International Journal of Farming and Allied Sciences
Available online at www.ijfas.com
©2014 IJFAS Journal-2014-3-10/1069-1074/ 31 October, 2014
ISSN 2322-4134 ©2014 IJFAS

Evaluation of *Allium sativum* and *Allium cepa* intercrops on the control of *Brevicoryne brassicae* (Homoptera: Aphididae) in *Brassica napus*

Innocent Pahla[1*], Tererai Tumbare[1], James Chitamba[2] and Arnold Kapenzi[3]

1.Department of Horticulture, Faculty of Natural Resources Management and Agriculture, Midlands State University, P. Bag 9055, Gweru, Zimbabwe
2.Publishing Department, Zimbabwe Publishing House (ZPH) Publishers, P.O. Box GD510, Greendale, Harare, Zimbabwe
3.Department of Land and Water Resources Management, Faculty of Natural Resources Management and Agriculture, Midlands State University, P. Bag 9055, Gweru, Zimbabwe

Corresponding author: Innocent Pahla

ABSTRACT: Cabbage aphid (*Brevicoryne brassicae*) poses a threat to production of most vegetable crops including rape (*Brassica napus*). A trial was carried out at the Midlands State University Research Field in Zimbabwe (2013) to determine the effectiveness of intercropping rape with garlic (*Allium sativum*) and onion (*Allium cepa* cv. King onion) on cabbage aphid infestation and yield of rape (*Brassica napus* cv. Giant rape). The experiment was laid out as a Randomized Complete Block Design with 4 treatments (sole cropped rape, rape + onion intercrop, rape + garlic intercrop, and onion + garlic + rape intercrop) replicated 5 times. Data on aphid counts, cumulative rape leaf mass and rape leaf damage was collected from week 3 to week 6 after planting. The results showed that intercropping rape with garlic and onion had significant ($p<0.001$) effect on rape fresh mass, leaf damage and aphid population. Intercropping rape with garlic recorded the lowest aphid population, least leaf damage and highest leaf mass as compared to all other treatments. However results from intercropping rape with garlic and onion were not significantly different from intercropping rape with garlic. Basing on the research findings, it was concluded that intercropping rape with garlic is an effective practice in the control of aphids in rape recommendable for adoption by resource-poor smallholder vegetable producers.

***Keywords*:** Aphid infestation, *Brevicoryne brassicae*, Intercropping, Rape yield, Repellents

INTRODUCTION

Rape (*Brassica napus* L.) is a sub-tropical plant which belongs to the family *Brassicaceae* that includes covo (*Brassica carinata*), mustard (*Brassica juncea*), cauliflower (*Brassica oleracea* var. *botrytis*) and other crucifers (Karban and Baldwin, 2007). Rape is one of the most important and widely grown vegetable crops for resource poor Zimbabwean small-scale farmers for subsistence and as source of income (Mudzingwa, 2013). Its leaves are rich in vitamin A, ascorbic acid and thiamine and have high levels of glucosinates, which during preparation form compounds with anti-oxidants and have anti-cancer activities (Holland, 1991). Some smallholder farmers make a living from the crop in most areas of Mashonaland provinces of the country (Jackson, 1997). The farmers often supply the vegetable crop to urban markets while some grow the crop in home gardens exclusively for home consumption.

Unavailability of inputs and poor crop management has contributed negatively to the yield and quality of the crop (Chadha, 2003). Dobson . (2002) reported that pests and diseases are major constraints causing losses in quality, marketability and up to 80% on yield. Crop yields have remained far below the crop's genetic potential in the

smallholder sector due to diseases and pest attack. Several pests affect rape including bagrada bug, diamond back moth, cut worm, white grub and aphid (*Brevicoryne brassicae*). However, aphids are considered by most farmers in Zimbabwe as the most common pest of rape (Turner and Chivinge, 1999). The aphids feed by sucking the sap from the plant leaves and tender tissues and in large numbers they remove sufficient sap to kill the leaves and the growing tip (Pollard, 1973). Infested seedlings become stunted and their form is usually distorted. Excessive feeding on mature plants causes wilting, yellowing and general plant stunting (Hill, 1983). Aphids have also been identified to transmit more than 23 pathogenic diseases as a vector in many cruciferous plants (Kessing and Mau, 1991).

Dube . (1998) reported that aphids threaten profitability of the crop if not properly managed and may induce substantial yield losses of up to 50%. Many smallholder farmers predominantly use synthetic pesticides which include Dimethoate to control aphids (Turner and Chivinge, 1999; Sibanda ., 2000). There are however concerns about the risks of chemicals to the vegetable producer, consumer and the environment. Chemicals are expensive and harmful to both man and the environment. Agronomists are facing challenges of the build-up of resistance to some of the pesticides in target pest populations (Gerhandson, 2002). Silva . (2012) highlighted that the aphid has developed resistance to at least seventy different synthetic compounds, and different insecticide resistance mechanisms have been reported worldwide.

It is within this challenge that it becomes imperative to explore possible utilization of relatively cheaper, accessible, safer and environmentally friendly alternatives, to the presently dominating synthetic pesticides. These include organic pesticides and diatomaceous earth. Simmonds . (1992) reported that *Allium* spp. are very effective antifeedants and have strong pungent repelling action. Garlic (*A. sativum*) and onion (*A. sativum*) have been found to contain highly volatile compounds that are extracted by water as it transpires from the crop plants. The resultant mixture of these compounds produces the characteristic pungent smell that is known of garlic and onion. Cut garlic cloves produce an odourless, sulphur containing amino acid derivative that reacts with the enzyme allinase to form allicin and other sulphur compounds. Allicin breakdown into Diallyl disulphide which is largely responsible for the garlic odour.

Locally, the use of cultural methods of controlling pests supports the Agricultural Ethics Assessment of Zimbabwe (AEAZ) policy, which emphasizes that modern agriculture has to tackle a series of awareness of products with low social and environmental impacts. Intercropping with pest repellent plants (PRPs) is one of the practices that have been reintroduced as a measure to reduce pest population in Brassicas and proves to be effective in other crops such as cabbage on controlling diamond back moth (DBM) and in cowpeas controlling aphids. Intercropping, the agronomic practice for the development of sustainable food production systems (Eskandari and Ghanbari 2010), plays an important role in controlling pests and protecting beneficial insects relevant to enhancing biodiversity in an agroecosystem (Konar . 2010; Suresh . 2010). Thus, there is need to harness the characteristic effect of PRPs to the benefit of pest management and equip organic farmers with the best intercropping system that can effectively keep the aphids below economic injury levels.

Considering the economic importance of rape as a vegetable crop in Zimbabwe as well as the destructive nature of aphids to the crop, the present study was carried out with the main objective of determining the effectiveness of intercropping rape with garlic and onion on cabbage aphid infestation and yield of rape.

MATERIALS AND METHODS

Study site

The experiment was carried out at Midlands State University located in Gweru, Zimbabwe. The area is found in Agro-ecological Region 3 located at 29°45'E and 19°45'S and the altitude is 1420 m above sea level. The annual temperature ranges from 19-28°C and the annual rainfall received ranges from 600-750mm. Soils at the experimental site are red clays to sandy clay loams derived from Gneissic granite and are generally deep (0.6-1.0 m).

Experimental design and treatments

The experiment was laid out as a Randomized Complete Block Design with 4 treatments replicated 5 times to give 20 experimental units. Treatments were rape + onion, rape + garlic, rape +g arlic + onion and sole rape (control). Gradient was the blocking factor.

Experimental Procedure

Land preparation was done 1week before planting the intercrops. A garden pick and hoe were used to dig up the land and a wooden pounder and rake were used to break large clods and level the surface respectively. 20 plots each measuring 1 m × 1 m were made and replicates in each block were separated by 1 m spacing. Well decomposed

cattle manure was applied at a rate of 10 tonnes ha^{-1} (10 kg m^{-2}) in each plot and incorporated. Randomization was done using the box method to allocate treatments to plots. Nine weeks old garlic chives and onion (*A. cepa* cv. King) seedlings were sourced from Sams Nurseries, Gweru, Zimbabwe, and were planted on the 3rd of August 2013 (3weeks and 3 days) before planting rape. Irrigation was done to field capacity to avoid stressing the seedlings after transplanting. Straight planting rows were made using a garden line and a pre-marked meter rule and dibber were used to mark the planting stations which were spaced uniformly at 20 cm × 25 cm across all blocks. The 2 intercrops were planted earlier to synchronize aphid infestation on rape with advanced growth stages of the intercrops when they render more effective aphid repellency. Healthy Giant rape seedlings sourced from Sams Nurseries were planted in their respective rows and planting stations on the 24th of August. Irrigation was also done to field capacity before planting. Each plot consisted 5 rows with the 2 border rows being rape. The total plant population per plot (both rape and the intercrops) amounted to 20 plants. No chemicals or inorganic fertilizers were used throughout the experiment. However basic management practices e.g. weeding and irrigation were done uniformly.

Data collection and analysis

Aphid count (nymphs, winged and wingless adults) was done starting from 3 weeks to 6 weeks after planting rape. Three sample plants for collection of data were selected from the middle row. The sample plants had to be within not less than 1 m radius from any adjacent group of sample plants to avoid variations that might have been a result of contamination from adjacent plots and the 2 rows guarding each plot were not considered for sampling for the same reason. At 3 weeks after transplanting rape, aphid count commenced and the operation was done by visual searches. Aphid clusters were removed from the rape plants using a soft brush onto a tray where counting or estimation of the number of aphids was done. An aphid assessment score sheet with scores ranging from 0-5 was used for the mean number of aphids per plant. Harvesting commenced at week 4 to week 6 and the cumulative fresh mass of marketable leaf bundles were measured using a balance. The average number of damaged (bored, shrivelled or yellowing), leaves were counted before every harvest from week 4 to week 6.

Data collected was subjected to analysis of variance (ANOVA) using GenStat 14th Edition Statistical Package and the Least Significant Difference (LSD) was used in separation of treatment means where significant differences were noted.

RESULTS AND DISCUSSION

Effect of intercropping rape with garlic and onion on aphid infestation

The results showed that intercropping rape with garlic and onion had a significant ($p<0.001$) effect on aphid population throughout the data collection period except in week 1 (week 3 after planting rape). Aphid populations in sole cropped rape exponentially increased from week 4 and had the highest number of aphids from week 4 to week 6. Garlic + rape recorded the least aphid populations throughout the experiment followed by garlic + onion + rape and onion + rape (Figure 1). Data collected from onion + rape treatment was significantly different from garlic + rape from week from week 4 to week 6. Garlic + onion + rape treatment was however not significantly different from any of the other 2 intercrop treatments from week 4 to week 6 (Figure 1).

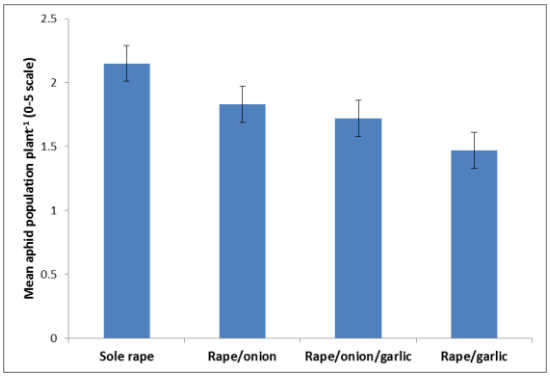

Figure 1. Effect of intercropping rape with onion and garlic on aphid population

No significant differences on aphid population amongst all treatments were observed in the first week of data collection (week 3 after planting rape). This could have been a result of the stage of development of the intercrops

(garlic and onion) which was possibly still premature to render any notable repellent effect on pests. However from week 4 onwards, intercrop treatments significantly reduced aphid population as compared to sole cropped rape. This could have been a result of the improved exhibition of repellent characteristics by the intercrops. Aphids are wingless but can produce wings and fly away when food resources are limited (Dube ., 1998) hence low aphid populations on intercropped treatments can be attributed to the repellent effect of garlic and onion which could have led to migration of the aphids to other target areas.

Highest aphid populations noted in the sole cropped rape treatment through the sampling period concur with findings by Minja . (2001) who observed that if aphid population is left unchecked, they multiply enormously and are only limited by food source besides other selection pressures. Mudzingwa . (2013) reported that the rapid aphid proliferation could be attributed to their rapid development time (8-12 days) from first instar nymph to adult, possible reproduction in absence of males and extended reproductive life span (30 days at 5-6 nymphs day^{-1}). The high aphid population in sole cropped rape plants also complements findings by Hai-bo . (2013) who observed that monocultured plants show more aphids than intercrops as a result of lack of any protective measure against pests.

The effectiveness of garlic in reducing aphid population can be attributed to the fact that the plant contains a group of closely related compounds (allicins) which are responsible for the pesticidal properties (Mudzingwa ., 2013) and repellence against aphids (Tada ., 1988). This is due to the presence of sulphur containing amino acid derivatives in garlic which reacts with the enzyme allinase to form allicin and other sulphur compounds. Allicin breaks down into Diallyl disulphide, which is largely responsible for the pungent garlic odour. This is in agreement with findings by Sarker . (2007) who noted that garlic intercrop treatments showed positive effectiveness as evidenced by lowest aphid population because of the high levels of volatile substances (allicin) that repel aphids. Simmonds . (1992) reported that *Allium* spp. are very effective antifeedant and Kirtikar and Basu (1975) reported that *Allium* spp. have strong pungent repelling action. Therefore, the differences in the efficacies of the treatments are a result of the differences in the physical properties and potency of the active compounds in the various treatments used. These results are similar to Asare-Bediako . (2010) who reported that onion and garlic intercropping systems were also found to have repellent effects on diamond back moth to reduce pest's populations because the company plants act as physical barriers to the movement of the insect pest, natural enemies are more abundant and/or the chemical or visual communication between DBM and the cabbage is disrupted.

Effect of intercropping rape with garlic and onion on leaf damage

There were significant differences (p=0.001) in leaf damage from week 3 to week 6. However there were no significant differences amongst all intercrop treatments. Garlic + rape recorded the lowest mean leaf damage compared to all other treatments with sole cropped rape treatment recording the highest number of aphid damaged leaves thus the lowest number of marketable leaves (Figure 2).

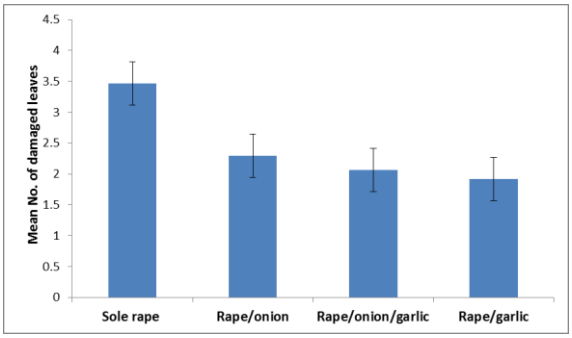

Figure 2. Effect of intercropping rape with garlic and onion on leaf damage

Sole cropped rape had the highest leaf damage which can be attributed to the highest aphid population observed and generally the diversity of pests that affected rape plants in this treatment. This is consistent with Townsend (2013) who reported that leaves become severely distorted when the saliva of aphids are injected into it. Hamman (1985) observed that if left unchecked, aphids in agro-ecology can deform and discolour or cause galls on leaves hence high leaf damage. Most of these sap sucking pests cause shrivelling and wilting of leaves as a result of their feeding habits. The results are also similar to the findings of (Asare-Bediako ., 2010) who observed that lower leaf and head damage accompanied with a higher yield were reported in cases of intercropping cabbage with onion and tomato. Yellowing of leaves which was the other determinant of unmarketability and damage of leaves could have

been a result of low nutrient levels caused by slow release of nutrients by cattle manure which was the only source of nutrients. Garlic and onion alter pest host finding behavior (Nottingham, 1987) and they deter insects' olfactory organs (Calvo-Gomez, 2004) leading to reduction in leaf damage. Moreover, natural enemies can be abundant in intercrops and the intercrops block visual communication between insect and host plant (Asare-Bediago ., 2010) hence low leaf damage.

Effect of intercropping rape with garlic and onion on mean cumulative leaf mass

Significant effect ($p<0.001$) was observed on the effect of intercropping on cumulative mean rape leaf mass between sole rape and all the intercrops throughout the experimental period. Sole cropped rape recorded the lowest cumulative mean leaf mass, with garlic + rape treatment recording the highest cumulative mean leaf mass. No significant differences on cumulative leaf mass were however observed amongst the 3 intercrops (Figure 3).

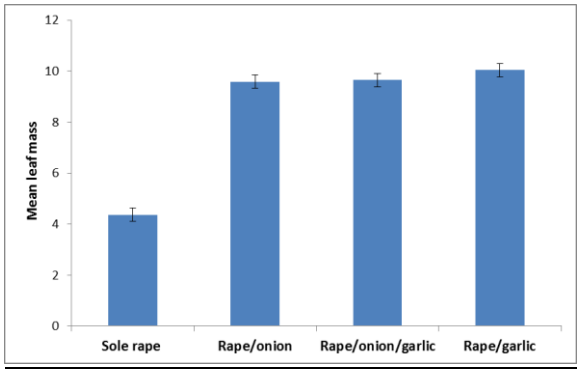

Figure 3. Effect of onion and garlic on cumulative rape leaf mass

The highest yields were obtained from garlic + rape intercrop, whilst sole cropped rape had the least. This could be attributed to the fact that rape plants under garlic or onion intercrops benefited indirectly from low aphid population and low damage level thus increasing yields. This is due to the repellency effect of garlic and onion on various microorganisms. The low mean cumulative fresh mass in sole cropped rape plants can be explained by the fact that aphids extract photosynthates from plant tissue and excrete toxic compounds which affect the growth of the plant. This is in agreement with Minja . (2001) who reported that aphid infestation and feeding damage results in curling and yellowing of leaves and stunted plant growth which in turn reduce leaf area index and consequently the quantities of carbohydrates that contribute to plant biomass resulting in lower fresh leaf yields of rape. The greater the number of aphids that feed on the plant, the greater the amount of assimilates that are extracted from the plant. These assimilates are vital raw materials for cell division and cell elongation which determine the eventual growth, development and yield of the rape crop (Borror ., 1976; Mudzingwa ., 2013). All these characteristics combined give rape plants intercropped with garlic or garlic + onion combination a greater yield advantage since they reduce aphid populations.

CONCLUSION

The present study showed that intercropping rape with garlic and onion is effective in controlling aphids and improving rape yield, with garlic being the most effective intercrop as evidenced by lowest aphid population, lowest leaf damage and highest rape fresh leaf mass. Garlic and onion intercrops can thus be utilised as good non-chemical and environmentally friendly aphid control alternatives to insecticides, recommendable for adoption by resource poor smallholder vegetable growers in Zimbabwe.

REFERENCES

Asare-Bediako E, Addo-Quaye AA and Mohammed A. 2010. Control of diamond back moth (*Plutella xylostella*) on cabbage (*Brassica oleracea* var *capitata*) using intercropping with non-host crops. Am. J. Food Technol. 5(4): 269-274.

Borror DJ; Delong DM and Triplehorn CA. 1976. an introduction to the study of insects, 4th Edition, Holt, Rinehart and Winston, New York, pp 852.

Calvo-Gómez O, Morales-López J and López MG. 2004. Solid-phase microextraction–gas chromatographic–mass spectrometric analysis of garlic oil obtained by hydrodistillation. J. Chromatogr. A 1036: 91-93.

Chadha JS, Sarno L and Valente V. 2003. Monetary policy rules, asset prices and exchange rates as affected by agriculture, American journal of Agricultural Economics 97 (2): 997-1145

Dobson H, Cooper J, Manyangirirwa W, Kuruma J and Chiimba W. 2002. Integrated vegetable pest management: safe and sustainable protection of small-scale brassica and tomatoes. Natural Resources Institute, UK.

Dube B, Gova M, Makaya PR, Mutimutema E, Savore P, Letheve X and Turner A. 1998. Important vegetable pests and diseases in Zimbabwe: Identification and control. AGRITEX/CIIFAD/Cooperation France-Zimbabwe, 72pp.

Eskandari H and Ghanbari A. 2010. Effect of different planting pattern of wheat (*Triticum aestivum)* and bean (*Vicia faba*) on grain yield, dry matter production and weed biomass. Notulae Scientia Biologicae 2: 111-115.

Gerhandson B. 2002. Biological substitutes for pesticides. Trend. Biotechnol. 20(8): 338- 343.

Hai-bo Z, Ju-Lian C, Yong L, Francis F, Haubruge E, Bragard C, Jingrui S and Deng-Fa C. 2013. Influence of garlic intercropping or active emitted volatiles in releasers on aphid and related beneficial in wheat fields in China. 2013. Journal of Integrative Agriculture, 12(3): 467-473.

Hamman PJ. 1985. Aphids on trees and shrubs. L-1227, Texas Agriculture Extension Service House and Landscape Pest, College Station, Texas. 2pp.

Hill DS. 1983. *Brevicoryne brassicae* (L.). In: Agricultural Insect pests of the tropics and their control. 2nd Edn., Cambridge University Press, London, pp: 154-155.

Holland B, Unwin ID and Buss DH. 1991. Vegetables, herbs and spices. The 5th Supplement to McCance and Wordowson's, The composition of foods, 4th Edition. Royal Society of Chemistry, Cambridge, UK.

Jackson JE, Turner AD and Matanda ML. 1997. Smallholder horticulture in Zimbabwe, University of Zimbabwe Publications, Harare, Zimbabwe

Karban R and Baldwin IT. 2007. Induced responses to herbivory. University of Chicago Press, Chicago.

Kessing JLM and Mau RFL. 1991. Crop knowledge master, *Brevicoryne brassicae* (L) Cabbage Aphid. Retrieved from: www.extento.hawai.edu/brevico.htm

Kirtikar KR and Basu BD. 1975. Indian medicinal plants (2nd Ed.) vol. II M/S. Bishen Sing, Mahendra Pal Sing, New Connaught Place, Dehra Dun, D-42, Vivek Vihar, Delhi, 1225-1227pp.

Konar A, Singh NJ and Paul R. 2010. Influence of intercropping on population dynamics of major insect pests and vectors of potato. Journal of Entomological Research 34: 151-154.

Minja EM, Silim SN and Kimani PM. 2001. Yield losses due to field pests and integrated pest management strategies in Brassicas. ICRISAT: Nairobi, Kenya.

Mudzingwa S, Muzemu S and Chitamba J. 2013. Pesticidal efficacy of crude aqueous extracts of *Tephrosia vogelii* L., *Allium sativum* L. and *Solanum incanum* L. in controlling aphids (*Brevicoryne brassicae* L.) in rape (*Brassica napus* L.). Journal of Research in Agriculture 2(1):157-163.

Nottingham SF. 1987. Effects of nonhost-plant odours on anemotactic response to host-plant odour in female cabbage root fly, *Delia radicum*, and carrot rust fly, *Psila rosae*. J. Chem. Ecol. 13: 1313-1318.

Pollard DG. 1973. Plant penetration by feeding aphids (Hemiptera, Aphidoidea): A Review, Bulletin of Entomological Research 62: 631-714.

Sibanda T, Dobson HM, Cooper JF, Manyangarirwa and Chiimba W. 2000. Pest management challenges for smallholder vegetable farmers in Zimbabwe. Crop Prot. 19(8-10): 807-815

Silva AX, Jander G, Samaniego H, Ramsey JS and Figueroa CC. 2012. Insecticide resistance mechanisms in the green peach aphid *Myzus persicae* (Hemiptera: Aphididae) I: A transcriptomic survey. PLoS ONE 7(6): e36366. doi:10.1371/journal.pone.0036366.

Sarker PK, Rahman MM and Das BC. 2007. Effect of intercropping with mustard with onion and garlic on aphid population and yield. Journal of Bio-Science 15: 35-40.

Simmonds MSJ, Evans HC and Blaney WM. 1992. Pesticide for the year 2000. Mycochemical and Botanicals, pp. 127-164. In: Kadir AA SA and Barolv H S (eds.) Pest management and environment in 2000. CAB International, Wallingford, Oxon, UK.

Simmonds NW, Smartt J, Millam S and Spoor W. 1999. Principles of crop improvement. Blackwell Publishers, UK.

Suresh R, Sunder S and Pramod M. 2010. Effect of intercrops on the temporal parasitisation of *Helicoverpa armigera* (Hub.) by larval parasitoid, *Campoletis chlorideae* Uchida in tomato. Environment and Ecology 28: 2485-2489.

Tada M, Hiroe Y, Kiyohara S and Suzuki S. 1988. Nematicidal and antimicrobial constituents from *Allium fistulosum* L. var. *caespitosum*. Agric. Bio. Chem. 52: 2383.

Townsend, T. 2013. Aphids. University of Kentucky College of Agriculture, Lexington, KY. (http://www2.ca.uky.edu/entomology/entfacts/ef103.asp). Accessed on 18 September, 2014.

Turner A and Chivinge, O. 1999. Production and marketing of horticultural crops in Zimbabwe: A survey of smallholder farmers in the Mashonaland East Province. CIIFAD, NY 14853.