ASSESSMENT ON THE EFFECTS OF INTERCROPPING PATTERNS ON INCIDENCE AND DAMAGE TO COTTON BY *DIAPAROPSIS CASTANEA*: HAMPSON (LEPIDOPTERA: NOCTUIDAE) IN MAGOYE, MAZABUKA DISTRICT OF ZAMBIA

[1] M. Chijikwa, [1] P.O. Y Nkunika & [2]B Siamasonta

[1] University of Zambia, P.o Box 32379, Lusaka, Zambia; [2] Cotton Development Trust, P.O. Box 670057, Mazabuka, Zambia

E-mail: chilala28@gmail.com; pnkunika@unza.zm, cdt@zamnet.zm

ABSTRACT

The Red bollworm, Diaparopsis castanea (Hampson) is an insect that has gone from being a minor cotton pest to being a major pest of cotton in Zambia. This study was conducted in Magoye, Mazabuka district, Zambia to assess the effects of intercropping patterns on the incidence and damage caused to cotton by D. castanea. The first part of the study involved conducting a survey among 80 randomly selected farmers in Magoye to determine the different types of intercropping patterns being used in the area. The second part of the study was an experimental field study to assess various intercropping patterns identified in the survey. The experiment was laid out in a randomized block design with four replications. Cotton cultivar CDT II (Gossypium hirsutum) was sown by hand in 100-cm spaced single rows. The intercrops selected were maize (Zea mays L.), sorghum (Sorghum vulgare L.) pigeon pea (Cajanus cajan L.), cowpea (Vigna unguiculata L.) and sunflower (Helianthus annus L.). The data collected was subjected to analysis of variance (ANOVA) technique and LSD using GenStat discovery edition 3 computer package. The survey revealed that only 28% of farmers in Magoye area were using intercropping as a pest control strategy. The intercrops were grown either as a strip/single row pattern alongside the cotton crop or in between each row of cotton. Analysis of variance (ANOVA) on the field study showed significant differences ($F = 2.22$; $d.f = 5$; $p<0.001$) in incidence of D. castanea egg, average damage to cotton bolls ($F = 1.25$; $d.f = 5$; $p<0.001$) and average seed cotton yield ($F = 1.17$; $d.f = 1.17$; $p<0.001$) across the various intercropping patterns.

Keywords: Diaparopsis castanea, cotton, intercropping effects, Magoye (Southern Zambia)

INTRODUCTION

The cotton plant, *Gossypium hirsutum* L, belongs to the family Malvaceae (Paterson, 2009). It is a shrub native to tropical and subtropical regions around the world, including Africa. Cotton, considered as white gold, is one of the most important cash crops that is cultivated among small holder farmers in Zambia. In Zambia, cotton is grown mainly for lint which is used in the textile industry and hospitals while the seed is used for oil extraction (Pearson, 1958). Cotton is attacked by many pests at every stage of the production cycle and this poses a threat to increasing cotton production among farmers (Williams, 2006).

Cotton pests can be divided into early and late season pests. Early season pests are those which attack the plant from the time of planting until peak flowering and then gradually decline in number while late season pests are those which begin their attack at the peak of flowering and continue up to harvesting. *Diaparopsis castanea* (red bollworm) is a major late season pest found in Zambian cotton. The caterpillar (developmental stage of the pest that damage the crop) prefers to attack the reproductive parts of the cotton plant, feeding on flowers, squares and bolls (Braun, 1991). This caterpillar remains hidden inside the cotton square/boll and will only emerge once it has devoured the entire contents of the fruiting structures (Munroe, 1987; Hill, 1983). This presents a challenge in the control of the pests as remaining in the fruiting structure protects it from the action of non-systemic pesticides once applied.

Intercropping is the growing of two or more crop species simultaneously on the same piece of land. (Hokkanen, 1991; Capinera *et al.,*1985). This control strategy is highly favoured among small-holder farmers as it offers production of a diversity of food items at a time and farmers are also protected against crop failure if a specific pest outbreak occurs. Intercropping provides shelter for natural enemies of crop pests and the presence of a more diversified flora has a negative effect on the ability of the insect pests to find and use their host plant (Dent, 1991).

MATERIALS AND METHOD

The study was conducted in two parts during the 2010/11 farming season. The survey (part A) involved the random selection of 80 small holder farmers in the study area (Magoye). In obtaining the sample for the survey, stratified random sampling was used. The main rail line and secondary feeder road running through CDT, Magoye was divided into four areas namely North-East, North-West, South-East and South-West (fig.1). Twenty farmers were interviewed from each of the four areas to make a total of eighty farmers. The Participatory Rural Appraisal (PRA) technique, using questionnaires was employed to identify the various intercropping patterns that were being used in the area. Chi-square test was used to determine which socio-economic factors had any influence on farmers' attitude towards intercropping.

The field experiment (Part B) was laid out in a randomized block design with four replications. The six intercropping patterns were randomized in the main plots. Plot sizes were 4.8m x 9m with intercrops planted in between each row of cotton. Cotton cultivar CDT II (*Gossypium hirsutum spp*) was sown by hand in 100-cm spaced single rows on 1st November 2010. Maize (*Zea mays L.*), and Sorghum (*Sorghum vulgare* L.) were sown two weeks after cotton planting. Pigeon pea (*Cajanus cajan L.*) and Cowpea (*Vigna unguiculata L.*) were planted 3 weeks after cotton sowing and Sunflower (*Helianthus annus L.)* was planted 5 weeks after cotton sowing. Observations on incidences of *D. castanea*, incidences of natural enemies, damage caused by the *D. castanea*, average boll weight, plant height and seed cotton yield were recorded. The data collected was subjected to Analysis of Variance (ANOVA) and means were separated using the Least Significant Difference (LSD) statistic.

RESULTS AND DISCUSSION

The survey revealed that farmers in Magoye area were using two types of cultural practices to control insect pests in their cotton fields (Fig 2), these were; crop rotation (72.5%), intercropping plus crop rotation (27.5%). The majority of farmers (72 %) interviewed, did not use any form of intercropping. Despite some farmers in Magoye using intercropping, it was clear from this study that there was no definite pattern in how the intercrops were planted. Row(s) of the intercrop were planted either beside the cotton field or in single rows in-between several rows of cotton (fig 3). These types of intercropping patterns are more traditional practices used over many generations than the refined intercropping systems being promoted in sustainable agriculture (Jalloh, 2001). Multiple-cropping is quickly diminishing among small holder farmers in Magoye. As more and more farmers are encouraged to enter market systems by planting monocrops to produce marketable surplus, intercropping becomes unfavourable. This is despite all the information available on the negative effect of monocultures concerning insect pest problems (Perrin, 1997; Pimentel and Goodman, 1978) and the positive attributes of crop diversity for decreasing pest impact (Perrin, 1997; Cromartie, 1981).

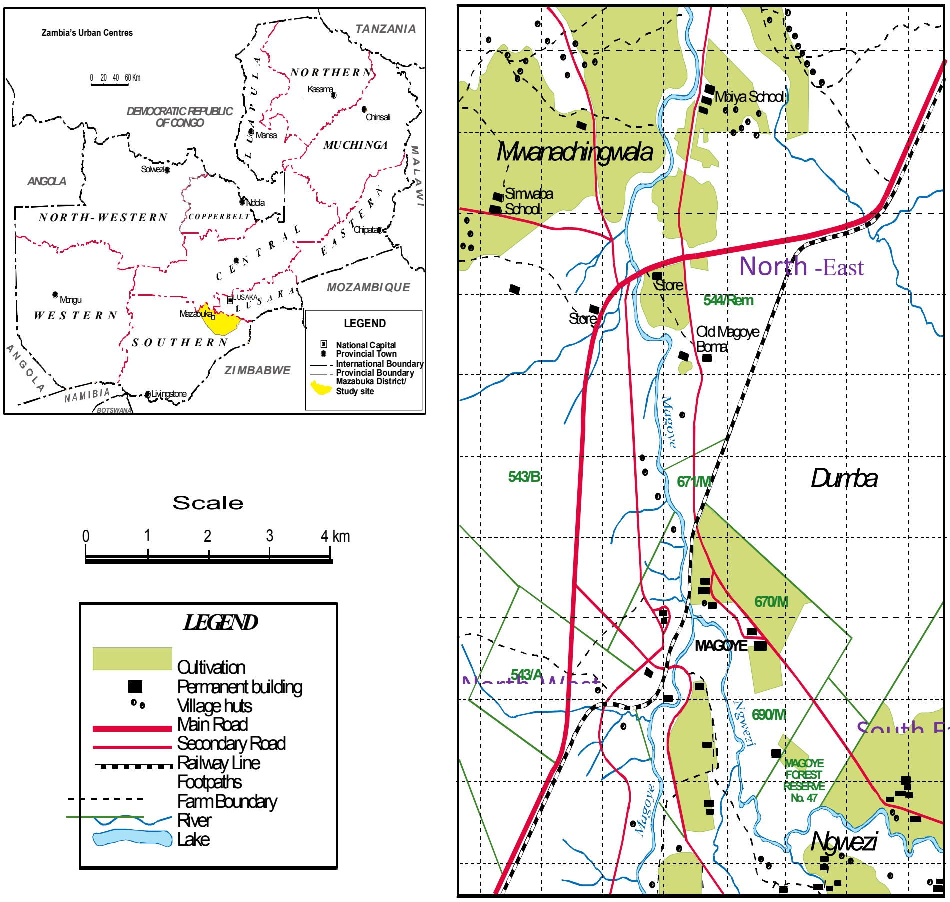

Fig.1: General map showing surveyed area and location of field study site (Source: Cartography department, Geography department, UNZA)

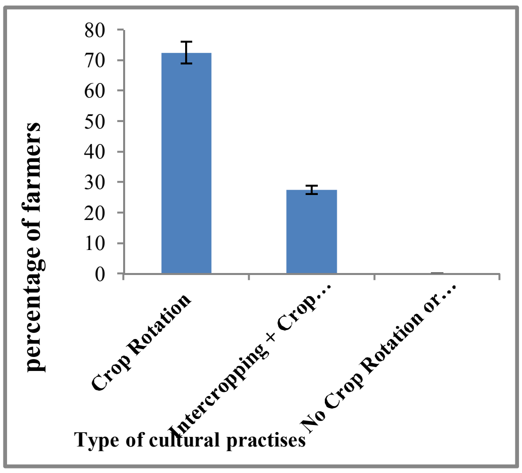

Figure 2: Percentage of farmers using different types of cultural practices in Magoye, Mazabuka district, Zambia.

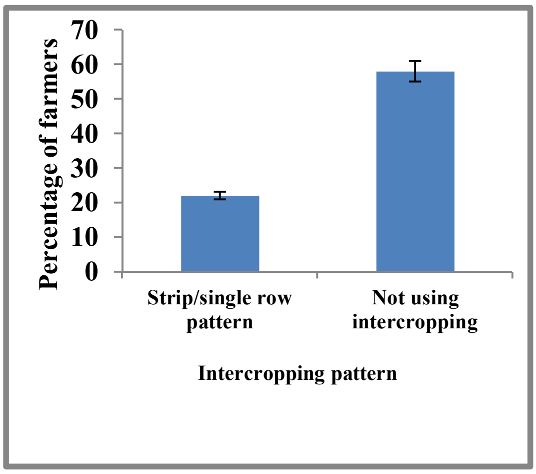

Figure 3: Percentage of farmers using row intercropping pattern in Magoye, Mazabuka district, Zambia.

Table 1: Mean incidence (+/- SE) of *D. castanea* egg and larvae on cotton in the various treatments.

Treatment	**Red bollworm egg**	**Red bollworm Larvae**
Cotton – Maize	1.25±0.61 ^{ab}	10.75±1.68^{a}
Cotton – Sorghum	2.25±0.70 ^{a}	6.75±1.39^{a}
Cotton – Pigeon pea	0.5±0.41 ^{b}	9.75±3.08^{a}
Cotton – Cowpea	1±0.33^{ab}	6.5±1.65^{a}
Cotton – Monocrop	0.5±0.24 ^{b}	5.5±1.22^{a}
Cotton – Sunflower	0.75±0.39 ^{b}	9.25±3.06^{a}

Means bearing different letters in a column differ significantly at 0.05 probability levels

Table 2: Mean (+/- SE) square and boll damage caused to cotton by *D. castanea* under the various treatments.

Treatment	**Average damaged Square per six plants**	**Average damaged bolls per six plants**
Cotton – Maize	7.25±1.17^{ab}	7.00±2.56 ^{a}
Cotton – Sorghum	8.25±1.65^{ab}	4.75±0.70^{ab}
Cotton - Pigeon pea	9.5±0.78 ^{a}	2.75±0.91 ^{b}
Cotton – Cowpea	5.50±1.72 ^{b}	3.75±1.02^{ab}
Cotton – Monocrop	6.00±1.45^{ab}	4.25±1.17^{ab}
Cotton – Sunflower	7.25±1.74^{ab}	6.00±1.91^{ab}

Means bearing different letters in a column differ significantly at 0.05 probability levels

Table 3: Types of natural enemies recorded on cotton under the various intercropping patterns in Magoye, Mazabuka district.

Natural enemies	Intercropping pattern					
	Cotton – Maize	Cotton – Sorghum	Cotton – Pigeon pea	Cotton – Cowpea	Cotton – Monocrop	Cotton – Sunflower
Spider	✓	✓	✓	✓	✓	✓
Lacewing egg	✓	✓	✓	✓	✓	✓
Lacewing larvae	✓	✓	✓	×	✓	✓
Syrphids	✓	✓	✓	✓	✓	✓
Hoverflies	✓	✓	✓	✓	✓	✓
Ladybird larvae	✓	✓	✓	✓	✓	✓
Ladybird Beetles	✓	✓	✓	✓	✓	✓
Wasps	✓	✓	×	×	×	×
Preying mantis	×	✓	×	×	✓	×
Rove beetles	✓	✓	✓	×	×	✓
Housefly	✓	✓	✓	✓	✓	✓
Earwigs	✓	✓	✓	✓	✓	✓

✓ = present and x = absent

Table 0: Results of seed cotton yield for the various intercropping patterns.

Treatment	**Yield (kg/ha)**
Cotton-maize	169±25.60^{b}
Cotton-sorghum	235± 32.51^{ab}
Cotton-pigeon pea	240± 59.1^{ab}
Cotton-cowpea	260±59.1^{ab}
Cotton-monocrop	275±59.1^{ab}
Cotton-sunflower	303±59.1^{a}

Means bearing different letters in a column differ significantly at 0.05 probability levels

The experimental study showed variability in the incidence of *D. castanea* egg on cotton under the various intercropping patterns. This supports the hypothesis that there are significant differences in the incidence of *D. castanea* among the various intercropping patterns. There were more *D. castanea* eggs in the cotton–sorghum (2.25±0.70) treatment than any of the other intercropping pattern (Table 1). This behaviour suggests that *D. castanea* adults exhibited oviposition preference for cotton–sorghum treatment. Even though *D. castanea* eggs were highest in cotton– orghum, the larvae did not show any feeding preference among all the intercrops (Table 1). Cotton - Sorghum treatment can therefore be described as a dead-end intercropping pattern. This term describes plants that are highly attractive to insects but on which they or their offspring cannot survive (Shelton and Nault, 2004). The intercrop served as a sink for *D. castanea*, since the pest showed high ovipositional preference for it, but the eggs do not produce larvae that survive. Van den Berg *et al.,* (1993) also reported that intercropping cotton with sorghum does not suppress the red bollworm population relative to that in sole cotton.

There were significant differences in the damage caused by *D. castanea*, as was evident by the variation in cotton square and boll damage among the intercropping patterns (Table 2). Cotton–pigeon pea (9.5±0.78) intercrop suffered the most damage to the cotton squares while cotton–maize (7.00±2.56) had the highest damage to the cotton bolls. Since pigeon pea contains nitrogen fixing bacteria, it is able to make nitrogen in the soil available for use by the nearest plant (Adu-Gyamfi *et al.*, 1997), in this case cotton. This results in a healthy cotton crop which is more susceptible to pest attack (Thacker, 2002) and in turn suffers high plant damage. Maize on the other hand, is naturally attractive to lepidopteran pests, especially *Heliothis spp*, making it very susceptible to bollworm damage (De souse, 2007). This partly explains the reason as to why boll damage was highest in cotton – maize intercropping pattern.

Cotton, in cotton–sorghum treatment attracted the widest range of natural enemies of the cotton plant (Table 3). These included; spider spp, lacewings, surphids, hoverflies, ladybirds, wasps, praying mantis and rove beetles. Intercrops can also reduce insect pest populations by enhancing populations of natural enemies within the field. Virk *et al.,* (2004) reported that, a sorghum trap crop used to manage cotton bollworm (*Helicoverpa armigera*) also increases rates of parasitism by *Trichogramma chilonis*. The increase in parasitism further enhances the effectiveness of habitat manipulation strategies. The most important effect of intercropping cotton with sorghum appeared to be that it enhanced the abundance of natural enemies harboured by cotton. Sorghum has been known to act as a sink source of generalist insect predators for cotton pests (Prasifika *et al*., 1991). Intercropping studies conducted by (Mamogobo *et al*., 2008) in South Africa also indicated that intercropping cotton with sorghum increased the number of spiders and predatory ant populations. It is important to bear in mind that in order to take full advantage of the attractiveness of generalist predators to sorghum, the flowering of the intercrop must occur at the same time with cotton flowering. Otherwise the intercrop will be unable to compete successfully with cotton for the pest (Russel, 2004).

Based on overall seed cotton yield (Table 4), cotton-sunflower treatment was the most effective intercropping pattern as it produced the highest yield of 303±59.1 kg/ha. All the treatments, apart from cotton–sunflower, showed a reduction in overall yield when compared to the cotton–monocrop (control) treatment. Similar results have been recorded by previous authors (Mohammad, *et al.,* 1991 and Van der Berg *et al.*, 1993). Cotton-maize intercropping pattern showed the highest reduction in seed cotton yield (169±25.60 kg/ha). This could be attributed to the shadow-shading effect of maize on cotton due to its fast growth during the early stages.

ACKNOWLEDGEMENTS

My principal supervisor Professor P. O. Y Nkunika and co – supervisor Dr. B Siamasonta for their encouragement and guidance during my studies. Cotton Development Trust (CDT) for providing the financial assistance towards this work through the Agricultural Development Support Program (ADSP) under the Ministry of Agriculture of Zambia.

LITERATURE CITED

Adu-Gyamfi JJ, O Ito, T Yoneyama & K Katayama 1997. Nitrogen management and biological nitrogen fixation in sorghum / pigeon pea intercropping on Alfisols of the semi-arid tropics *Soil Science and Plant Nutrition* 43:1061-1066.

Braun M 1991. *IPM Training Manual: Tanzanian German IPM project GTZ.*PPD. Chinyanga, Tanzania.

Capinera JL, TJ Weissling & E Schweizer 1985. Compatibility of intercropping with mechanized agriculture: Effects of strip intercropping of pinto beans and sweet corn on insect abundance in Colorado. *Econ. Ento.* 78:354-57.

Cromartie WJ 1981. The environmental control of insects using crop diversity. In: *CRC Handbook of Pest Management in Agriculture*, Boca Raton.

De souse HFA 2007 Effects of strip intercropping of cotton and maize on pest incidence and yield in Morrumbala District, Mozambique *Afr. Crop Sci. Conf. Proces.* 8:1053-1055.

Dent D 1991 *Insect Pest Management* Redwood Press Ltd. UK.

Hill DS 1983. *Agricultural insect pests of the tropics and their control*. 2nd ed. Cambridge University Press , United Kingdom.

Hokkanen 1991 Trap cropping in pest management. *Ann. Rev. of Ent.* 36:119-138.

Jalloh A 2001. *Promoting appropriate intercropping technologies for sustainable agriculture production in Africa: A farmer centered approach* Institute of Agricultural Research, Sierra Leone.

Mamogobo MD 2008. *Intercropping cotton with grain sorghum and pigeon peas for bollworm control* Tshwane University of Technology: Department of crop science, South Africa.

Mohammad MK., GMS El-din & AA Hosny 1991. Evaluating three patterns of intercropping cotton and forage cowpeas. *Ann. Agric. Sci. Moshtohor,* 29: 1269–84.

Munro JM 1987. *Cotton* . Longman group, UK

Paterson AH 2009. *Genetics and Genomics of Cotton*. Springer. New York

Pearson EM 1958. *The insect pests of cotton in Tropical Africa* CIE, London.

Perrin RM 1977. Pest management in multiple cropping systems *Agro-Ecosystems* 3:98- 118.

Pimentel D & N Goodman 1978 Ecological basis for the management of insect populations *Oikos* 30:422-37

Prasifika JR., PC Krauter, KM Heinz, CG Sansone & RR Minzenmayer 1991 Predator Conservation in Cotton: Using Grain Sorghum as a Source for Insect Predators. *Biol. Cont.* 16 (2): 223–229.

Russell D 2004. Insect Pest Management for least Developed Countries. In: Horohz AR & I Ishaaya (eds). *Insect Pest Management:*

field and protected crops. Springer-Verlog Berlin Heidelberg Pp 141-179.

Shelton AM & BA Nault 2004. Dead-end trap cropping: a technique to improve management of the diamondback moth, *Plutella xylostella* (Lepidoptera: Plutellidae) *Crop Prot.* 23:497–503.

Thacker JRM 2002. *An introduction to Arthropod pest control* Cambridge university press, UK

Van den berg H, MJW Cock, GI Odour & EK Onsongo 1993. Incidence of *Helicoverpa armigera* (Lepidoptera.: noctuidae) and its natural enemies on smallholder crops in kenya. *Bull. of Ento. Res* 83: 321- 328.

Virk JS, KS Brar & AS Sohi 2004. Role of trap crops in increasing parasitation efficiency of *Trichogramma chilonis* Ishii in cotton. *J of Biol. Control* 18:61–64.

Williams MR 2006. Cotton losses: 2005 In: *2006 proceedings of Beltwide Cotton Conference* (National Cotton Council) Pp 1151-1204, South Antonio, Texas.