accurence and rated 3. Leaf miners (*Liriomyza* spp.) had medium frequency of accurence and rated 3. Flower beetles (*Mylabris* spp.), leaf beetles (*Apion* spp.), and grasshoppers (*Melanoplus* spp.) were also recorded and had low frequency of occurrence and rated 4. These results agree with the findings of Thejaswi *et al.* (2007) and Rekhas 2005 who reported similar arthropod pests composition in *Dolichos lablab* in India and Kamau *et al.* (2010) in Kenya.

*H. amigera* was reported to bore clean and circular holes with one larvae damaging several pods and causing them to wilt (Sporadic infestation) (Rekhas, 2005). Rekhas (2005) also reported that *M. testulalis* laid eggs individually on the young shoots of the crop and flower

buds where they hatched to 1st instar larvae eat their way into the tender growing shoots where they are protected from larval parastoids and other natural enemies such as ants and beetles. The young larvae were also found boring into the half matured pods a feeding habit that was reported by Yucheng *et al.* (2003), Rekhas (2005) and Thejaswi *et al.* (2007). Thejaswi *et al.* (2007) also reported that the young larvae of *H. amigera* entered into the seeds and fed on the contents of pods remaining inside whereas, the grown up larvae caused damage by excavating the seeds. The infested pods when opened revealed the presence of caterpillars and excretory pellets and few silken threads a condition that was also reported by Rekhas (2005). Unlike *H. amigera, M. testulalis* made webs holding together flowers, pods and leaves, a phenomenon that was also reported by Reed *et al.* (1989).

The thrips (*Megalurothrips sjotedt* (Trybom), *Frankliniella occidentallis* (pergande), *Frankliniella schultzei* (Trybom) *and Hydatothrips* spp.) were common sucking arthropod pests in *Dolichos lablab* in both Meru and Yatta. *Hydatothrips* spp. was on the surface of young fresh leaves and had a characteristic of being inactive. This behaviour was also reported by Gitonga (1999) when he studied the bio ecology of thrips in french beans in agro ecosystems central and upper eastern Kenya. The thrips infestation on *D. lablab* was characterized by streaking on the shoots, flowers and scarification and malformation of the pods. In severe thrips attack the flower buds did not open and together with the young pods prematurely aborted. These findings corroborate with the findings of Thejaswi *et al.* (2007).

The infestation of *Clavigralla* spp. was manifested by tiny depressions on the pods wall and seed coat, an observation that agrees with the findings of Reed *et al.* (1989). In severe

conditions as it was in farm 6 and 8, the seeds shriveled and lost viability or the whole pod shriveled a condition that was also observed by Rekha and Mallapur (2009). Rekha and Mallapur (2009) also reported that the feeding behavior of these sucking bugs on developing shoots lead to distortion; poor growth and shoot die back.The flower beetles fed on the flowers of *Dolichos lablab* and interfered with fertilization and greatly reduced the number of the pods that were formed. These results agree with the finding of Rekha and Mallapur (2009) and Thejaswi *et al.* (2007) who found that the flower beetles fed on the flowers of *D. lablab* and resulted to low yields.

The red spider mites, *Tetranychus* spp. (Acarina) are mites that are highly polyphagous infesting all the major crops in Kenya (Stiller, 2003). The damage of *Tetranychus* spp. was evident by the clusters of yellow spots on the upper surface of the leaves and webs formation on the lower surface of the leaves with all the developmental stages. These findings agree with Kaimal and Ramani (2011) who observed yellow clusters on the leaves of *D. lablab* infested by *Tetranychus* spp. The spider mites feeding behavior reduces the rate of photosynthesis, which results to reduced production of the crop. This observation was also reported by Varela *et al.* (2003).

*Liriomyza* spp. is a polyphagous pest that infests cultivated crops such as French beans, sugar snap peas, snow peas and other vegetable crops as reported by Weintraub and Horowitz (1995). The leaf miners were found to tunnel between the lower and the upper epidermis of the leaves (the spongy mesophyl layer of the leaves). Seif *et al.* (2001) reported that this

feeding behavior reduces the ability of the plant to photosynthesize and leads to low growth rate and subsequent low quantity and quality of the crop.

**5.2 Comparison of diversity and infestation levels of arthropod pest species of *D. lablab* in Meru central and Yatta sub-counties**

Results revealed that many of the arthropod pests' infestation levels did not have significant difference between the two sub-counties; however, infestation levels of others were significantly different between the two sub-counties. *Clavigralla* spp., *Liriomyza* spp., *Bemisia* spp., *and Aphis* spp. were significantly higher in Meru central than Yatta, while *M. testulalis, F. occidentallis, F. schultzei and Melanoplus spp.* were significantly higher in Yatta than Meru central. *Melanoplus spp.* was significantly higher in Yatta than in Meru. The findings of Sithananthan *et al.* (2002) agree with these results because they found out that arthropod pests' infestation level and damage varies between crops, regions, and between seasons.

In both Meru central and yatta sub-counties of eastern province, Whiteflies were found to infest *D. lablab*. These findings are in line with the findings by Mohammed *et al.* (1999) who reported that white flies were major insect pest of legumes in the dry parts of Kenya. White flies infestation in Yatta was significantly higher than Meru central, this is because the altitude inYatta study sites (1240m – 1320m) was higher than Meru (880m – 1038m), Mohammed *et al.* (1999) and Koppert (2003) found that, *Bemisia* spp. survival is temperature depedent due to difference in altitude. At higher temperature (28°c - 30°c) the adult female lived for 10 to 15 days, but for lower temperatures the female adult would live for one to two months. *Bemisia* spp. caused direct damage to plants by sucking plant sap and removing

plant nutrients, there by weakening the plants. This effect of infestation of *Bemisia* spp. was also reported by Reddy *et al.* (2003). In both Meru central and yatta sub-counties of eastern region of Kenya, *Aphis* spp. was found to infest *D. lablab*; these results corroborate the findings of Kamau *et al.* (2010), where they found that *Aphis* spp. was an important pest of *D. lablab* in eastern region of Kenya. Aphids (*Aphis* spp. Homoptera) were more abundant in Yatta than in Meru. Yatta is at a higher altitude and therefore hotter and humid than Meru and this explains why there was higher aphids infestation level in Yatta than in Meru. This condition was also reported by Nampala *et al.* (2002) and Hassan *et al.* (2009). In the two sub-counties aphids had not infested all the farms, Thejaswi *et al.* (2007) found that aphids' colonies do not occur uniformly across the fields. Rekhas (2005) and Varela *et al.* (2003) found that *Aphis* spp. colonies preferred to attack the inflorescence, tender pods and also the terminal twigs resulting in twisting of pods and stunted plant growth. Further more Thejaswi *et al.* (2007) and Varela *et al.* (2003) found that aphids fed by sucking the plant sap, which resulted to wrinkled leaves, stunted growth and pods became deformed. The Grasshoppers found attacking *D. lablab* were mainly *Melanoplus* spp. and *Acrida* spp. but *Melanoplus* spp. were more abundant. They were mainly defoliators, feeding on the leaves where they greatly reduced the photosynthetic area. *Melanoplus* spp. was mainly found infesting the rain fed *D. lablab* in the wet season.

### 5.3 Effects of dry and wet seasons on diversity and infestation levels of arthropod pest species attacking *D. lablab* in Meru central and Yatta sub-counties

Results in effects of dry and wet seasons on diversity revealed that the Shannon diversity index in Meru for both seasons was 4.0 while in Yatta for both seasons was 3.9. This is because most of the arthropod pest species recorded were polyphagous and therefore well

distributed within the two seasons in both Meru central and Yatta sub-counties. These results are in line with the findings of Thejaswi *et al.* (2007) who reported that the arthropod pests were evenly distributed among the others in dry and wet seasons in Karntaka India. Results on effects of dry and wet seasons on infestation levels revealed that the levels of infestation were different for different arthropod pest species in the two sub-counties; *H. amigera, Clavigralla* spp., *Mylabris* spp., *Frankliniella occidentallis, Liriomyza* spp. *and Bemisia* spp.were significantly higher in dry season than wet season in both sub-counties. Zahid *et al.* (2008) reported that dry and hot conditions in the dry season allow *H. amigera* larvae to winter-over in areas where they are now limited by cold, thus causing greater infestation during the following crop season. The low number of the early instars larvae of *H. amigera.* during the month of July and august and increased in the month of September was due to the fact that, the early instars larvae have less tolerance to prevailing cool temperature, this was also reported by Zahid and Mohammed (2005).This is why infestation level of *H. amigera* was significantly higher in wet season than dry season.

All the thrips species infestation levels were significantly higher in wet season than dry season. These difference in thrips population in the two seasons could have been due to the previous dry season followed by the wet season where the dry season supported less vegetation and lowerd the thrips host range compared with the second and wet season, this agrees with the findings of Kasina *et al.* (2009) who reported similar phenominone in the French beans. The infestation of *M. sjostedti* generally declined towards the end of the dry season because the crop continued drying due to the drought that led to failure of the crop to produce new shoots and flowers for the thrips oviposition and feeding. This agrees with the findings of Stiller (2003) who reported that shoots and flowers were parts of the plants used

by the thrips oviposition and feeding. These findings are also in line with the findings of Rekhas (2005) in the studies of status and seasonal dynamics of arthropod pest species attacking *D. lablab*, who found that the total number of thrips trapped in the wet season, was higher compared with the first dry season.

The population of *Clavigralla* spp. increased in June up to mid august this is because there was little moisture in the soil due to the drought that prevailed and the harvesting of the crop had started and this left few shoots and pods remaining for infestation. This population dynamics of *Clavigralla* spp. was also reported by Thejaswi *et al.* (2007). Results on effects of dry and wet seasons also revealed that the mean numbers of *Clavigralla* spp. was significantly higher in wet season than in dry season. This phenominone was also reported by Thippeswamy and Rajagopal (1998) in the studies of the incidence of heteropteran bugs on *D. lablab* in Karnata India. Thippeswamy and Rajagopal (1998) reported that the total number of *Clavigralla* spp. in the wet season was higher compared with the dry season. The wet season also supported more vegetation which provided a wide range of plant host range hence increased insect pest population. This is due to the fact that most of the arthropod pests recorded are in *D. lablab* are polyphagous. The results also revealed that *Melanoplus* spp. was found infesting the crop during the wet season. This agrees with the findings of Koppert, (2003), who reported that *Melanoplus* spp. laid eggs at the summer and the eggs hatch when moisture is available and hatching is determined by the availability of moisture in the siol where the eggs are laid.

**5.4 Effects of irrigation (vegetable type) and rain fed (grain type) conditions on infestation levels of arthropod pest species attacking *D. lablab* in Meru and Yatta sub-counties**

Results on effects of irrigation and rain fed effects on infestation levels revealed that pod borers (*H. amigera* and *M. testulalis*) had significantly higher infestation levels in rain fed *D. lablab* compared to irrigated *D. lablab*. This was because the green pods attacked by these pod borers remained on the farm while fresh untill they dried, unlike the irrigated system where the fresh green pods were harvested once in a week. In both systems and sub-counties there were serious infestations which were above the economic injury levels of two larvae per plant. This observations were in line with observations made by Rekhas (2005). The relative humidity was high in Meru due to irrigation and high temperature in the month of September; this suggests why the *H. amigera* infestation levels increased in September and it agrees with the result of Zahid *et al.* (2008), Mallikarjunappa (1989) and Rekhas (2005) who reported that the peak period of infestation was observed from December to February and declined as the summer advanced and the pest become almost inactive during May, when high temperature prevailed.

Results also revealed that thrips infestation was significantly higher in irrigated *D. lablab* compared to rain fed *D. lablab*. Irrigation provided good growing conditions for the *D. lablab* plants to ensure rapid growth and this provided enough shoots and flowers for feeding from. This is in line with the findings by Kasina *et al.* (2009) who found that flower thrips infestation was high in the shoots and flowers compared to other parts of the crop. However, environmental stress such as drought weakens plants and makes them more susceptible to thrips attack. This explains why the *M. sjostedti* infestation levels were high in rain fed *D.*

*lablab*. This phenomenon was also observed by Gitonga (1999) in French beans who reported that plants under water stress are very susceptible to direct thrips damage. *Megalurothrips sjostedti* is widely spread in sub Saharan Africa and highly polyphagous in the family *leguminosea*. This suggests why *M. sjostedti* was more abundant than the other thrip species.

Sucking bugs were mainly the *Clavigralla* spp. and there infestation was significantly higher in rain fed *D. lablab* (Grain type) than irrigated *D. lablab* (Vegetable type). This can be associated with the continuous chemical control and harvesting of the crop, a phenominone that was observed by Seif *et al.* (2001) in French beans, who reported that in an effort to control the flower sucking arthropod pest species such as *M. sjostedti*, the sucking bugs were also controlled.

The red spider mites, *Tetranychus* spp. (Acarina) is a mite that is highly polyphagous infesting all the major crops in Kenya (Reed *et al.*, 1989). The increase in the infestation in Yatta and Meru in august and September was due to the increase in temperature and relative humidity due to continued irrigation. This trend was also reported by Koppert (2003). Spider mites are controlled by naturally occurring arthropod enemies and fungal infection (predator spider mites, fungal infection and insects). However, when there are prolonged periods of low humidity (dry season), the fungus is suppressed, allowing the spider mite population to proliferate (Koppert, 2003), a condition that prevailed in the dry season.

The leaf miners (*Liriomyza* spp.) were also important insect pest attacking irrigated *D. lablab*. Its infestation was significantly higher in irrigated *D. lablab* compared with rain fed *D. lablab*. Irrigated *D. lablab* had fresh and succulent leaves, a condition preferred by the

*liriomyza* spp. these results corroborate with the findings by Weintraub and Horowitz (1995) and Chabi *et al.* (2008) who reported that irrigation coupled with high temperatures led to the increased infestation of *Liriomyza* spp. Whiteflies (*Bemisia spp.* (Homoptera) infestation level was also higher in irrigated *D. lablab* compared with rain fed *D. lablab*. In the irrigated *D. lablab* (vegetable type), the relative humidity was high due to irrigation and temperature during this season was equally high, this suggests why the population of whiteflies remained high in irrigated conditions. These agrees with the findings by Koppert (2003) and Muchemi (2000), who reported that Low humidity, dry conditions and high temperatures led to low or no infestation of *Bemisia* spp. in the rain fed conditions.

**5.5 Differences in infestation levels of arthropod pest species attacking rain fed *D. lablab* at different phenological stages in Meru central and Yatta sub-counties**

The observations of the insect pest in Yatta and Meru sub-counties over the two cropping seasons provided the baseline information on insect dynamics, the critical phenological stage of insect pest infestation and the appropriate time for the crop protection. The results on differences in infestation levels in different phenological stages showed that arthropod pest species occurred at different times of crop growth and there was a trend of most arthropod pest species to increase from low infestation levels to high infestations levels at the flowering and podding growth stage.

*Aphis* spp., *Bemisia* spp. and *Tetranychus* spp. infested the crop in all stages of growth of *D. lablab*. The arthropod pests infested the crop at different growth stages of the crop even when their populations were controlled by climatic factors and natural enemies. This trend was also reported by Muchemi (2000). *H. amigera* was a serious insect pest of *D. lablab* and was

found to infest the crop at the flowering and podding stage in the dry and wet seasons. Rekhas (2005) reported that *H. amigera* infestation can start in seedling stage as defoliators and may not cause economic damage to *D. lablab*. The flowering and podding stage at which they infested the crop was critical as the infestation resulted in significant damage to the quality and quantity of pods. The study of seasonal infestation level of *D. lablab* arthropod pests in India (Karnataka) by Thejaswi *et al.* (2007) made similar observations. *H. amigera* begun oviposting at the vegetative and flower budding stage of *D. lablab*, an observation made by Reed *et al.* (1989) when he studied the arthropod pests infesting French beans in the tropics. *Maruca testulalis* infestation started at the vegetative and flower budding phenological stage in both irrigated and rain fed *D. lablab* and in both sub-counties. The first instar larvae were found to bore holes in the flower buds and made silk web on the flowers. This feeding habit was also reported by Yucheng, *et al.* (2003).

*Mylabris* spp. (flower beetles) infestation started at the vegetative and flower budding. At the flowering and podding stage *Mylabris* spp. was a major pest damaging the flowers and reduced the number of pods born from one shoot. These findings were also reported by Rekhas (2005). *Clavigralla* spp. infestation started at the vegetative stage of *D. lablab* with the highest infestation of the nymphs and adults found at the flowering and podding stage of the crop. Thejaswi *et al.* (2007) found that the stage at which *Clavigralla* spp. infests the crop is critical as the infestation resulted in significant damage to the quality and quantity of pods.

*Megalurothrips sjostedti*, *Frankliniella occidentallis* and *Frankliniella schultzei* were common thrip species of importance in *D. lablab* and started their infestation at the

vegetative stage. *Megalurothrips sjostedti* and *Frankliniella occidentallis* were mainly found on the flowers, a condition that was also reported by Seif *et al.* (2001) and Varela *et al.* (2003). Their infestation increased to the peak at the flowering and podding stage where most of the thrips were found in the flowers, this observation was in line with the studies done by Gitonga (1990) when he studied the bio ecology of thrips on French beans. *Megalurothrips sjostedti* were more abundant in the flowers than the two *Frankliniella* species, a phenomenon that was also found by Muchemi (2000). *Hydatothrips* spp. were mainly found on the leaves and there infestation started at the seedling stage of *D. lablab*. *Frankliniella occidentallis* were found to thrive well on the young leaves of shoots, unlike *M. sjostedti* which only inhabited flower buds and flowers. These results conform to the findings of Kasina *et al.* (2009) in the studies of seasonal population dynamics of the flower thrips in French beans. Kasina *et al.* (2009) reported that, in crop development the *Frankliniella occidentallis* can only forage on vegetative plant parts when the crop has not flowered. As adults are known to prefer flowers (Kirk, 1997), they probably lay their eggs and then fly to plants parts with flowers. Kasina *et al.* (2009) reported that *Frankliniella occidentalis* infest fast growing parts of a host crop because they are high in nitrogen. Similarly, during the vegetative and flower budding phase of the crop, *M. sjostedti* were found on the terminal buds from where they moved to the flowers immediately after the onset of flowering. Petioles, leaves, flower buds, flowers and pods were used as oviposition substrates by the thrips to varying extents. These observations agree with the observations made by Thejaswi *et al.* (2007) in the studies on arthropod pest species population dynamics in *D. lablab* Karnataka India and Gitonga (1999) in the studies on the bio ecology of thrips on french beans in Kenya. *Apion* spp. and *Melanoplus* spp. were mainly infesting the crop at the

seedling and vegetative stage of *D. lablab* in both sub-counties and systems. These two arthropod pests were mainly defoliators whose damage had no economic implications.

**5.6 Comparison of infestation levels of arthropod pest species in cropping patterns of *D. lablab* in Meru central and Yatta sub-counties**

During the two seasons and in both sub-counties, cropping combinations significantly influenced infestation and severity of the major *D. lablab* arthropod pests. Nampala *et al.* (2002) reported that crops grown simultaneously enhance the infestation level of predators and parasites, which in turn prevent the build-up of arthropod pests, thus minimizing the need of using expensive and dangerous chemical insecticides. This explains why irrigated *D. lablab* grown alone had a higher infestation of thrips compared to irrigated *D. lablab* grown with sorghum and pegion peas in season two. Lithourgidis (2011) reported that the worsening of most arthropod pest species problems has been associated with the expansion of monocultures at the expense of the natural vegetation, there by decreasing local habitat diversity. Lithourgidis (2011) findings explain why infestation of *M. testulalis* larvae was highest in farms where irrigated *D. lablab* was grown alone in Yatta. Sorghum seems to be a better 'natural control' plant than maize because it is more attractive to *H. amigera*, and attracts more anthocorid bugs during flowering which are parasitoids of *H. amigera* a phenomenon that Sithananthan *et al.* (2002) also reported. Sorghum varieties are better adapted than maize to the dry climatic conditions similar to those of Meru central and Yatta sub-counties. According to Nampala *et al.* (2002) in studies of this pest and its natural enemies in legumes, maize and sorghum in Kenya, the survival of *H. amigera* is low in maize and sorghum.

The results also revealed that thrips infestation was significantly higher in irrigated *D. lablab* grown with bananas compared to other cropping patterns. This was due to the effects of shading the *D. lablab* crop by the banana crop which influenced the infestation level and activity of the thrips. However, thrips reduction is not necessarily translated in yield increase; for instance, Nampala *et al.* (2002) also reported that sorghum intercrops with legumes may increase the thrips infestation but reduce the effects of thrips damage to the legumes. The effect of intercropping on thrips numbers and damage depends, among other factors, on the selection of plants.

*Megalurothrips sjostedti* and *Frankliniella occidentallis* infestation was lowest in rain fed *D. lablab* grown with pigeon peas and sorghum this was due to the redistribution of the thrips among the crops since it is polyphagous. This was also reported by Nampala *et al.* (2002). Nampala *et al.* (2002) found that in Kenya, populations of the African flower thrips *M. sjostedti* and *F. occidentallis* on cowpea buds were almost halved by intercropping the cowpea with sorghum and maize, but although thrips infestation was not halved in rain fed *D. lablab* grown with sorghum and pegion peas, the infestation reduced significantly in farm 3 in Meru.

The *Clavigralla* spp. infestation was significantly higher in rain fed *D. lablab* intercropped with pigeon peas and sorghum probably because pigeon peas is a major host of *Clavigralla* spp. This is as it was observed by Reed *et al.* (1989). This phenomenon was consisted in the two cropping seasons. Nampala *et al.* 2002 attributed the high infestation of pod sucking bugs on legumes that were intercropped with sorghum to the fact that sorghum is not a known host of the sucking bugs.

## 5.7 Conclusions

1. A variety of arthropod pest species that included; *Clavigralla* spp. (Hemiptera), thrips; *M. sjostedti*, *F. occidentallis* *F. schultzei*, and *Hydatothrips* spp., (Thysanoptera), *Bemisia* spp. (Diptera) and *Tetranychus* spp. (Acarina) pod borers, which included; *H. amigera* and *M. testulalis* (lepidoptera) while the defoliators were *Liriomyza spp.*, (Diptera) *Mylabris* spp., *Apion* spp. (coleoptera) and *Melanoplus* spp. (Orthoptera) were found attacking *D. lablab* in Meru and Yatta sub-counties of eastern region of Kenya.

2. *Frankliniella occidentallis*, *F. schultzei* and *Melanoplus spp.* infestation levels were significantly higher in Meru than in Yatta, while *Liriomyza* spp., *Bemisia* spp. and *Aphis* spp. infestation was significantly higher in Yatta than in Meru.

3. In Meru central, *H. amigera*, *Clavigralla* spp., *Liriomyza* spp., *Bemisia* spp. and *Aphis* spp. infestation levels were significantly higher in the wet season than the dry season, while *M. sjostedti* infestation was significantly higher in dry season than in the wet season.

4. In Yatta, *M. sjostedti*, *H. amigera*, *Mylabris* spp., *Clavigralla* spp., *Liriomyza* spp., *Bemisia* spp., *Aphis* spp. and *F. occidentallis* infestation levels were significantly higher in the wet season than the dry season.

5. *Megalurothrips sjostedti*, *F. occidentallis* and *F. schultzei* infestation levels were significantly higher in irrigated *D. lablab* (vegetable type) than rain fed *D lablab* (grain type) in both Meru central and Yatta sub-counties.

6. All the arthropod pest species recorded in rain fed *D. lablab* (*Megalurothrips sjostedti, F. occidentallis, F. schultzei, H. amigera, Clavigralla* spp. *Mylabris* spp.) started their infestation at the vegetative phenological stage except *liriomyza* spp., *Bemisia* spp. and *Aphis* spp whose infestation started at the seedling phenological stage.

7. The population of sucking arthropod pests for instance Thrips, whiteflies and spider mites were significantly higher in *D. lablab* intercropped with bananas compared to other intercrops.

## 5.8 Recommendations

The results obtained from this study provide basic information on the insect pest species attacking *D. lablab* during wet and dry seasons, in irrigated (vegetable type) and rain fed (grain type), at different phenological stages and different cropping patterns. The information obtained will form an important basis for further research work in trying to look for appropriate control measures of arthropod pests associated with the crop in order to reduce damage caused to this crop, and achieve its economic potential in Kenya. It is on this basis that the following recommendations and suggestions for further research were arrived at.

### 5.8.1 Recommendations to Farmers

1. During the wet season, control of most of the arthropod pests should be intiated during the vegetative and flowering stage of growth.

2. Control of *Clavigralla* spp. should start at the vegetative stage in both Meru and Yatta sub-counties.

3. Thrips should be controlled during the vegetative stage of *D. lablab* to avoid infestation at the flowering and podding stage especially for vegetable type of *D. lablab* to avoid distortion of the pods which are rejected in the export market.

4. *Mylabris* spp. is a major pest of *D. lablab* at the flowering and podding stage and should be controlled during the vegetative and flower budding stage.

5. *Bemisia* spp., *Aphis* spp. and *Liriomyza* spp. infest the crop in all the stages of development and therefore these arthropod pests sould be controlled throughout the growing period of *D. lablab*.

6. Farmers should avoid intercropping *D. lablab* with bananas as shading of the bananas provided cool conditions that enabled the thrips, whiteflies, and spider mites to thrive.

### 5.8.2 Suggestions for further studies

1. To study biology and life history of the arthropod pests before intiating control measures.
2. Further field studies on the effects of popular *D. lablab* intercrops on infestation levels of the recorded major arthropod pests and yield loss due to these arthropod pests.
3. *D. lablab* varietal host preference of the recorded major arthropod pests attacking *D. lablab*
4. Assessing the physiological impact of insect pest infestation and its implications on plant development and growth since this may provide a better indication of the processes involved in yield reduction especially in a complex multitude pest infestation like the one in *D. lablab*.

5. Diversity of natural enemies of the major arthropod pests documented on *D. lablab* and how they can be used in integrated pest management.

6 Effectiveness of common insecticides used by farmers in control of the major arthropod pests in *D. lablab*.

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**Appendix I**

**Global positioning system readings of study sites**

| Location and site number | | Farmers name | Altitude | Latitude | Longitude |
|---|---|---|---|---|---|
| Mitunguu (irrigated) | 01 | Kinyua | 1038 | S00.12188 | E037.77564 |
| | 02 | Kinyua | 1013 | S00.12087 | E037.77485 |
| | 03 | Muriuki | 1013 | S00.12087 | E037.77485 |
| | 04 | Mbaabu | 1137 | S00.09920 | E037.9914 |
| Makandune | 05 | Margaret | 907 | S00.07963 | E037.83609 |
| (non irrigated) | 06 | Joshua | 930 | S00.07536 | E037.82539 |
| | 07 | Mitwiri | 936 | S00.07260 | E037.82693 |
| | 08 | Mati | 884 | S00.09965 | E037.82476 |
| Kithimani (irrigated) | 09 | Boniface | 1277 | S01.16008 | E037.51110 |
| | 10 | Kisilu | 1272 | S01.17286 | E037.50438 |
| | 11 | Kang'ethe | 1270 | S01.18455 | E037.48956 |
| | 12 | Mutiso | 1293 | S01.18169 | E037.47324 |
| Matuu (non irrigated) | 13 | Msambune | 1241 | S01.14670 | E37.53041 |
| | 14 | Mwaamu | 1264 | S01.16557 | E037.56424 |
| | 15 | Muthengi | 1265 | S01.16356 | EO37.5593 |
| | 16 | Mwangangi | 1316 | S01.16785 | E037.43489 |

**Appendix II**

# DOLICHOS LABLAB FIELD RECORD SHEET

Farmers Name .....
Location .....
Date: .....

Name of recorder: .....
Crop Type .....
Phenological stage .....

| | | Pod borers | | | | | | Sucking bugs | | | | | Thrips | | | | | | Damage score | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *H. amigera.* | | | | *M. testulalis* | | | Eggs masses | Nymphs | Adults | Pods dam | Flower beetle | T A | T B | T C | T D | I M | Dam score | Leaf miner | White fly | Aphids | Leaf rust | P mildew | D mildew | Bacterial blight | Pods dam | Apion spp | Mel spp |
| St. no. | eggs | larvae | | Pod dam | eggs | larvae | | Pod dam | | | | | | | | | | | | | | | | | | | | |
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***Helicoverpa & Maruca;***
Eggs & larvae of *Helicoverpa & maruca* actual counts
Damaged pods by *H. amigera and M. testulalis* actual counts
**Sucking bugs**; eggs masses, nymphs adults & damaged pods actual counts
**Flower beetles;**
Actual count of the adults
**Thrips;**
TA– Black with white bands on the abdomen
TB – yelowshih orange
TC – lazy, smaller than TA, dark brown and with white bands on the abdomen
KEY:St. no – Station number
SL – Small larvae1st – 3rd instar
D. Mildew – down mildew
GT – Grand total IM – immature
Male spp. – Melanoplus spp.

TD – ivory colour
Thrips overall damage score;
0 clean
1 Few slippery streaks on buds/pods
2 heavy streaking on flower buds/pod and presence of feeding nymphs & adults
**Aphids;**
0 = clean
2 = one/two adults
2 = many adults and nymphs
3 = black mould
**Spider mites**:
Damage score
II – Large Larvae 4th – 6th instar
Dam – Damage

0 = clean
1 = slight mottling of leaves
2 = presence of live mites & eggs on the lower leaf surface
**Leaf miner;**
Damage score
0 = Clean
1 = few feeding &oviposition punctures
2 = many punctures & mines
**White flies;**
Damage score
0 = clean
1 = one/two adults and few eggs
2 = Many adults and nymphs