Journal of

Entomology

ISSN 1812-5670

Academic Journals Inc.

www.academicjournals.com

Journal of Entomology 5 (3): 156-163, 2008
ISSN 1812-5670

Effect of Chemical Spray on Insect Pests and Yield Quality of Food Grain Legumes

J.W. Muthomi, P.E. Otieno, G.N. Chemining'wa, J.H. Nderitu and J.M. Wagacha
Department of Plant Science and Crop Protection, University of Nairobi,
P.O. Box 30197, 00100 GPO, Nairobi, Kenya

Abstract: Effectiveness of dimethoate 40 EC and copper oxychloride mixture in the management of legume pests and diseases was tested in field experiments during 2005 growing seasons. Grain legumes used were the common bean (*Phaseolus vulgaris* L. var. GLP 2), the lima bean (*Phaseolus lunatus* L.), the green gram (*Vigna radiate* L.), the lablab (*Lablab purpureus* L.) and the chickpea (*Cicer arietinum)*. The experimental design was a randomized complete block design in a split plot replicated thrice. The parameters observed were insect pest incidence, number of pods per plant, percent seed damage and total grain yield. Pesticides spray significantly reduced the incidence of insect pest species like; the flower thrips (*Megalurothrips sjosdetji* Trybom), the African bollworm (*Helicorverpa armigera* Hubner) and the legume pod borer (*Maruca testulalis* Geyer). Pod and seed damage were significantly reduced in lablab, chickpea and green gram. Only lablab, chickpea and green gram showed significant increase in number of pods per plant and total seed yield resulting from pesticide spray. In addition, the quality of yield increased through reduction of shrivelled and discoloured seeds due to diseases. The study showed that the use of dimethoate and copper oxychloride was beneficial for the management of the common insect pests and diseases in legumes. However, studies on the optimum number of sprays, time of application and use of other control measures that are ecologically viable for the management of the pests ought to be done.

Key words: Grain legumes, insect pests, diseases, pesticides, yield

INTRODUCTION

Majority of people in the developing countries are engaged in agriculture, but productivity is low due to plant diseases (Okori *et al*., 2004; Adejumo, 2005) and insect pests (Nampala *et al*., 2002). Food grain legumes have comparatively high protein content and comprise a major source of cheap protein for many people in Africa. However, grain legumes are subject to attack by many insect pests and diseases (Allotey and Oyewo, 2004; Tefera, 2005; Miklas *et al*., 2006). Therefore, high crop yields can be achieved, if plants are protected from diseases and insect pests. However, most small-scale farmers do not adequately control insect pests and plant diseases because of the high cost of chemicals and labour (Opole *et al*., 2005).

Various legume insect pest management strategies have been successfully used. They include biological control (Cox *et al*., 2006; Ugine *et al*., 2007), botanical pesticide mixtures such as aqueous neem and eucalyptus leaf extracts (Oparaeke *et al*., 2006), cultural control (Nampala *et al*., 2002) and chemical control (Heitholt *et al*., 2006; Seal *et al*., 2006). The tendency, however, has been to rely heavily upon chemicals for control of such diseases and insect pests. This is because fungicides and insecticides are considered to be reliable because of their quick and effective action (Adejumo, 2005;

Corresponding Author: J.W. Muthomi, Department of Plant Science and Crop Protection, University of Nairobi, P.O. Box 30197, 00100 GPO, Nairobi, Kenya Tel: +254 722984179

Seal *et al*., 2006). Various chemicals have been evaluated and reported to be effective against major crop diseases and insect pests. Although the use of chemicals as a control measure is advisable, various problems have arisen. Other than the prohibitive costs of pesticides, high applications have dangerous effect on the environment and on human health besides the risk of development of resistance. However, evaluation of pesticides in relation to their efficacy and economic viability is not exhaustive in most crops in Kenya, particularly the grain legumes. Therefore, this study was conducted to evaluate effect of chemical pesticide spray on the incidence of insect pests, foliar fungal diseases and yield of selected food grain legumes.

MATERIALS AND METHODS

Experimental Design and Treatments

Field experiments were conducted during the long (March-July) and short (October-December) rain seasons of 2005 at the Faculty of Agriculture field station, University of Nairobi, Kenya. The grain legumes used were the common bean (*Phaseolus* vulgaris L. var GLP 2), lima bean (*Phaseolus lunatus* L.), green gram (*Vigna radiata* L.), lablab (*Lablab purpureus* L.) and chickpea (*Cicer arietinum*). Pesticide treatments consisted of application of a mixture of dimethoate 40% emulsifiable concentrate, at a rate of 0.7 L ha^{-1} for the control of a broad spectrum of grain legume insect pests and copper oxychloride, a preventive fungicide, applied at a rate of 2 kg ha^{-1} for the control of a broad spectrum foliar fungal diseases (Dike, 1997). Control plots received neither insecticide nor fungicide treatment. The experimental design was randomized complete block design in a split plot layout and replicated four-times. The pesticide treatment formed the main plots with the grain legumes making the subplots. Each plot measured 3×2 m with a 1 m alley between the plots and blocks to minimize interplot interference. The legumes were planted at a spacing of 30×15, 30×10, 45×35, 45×35 and 75×45 cm for common bean, green gram, lima bean, chickpea and lablab, respectively. Nitrogen, phosphorous and potassium (N_{23}:P_{23}:K_0) fertilizer was applied at the rate of 200 kg ha^{-1} and mixed thoroughly with the soil to avoid direct contact with the seeds. The two chemicals were tank mixed and sprayed, beginning two weeks post-emergence. Spraying was done in early morning when it was cool and not windy to avoid pesticide drift.

Insect Pests' Population Assessment

The populations of the three major field insect pests: flower thrips (*Megalurothrips sjosdetji* Trybom), African bollworm (*Helicorverpa armigera* Hubner) and legume pod borer (*Maruca testulalis* Geyer), were assessed commencing at plant flowering stage. Five plants per plot were randomly sampled and tagged for weekly *in situ* observation. Two flower buds or flowers were picked from each of the tagged plant and washed twice in 50% ethyl alcohol before and after dissection to ensure maximum insect recovery. Counts of all the flower thrips and legume pod borers present were made under a binocular microscope. Assessment of the African bollworm population was however done by the direct count method on the tagged plants from commencement of flowering stage till pod maturity. Assessment was terminated at physiological maturity.

Assessment of Yield and Yield Components

At maturity, ten plants not used for the insect pest assessment were randomly selected from each test plot and tagged for yield and yield components assessment. Pods were harvested as they matured to prevent loss through shattering. Parameters determined were the number of pods per plant, number of seeds per pod and total seed yield. The pods for each harvest were counted until the final harvest and expressed as average number of pods per plant. The borer-damaged pods were separated from the undamaged pods. The effect of pests and diseases on yield was determined as the percentage number of borer damaged pods, percent insect damaged, discoloured and shrivelled seeds. The harvested pods from the sampled plants were shelled separately and the physically damaged, discoloured and shrivelled seeds were separated from the healthy seeds and weighed. The final grain yield was determined by weighing all the seeds from the sampled plants for estimation of the grain yield per hectare.

Data Analysis

All data were subjected to analysis of variance (ANOVA) using the PROC ANOVA procedure of Genstat (Lawes Agricultural Trust Rothamsted Experimental Station, 1998, version 8) and differences among the treatment means compared using Fisher's Protected LSD test at 5% probability level.

RESULTS

Effect of Insecticide Spray on the Population of Insect Pests

Spraying regime, legume species and their interactions on number of the flower thrips per flower were significant ($p<0.05$) in both rain seasons (Table 1). Spraying significantly reduced the number of flower thrips per flower in all the tested legume species. Averaged across legume species, sprayed plots recorded between 45 and 65% lower numbers of *M. sjosdetji* per flower relative to the unsprayed checks. The highest number of flower thrips per flower was recorded in the common bean followed by the lablab and the green gram. Chickpea and lima bean had the lowest but statistically similar numbers of flower thrips per flower. Generally, higher populations of flower thrips were recorded during the short rain season than the long one.

Spraying significantly reduced the number of African bollworm per plant in all legume species tested in both seasons except for the lima bean during the short rain seasons (Table 2). The number of *H. armigera* per plant was also significantly different among the legume species. During the long rain season, chickpea had the highest number of African bollworm per plant followed by lablab and common bean. However, common bean and green gram were statistically similar in number of African bollworms per plant. The lowest number of *H. armigera* per plant was recorded in the lima bean. Similar observations were made during the short rain season except that the green gram had higher number of African bollworm per plant than the lima bean.

The interaction between spraying and legume species on number of legume pod borers per flower was significant ($p<0.05$) in both rain seasons (Table 3). Spraying significantly reduced the number of the legume pod borer per flower in all the legume species except lima bean. The number of *M. testulalis* per flower also varied significantly among the legume species. During the long rain season, the lablab had the highest number of pod borers per flower followed by the chickpea, the common bean, the green gram and the lima bean. In contrast, during short rain season, the green gram had significantly higher number of legume pod borers than the common bean.

Table 1: Mean numbers of legume flower thrips (*Megalurothrips sjosdetji* Trybom) per flower on grain legume species with and without chemical spray during the long and short rain seasons of 2005

Legume species	Long rains			Short rains		
	Unsprayed	Sprayed	Reduction (%)	Unsprayed	Sprayed	Reduction (%)
Chickpea	1.6±0.08	0.6±0.03	62.5	3.7±0.19	1.4±0.07	62.2
Lablab	3.8±0.19	1.9±0.10	50.0	5.9±0.30	2.5±0.13	57.6
Common bean	4.9±0.25	2.6±0.13	46.9	7.0±0.35	3.4±0.17	51.4
Green gram	2.2±0.11	1.2±0.06	45.5	4.4±0.22	2.1±0.11	52.3
Lima bean	1.8±0.09	0.8±0.04	55.5	3.8±0.19	1.3±0.07	65.8

$LSD_{p\leq0.05}$; Spraying 0.1; Legumes 0.2; Spaying×Legume 0.3

Table 2: Mean numbers of the African bollworm (*Helicorverpa armigera* Hubner) per plant on grain legume species with and without chemical spray during the long and short rain seasons of 2005

Legume species	Long rains			Short rains		
	Unsprayed	Sprayed	Reduction (%)	Unsprayed	Sprayed	Reduction (%)
Chickpea	1.7±0.09	0.8±0.04	52.9	3.2±0.16	1.7±0.09	46.9
Lablab	1.0±0.05	0.4±0.02	60.0	1.8±0.09	1.0±0.05	44.4
Common bean	0.7±0.04	0.3±0.02	57.1	0.8±0.04	0.4±0.02	50.0
Green gram	0.6±0.03	0.2±0.01	66.7	0.9±0.05	0.6±0.03	33.3
Lima bean	0.4±0.02	0.1±0.01	75.0	0.5±0.03	0.2±0.01	60.0
$LSD_{p\leq0.05}$ Spraying	0.1			0.1		
$LSD_{p\leq0.05}$ Legumes	0.1			0.3		
$LSD_{p\leq0.05}$ Spraying×Legume	0.2			0.3		
CV (%)	20.7			23.7		

LSD = Least Significant Difference; CV = Coefficient of Variation

Table 3: Mean numbers of the legume pod borer (*Maruca testulalis* Geyer) per plant on grain legume species with and without chemical spray during the long and short rain seasons of 2005

Legume species	Long rains			Short rains		
	Unsprayed	Sprayed	Reduction (%)	Unsprayed	Sprayed	Reduction (%)
Chickpea	0.6±0.03	0.3±0.02	50.0	0.9±0.05	0.4±0.02	55.6
Lablab	0.7±0.04	0.4±0.02	42.9	1.1±0.06	0.6±0.03	50.0
Common bean	0.4±0.02	0.3±0.02	25.0	0.5±0.03	0.2±0.01	60.0
Green gram	0.4±0.02	0.1±0.01	75.0	0.7±0.04	0.4±0.02	42.9
Lima bean	0.2±0.01	0.1±0.01	50.0	0.3±0.02	0.1±0.01	66.7
$LSD_{p\leq0.05}$ Spraying	0.1			0.2		
$LSD_{p\leq0.05}$ Legumes	0.1			0.1		
$LSD_{p\leq0.05}$ Spraying×Legume	0.1			0.2		
CV (%)	16.3			22.7		

LSD = Least Significant Difference; CV = Coefficient of Variation

Table 4: Percent reduction in discoloured, insect damaged and shrivelled seeds after application of chemical spray on different food grain legumes during the long and short rain seasons of 2005

Legume species	Long rains			Short rains		
	Discoloured	Damaged	Shrivelled	Discoloured	Damaged	Shrivelled
Chickpea	29.3	100.0	42.3	62.3	36.0	50.7
Lablab	38.4	52.9	57.5	42.2	55.5	49.3
Common bean	26.0	36.5	30.5	18.4	18.3	20.8
Green gram	52.6	39.8	59.3	28.3	42.2	42.6
Lima bean	11.5	58.1	17.1	11.5	26.2	12.7
$LSD_{p\leq0.05}$	13.6	32.9	10.0	24.1	10.0	10.5
CV %	16.1	16.1	11.7	13.1	13.1	12.5

LSD = Least Significant Difference; CV = Coefficient of Variation

Effect of Chemical Spray on Yield and Yield Components Grain Legumes

Spraying significantly ($p<0.05$) reduced percent-discoloured seeds (11 to 62%), borer damaged seeds (18 to 100%) and shrivelled seeds (12 to 59%) in all the legume species except the common bean and the lima bean (Table 4), respectively. Overall, sprayed plots showed significantly lower seed damage relative to the unsprayed checks. Green gram showed the highest percent discoloured (34.2%) and shrivelled seeds (20.4%) whereas lablab had the highest percent borer damaged seeds (16.1%). The lowest seed damage was recorded in common bean. Spraying regime, legume species and their interactions significantly ($p<0.05$) influenced grain yield of the legume species tested (Fig. 1). Spraying significantly increased the grain yield of chickpea and lablab by 116 and 208% during long rain season and 115 and 60% during short rain season, respectively.

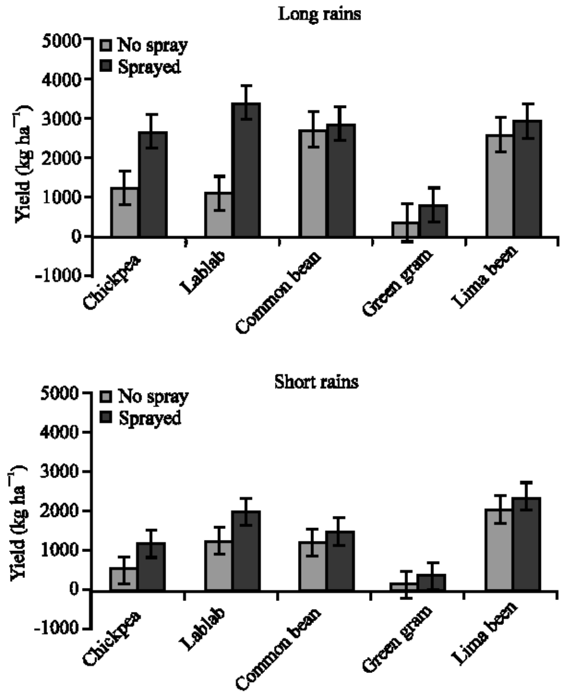

Fig. 1: Mean total grain yields (kg ha^{-1}) of grain legume species with and without chemical spray during the long and short rain seasons of 2005

DISCUSSION

In the present study, it was generally observed that there was a high insect pest incidence during the short rain season when the rains were low and temperature was higher than during the long rain season when the rains were heavy and temperature was low. Insect pests are known to develop and be more active during moderate to high temperatures. The extent of insect population and damage in any system is determined by plant species and the interaction between pest and environmental factors (Rao *et al*., 2000; Heitholt *et al*., 2006; Kekenou *et al*., 2006; Akande, 2007). Pesticide spray significantly reduced the incidence of major insect pests and diseases. The population of the pod borer was appreciably lowered by the application of dimethoate 40% EC. The findings of these studies support those of Mugo (1989) and Kimani and Mbatia (1990) and who reported that dimethoate reduced pod borer infestation on pigeon pea. Sharma and Singh (2003) have reported similar findings on chickpea.

Pod and seed yield losses caused by the pod borer and the pod-sucking bugs were rather devastating. Though little work has been conducted regarding pod loss due to pod borers and other pod feeding insect pests, greater attention has been paid to seed yield losses experienced because of the insect borers in most grain legumes. During this study, pesticide trials conducted showed that significant differences occurred between damaged pods on treated and untreated plots. The difference in pod damage is worth highlighting because damaged pods may not produce seeds or if so the seeds may be of low quality and sometimes may not be viable (Mugo, 1989). Thus, the pesticides used provided a good protection cover against pods infestation by the pod borers paving way for better seed yield.

Significantly higher grain yields were recorded in sprayed plots relative to the unsprayed checks. This implies that the incidence of insect pests and foliar fungal diseases attacking the grain legumes was lowered to a manageable level by application of pesticides. Sharma and Singh (2003) reported a significant decrease in pod damage with a corresponding increase in grain yield after treating chickpea with dimethoate against *H. armigera*. Similarly, a mixture of karate and dimethoate EC at 400 g ai/ha resulted in a reduction of pod and seed yield losses of up to 67 and 71%, respectively in bambara groundnut in Nigeria (Dike, 1997). In Kenya, Okeyo-Owuor and Kamala (1980) working on pigeon pea found that seed yield losses due to insect pod borers ranged between 25.8 and 62.7%. The spraying resulted in effective control of insect pests and foliar fungal diseases. This may have enabled the plants to manufacture and utilize assimilates and allocate them to produce more biomass.

High biomass yield is desirable for efficient utilization of water and nutrients. This enables a crop accumulate assimilates that are used for kernel development (Olupot *et al*., 2004). A high biomass yield also encourages efficient utilization of light and suppression of weeds (Abulo *et al*., 2005). All these factors contribute to the final grain yield. Similarly, loss of leaf area may result in yield reduction as it depresses the photosynthetic activity (Mapose and Cossa, 2005). Besides, Peterson *et al*. (2004) observed that there was a generalized primary physiological response to leaf-mass consumption injury by insects among the cultivated legumes which affects the plant gas exchange variables such as photosynthesis, stomata conductance, intercellular CO_2 and transpiration. Averaged across varieties, Kyamanywa (1996) reported that there was 93% loss in grain yield in untreated plots based on cowpea sprayed through out. The pesticides had better results probably because dimethoate 40% with both contact and systemic properties had effective impact on all grain legume insect pest complex that lower the seed yield. Similarly, copper fungicide with its protective action protected the legumes from attack by foliar fungal diseases. However, common bean and lima bean did not respond significantly to pesticide spray with respect to pod and seed yield. Green gram did not respond to pesticide spray with respect to total seed yield.

The study showed that the use of dimethoate and copper oxychloride was useful for the management of the common insect pests and diseases in legumes. However to avoid development of insect resistance as reported by Ekesi (1999), it is imperative to establish optimum spray-program timing. In addition, further studies on alternative non-chemical management strategies are recommended to avoid accumulation of residues in environment and human foods.

ACKNOWLEDGMENT

This study was funded by the Deans Committee research grant of the University of Nairobi, Kenya.

REFERENCES

Abulo, P., G. Olupot, V.A. Ochwoh and E. Adipala, 2005. Effect of phosphate fertilizer and pesticide application on the yield of groundnuts in Central Uganda. Afr. Crop Sci. Conf. Proc., 7: 37-40.

Adejumo, T.O., 2005. Crop protection strategies for major diseases of cocoa, coffee and cashew nut in Nigeria. Afr. J. Biotechnol., 4: 143-150.

Akande, S.R., 2007. Genotype by environment interaction for cowpea seed yield and disease reactions in the forest and derived savannah agro-ecologies of South-West Nigeria. Am. Eur. J. Agric. Environ. Sci., 2: 163-168.

Allotey, J. and E.O. Oyewo, 2004. Some aspects of the biology and control of *Callosobruchus maculatus* (F.) on some stored soybean *Glycine max* (L.) Merr varieties. Afr. J. Food, Agric. Nutr. Dev., 4. http://www.ajol.info/viewarticle.php?id=19850.

Cox, P.D., L. Matthews, R.J. Jacobson, R. Cannon, A. MacLeod and K.F.A. Walters, 2006. Potential for the use of biological agents for the control of *Thrips palmi* (Thysanoptera: Thripidae) outbreaks. Biocontrol Sci. Technol., 16: 871-891.

Dike, M.C., 1997. Effect of insect pests on pod and seed yields of bambara groundnut, *Vigna subterranea* L. Verde in Nigeria. Int. J. Pest Manage., 43: 191-192.

Ekesi, S., 1999. Insecticide resistance in field populations of the legume pod-borer, *Maruca vitrata* Fabricius (Lepidoptera: Pyralidae), on cowpea, *Vigna unguiculata* (L.), Walp in Nigeria. Int. J. Pest Manage., 45: 57-59.

Heitholt, J.J., A. Knutson, J.B. Faff and B. Langston, 2006. Early-season thrips (Thysanoptera: Thripidae) control and soybean yield in North Texas. South-Western Entomol., 31: 113-120.

Kekenou, S., S. Messi and M. Tindo, 2006. Insect pests' incidence and variations due to forest landscape degradation in the humid forest zone of Southern Cameroon: Farmers perceptions and need for adopting an integrated pest management Strategy. Afr. J. Biotechnol., 5: 555-562.

Kimani, P.M. and O.L.E. Mbatia, 1990. Seed production and distribution mechanisms. Case study for pigeon peas in Kenya. A report for the IDRC, Ottawa, Canada, pp: 84.

Kyamanywa, S., 1996. Influence of time of insecticide application on control of insect pests of cowpea and grain yield of cowpea at Mtwapa Coastal province of Kenya. Afr. Crop Sci. J., 4: 373-382.

Mapose, I.C. and L.S. Cossa, 2005. Yield and quality responses of cowpea varieties to partial defoliations as vegetable. Afr. Crop Sci. Conf. Proc., 7: 41-43.

Miklas, P.N., J.D. Kelly, S.E. Beebe and M.W. Blair, 2006. Common bean breeding for resistance against biotic and abiotic stresses: From classical to MAS breeding. Emphytica, 147: 105-131.

Mugo, H.M., 1989. Studies of insect pests of pigeon pea (*Cajanus cajan* Mill sp.) during the flowering and post flowering stage and their impact on seed yield in Kenya. M.Sc. Thesis, University of Nairobi, Kenya.

Nampala, P., M.W. Ogenga-Latigo, S. Kyamanywa, E. Adipala, N. Oyobo and L.E.N. Jackai, 2002. Potential impact of intercropping on major cowpea field pests in Uganda. Afr. Crop Sci. J., 10: 335-344.

Okeyo-Owuor, J.B. and C.P.M. Kamala, 1980. Insect pod borers of pigeon pea (*Cajanus cajan* (L.) Millsp) and their influence on developing pods and final seed yield in Kenya. Kenya J. Sci. Technol., 1: 79-86.

Okori, P., P.R. Rubaihayo, E. Adipala, J. Fahlesion and C. Dixelium, 2004. Population studies of fungal plant pathogens; Perspectives for control with specific reference to grey leaf sport. Afr. Crop Sci. J., 12: 243-249.

Olupot, G., J. Etiang, H. Ssali and M. Nahasirye, 2004. Sorghum yield response to Kraal manure combined with mineral fertilizers in Eastern Uganda. MUARIK Bull., 7: 30-37.

Oparaeke, A.M., M.C. Dike and C.I. Amatobi, 2006. Botanical pesticide mixtures for insect pest management on cowpea, *Vigna unguiculata* (L.) walp plants-The legume flower bud thrips, *Megalurothrips sjostedti* Trybom. J. Sustainable Agric., 29: 5-13.

Opole, R.A., P.W. Mathenge, E.O. Auma, H.A. Van Rheehen and P.W. Wambugu, 2005. Strategic practices for improving bean seed production in Western Kenya. Afr. Crop Sci. Conf. Proc., 7: 123-128.

Peterson, R.K.D., C.L. Shannon and A.W. Lenssen, 2004. Photosynthetic responses of legume species to leaf-mass consumption injury. Environ. Entomol., 33: 450-456.

Rao, M.R., M.P. Singh and R. Day, 2000. Insect pest problems in tropical agro forestry systems: Contributory factors and strategies for management. Agro For. Syst., 50: 243-277.

Seal, D.R., M. Ciomperlik, M.L. Richards and W. Klassen, 2006. Comparative effectiveness of chemical insecticides against the chilli thrips, *Scirothrips dorsalis* Hood (Thysanoptera: Thripidae), on pepper and their compatibility with natural enemies. Crop Prot., 25: 949-955.

Sharma, J.P. and K. Singh, 2003. Efficacy and economics of certain insecticides in the management of pod borer in chickpea. Indian J. Pulses Res., 16 (2): 167-168.

Tefera, T., 2005. Effect of common bacterial blight severity on common bean yield. Trop. Sci., 46: 41-44.

Ugine, T.A., S.P. Wraight and J.P. Sanderson, 2007. Effects of manipulating spray-application parameters on efficacy of the entomopathogenic fungus *Beauveria bassiana* against Western flower thrips, *Frankliniella occidentalis*, infesting greenhouse impatiens crops. Biocontrol Sci. Technol., 17: 193-219.