Metarhizium anisopliae and *Beauveria bassiana*:

Bio-control agents in Ethiopia

Background

The uses of bio–control agents are considered suitable alternatives to the use of chemical pesticides and the current demand for biological control products has arisen in large part because of problems that has developed from the use of chemical pesticides. These problems include resistance, pest resurgence, environmental pollution and risks to human health, which are reduced and minimized by using microbial bio-controls (**Dhaliwal and Koul, 2007**). There have been an upsurge in interest in microbial products and the reasons for this are many and include the following:

- Development of resistance to conventional synthetic pesticides
- A decline in the rate of discovery of new insecticides and a comparatively high rate of discovery of novel microbial agents
- An increased public awareness about adverse effects of pesticides
- Host -specificity of microbial pesticides
- Improvement in production and formulation technology of microbial pesticides
- Relaxation of regulations that govern the registration and use of many microbial pesticides

Of the various bio-control agents considered, the entomopathogenic fungus, *Metarhizium anisopliae and Beauveria bassiana* have received considerable attentions as a viable alternative to chemical pesticides. The fungi are highly specific to hosts. At field application rates, they are considered safe to non–target hosts. The fungi can be mass-produced relatively easily on artificial solid substrates and when formulated in oil, can be applied under a wide range of environmental conditions using commonly available pesticide application equipments (**Dhaliwal and Koul, 2007**).

Characteristics of *Metarhizium anisopliae* and *Beauveria bassiana*

Metarhizium anisopliae

A Russian entomologist, Metschnikoff, conducted the first systematic experiments on the control of injurious insects with microorganisms by infecting gubs of the grain beetle, *Anisopliae austriaca* with the green muscardine fungus, *Metarhizium anisopliae* (Metschnikoff, 1879) Sorokin. The fungus was found to be even more effective against the sugar beet curculio, Cleonus *punctiveventris* (Germ). But the real breakthrough in the development of microbial control came with the discovery and practical application of the milky disease bacteria, *Bacillus popilliae* Dutky, for the control of the Japanese beetle, *Popilliae japonica* Newman on turfs in USA during 1940s (**Dhaliwal and Koul, 2007**).

The **green muscardine** fungus, *Metarhizium anisopliae* (Metschnikoff) Sorokin, is a common and widely distributed fungus with a wide host range. It has been detected from at least 300 species of insects belonging to different orders including bugs, leafhoppers, planthoppers and beetles.

Taxonomy

Class: Hyphomycetes

Order: Moniliales

Family: Moniliaceae

Genus: *Metarhizium*

Species: *M. anisopliae*

Distribution in Ethiopia

The fungus was isolated and identified from parts of different insects from various parts of Ethiopia including Alamata, Arba Minch, Metahara, Wonji-Shoa and Finchaa **(Tesfaye, D. and Emiru Seyoum, 2010**; **Seneshaw Aysheshim *et al.*, 2003**; **Tesfaye Hailu *et al.*, 2012).**

Beauveria bassiana

The **white muscardine** fungus, *B. bassiana* (Balsamo) Vuillemin occur throughtout the world and it has the largest host range among the fungi imperfecti. It has

been detected from over 700 species and also occurs in the soil as a ubiquitous saprophyte.

Taxonomy

Class: Hyphomycetes

Order: Hypocreales

Family: Cordycipitaceae

Genus: *Beauveria*

Species: *B. bassiana*

Distribution in Ethiopia

The ubiquitous fungus, *Beauveria bassiana* was also isolated and identified from parts of different insects from many parts of Ethiopia including Fura, Sekota, Wikro, Erer, Gusquam, Debremarkos, Ashengie, Tikurinchini, Metahara, Wonji-Shoa and Finchaa. *B. bassiana* mainly infects insects belonging to Lepidoptera, Coleoptera and Hemiptera. It also occurs in Diptera and Hymenoptera **(Tesfaye, D. and Emiru Seyoum, 2010; Seneshaw Aysheshim *et al.*, 2003; Tesfaye Hailu *et al.*, 2012)**

Mode of Action and Infection Process

The development of fungal infections in terrestrial insects is largely influenced by environmental conditions. High humidity is vital for germination of fungal spores and transmission of the pathogens from one insect to another. Unlike bacteria and viruses, which must be consumed, toxicity from entomopathogenic fungi most of often occurs from contact of the fungal conidia with the host cuticle. With most entomopathogenic fungi, disease development involves the following steps:

- Attachment of the infective units like conidia or zoospores to the insect epicuticle.
- Germination of the infection unit on the cuticle.
- Penetration of the cuticle, either directly by germ tubes or by infection pegs from appresoria.
- Multiplication of the yeast phase-hyphal bodies in the haemocoel

- Death of the host.
- Growth in the mycelia phase with invasion of virtually all host organs.
- Penetration of hyphae from interior through the cuticle to the exterior of the insect.
- Production of infective units on the exterior of the insect.

In Ethiopia, *Metarhizium anisopliae* and *Beauveria bassiana strains* have been identified from different parts of the country, well-studied and proved to be effective against a broad range of insect pests **(Tesfaye, D. and Emiru Seyoum, 2010; Seneshaw Aysheshim *et al.*, 2003; Tesfaye Hailu *et al.*, 2012).**

Studies revealed that many strains of both isolates show high level of mycosis and laboratory based experiments and small-scale applications of the pathogens have been found to be effective against desert locusts and grasshoppers, greater wax moth (*Galleria mellonella*), the bean bruchid (*Acanthoscelides obtectus),* spotted stem borer, pink stemborer (*Sesamia calamistis* Hampson), and Chilio *partellus* (Swinhoe*),* cotton (melon aphids) *(Aphis gossypii).*

References

Dhaliwal, G. S. and Koul, O. (2007) Biopesticide and Pest Management: Conventional and Biotechnological Approaches. Kalyani Publishers, New Delhi, 455 pp.

Tesfaye D. and Emiru Seyoum (2010). Studies on the pathogenecity of native entomopathogenic fungal isolates on the cotton/melon aphid, Aphis gossypii (Homoptera: Aphididae) Glove under different temperature regimes.

Tesfaye Hailu, Thangavel Selvaraj, Leul Mengistu and Mulugeta Negery (2012). Evaluation of some native entomopathogenic fungi against pink stem borer (*Sesamia calamistis* Hampson) (Lepidoptera: Noctuidae) in sugarcane.

Seneshaw Aysheshim, Emiru Seyoum and Dawit Abate (2003). Evaluation of Ethiopian Isolates of Entomopathogenic Fungi as Potential Biological Control Agents of the Desert Locust, Schistocerca gregaria. Pest Management Journal of Ethiopia. **7**:1-9.

Some of the potential strains studied in Ethiopia include:

Name of Species	Institutions working on	Strains	Tested against	Stage of the insect infected	References
Metarhizium anisopliaea	• Desert Locust Control Organization-Eastern Africa • Addis Ababa University	DLCO28	Desert locust & Bean bruchid	Adult	• Desert Locust Control Organization-Eastern Africa. • Julia G. & Lina H. 2010. The Potential of entomopathogenic fungal isolates as an environmentally friendly management option against Acanthoscelides Obtectus.
		DLCO76		Adult	
		DLCO91		Adult	
	• Addis Ababa University	DLCO-AA-83	Greater Wax Moth	Adult	• Namusana H. & Emiru S. 2010. Evaluation of Native Fungal Isolates and Metarhizium anisopliae Var. acridum and Beauveria bassiana against the greater wax moth, Galleria mellonella (L) (Pyralidae: Lepidoptera) in Ethiopia.
		DLCO-AA-109		Adult	
	• Addis Ababa University & EARO, Plant Protection Centre, Ambo	EE	Desert Locust	Adult	• Seneshaw Aysheshim, Emiru Seyoum and Dawit Abate (2003). Evaluation of Ethiopian Isolates of Entomopathogenic Fungi as Potential Biological Control Agent of the Desert Locust.
	• Addis Ababa University & Ethiopian Institute of Agricultural Research, Werer Research Centre	MM	Cotton/melon aphid	Adult	• Tesfaye D. and Emiru Seyoum (2010). Studies on the pathogenecity of native entomopathogenic fungal isolates on the cotton/melon aphid, Aphis gossypii (Homoptera: Aphididae) Glove under different temperature regimes.
	• Alemaya University,	PPRC-4	Spotted stem	Larvae	• Tadele T. & Pringle L. 2004. Evaluation of

	Department of Plant Science	PPRC-19	borer	Larvae	Beauveria bassiana and Metarhizium anisopiae for Controlling Chilo partellus (Lepidoptera: Crambidae) in Maize.
		PPRC-61		Larvae	
		EE-01		Larvae	
	• Ambo Plant Protection Research Center, Ambo University Department of Plant Sciences, College of Agriculture, Veterinary Sciences, Ethiopian Sugar Corporation, and Showa Research Center	M2E	Pink stem borer	Larvae	• Tesfaye Hailu, Thangavel Selvaraj, Leul Mengistu and Mulugeta Negery (2012). Evaluation of some native entomopathogenic fungi against pink stemborer (*Sesamia calamistis* Hampson) (Lepidoptera:Noctuidae) in sugarcane.
		F3E		Larvae	
		W8D		Larvae	
		W11D		Larvae	
Beauveria bassiana	• Desert Locust Control Organization-Eastern Africa • Addis Ababa University	DLCO43	Desert locust & Bean bruchid	Adult	• Desert Locust Control Organization-Eastern Africa. • Julia G. and Lina H. (2010). The Potential of entomopathogenic fungal isolates as an environmentally friendly management option against Acanthoscelides Obtectus.
		DLCO41		Adult	
		DLCO87		Adult	
	• Addis Ababa University	DLCO-AA-14	Greater Wax Moth	Adult	• Namusana H. and Emiru Seyoum (2010). Evaluation of Native Fungal Isolates and Metarhizium anisopliae Var. acridum and Beauveria bassiana against the greater wax moth, Galleria mellonella (L) (Pyralidae: Lepidoptera) in Ethiopia.
		DLCO-AA-5		Adult	
		IITA-18		Adult	
	• Addis Ababa University & Ethiopian Institute of Agricultural Research, Werer Research Centre.	DLCO105	Cotton/melon aphid	Adult	• Tesfaye D. & Emiru Seyoum (2010). Studies on the pathogenecity of native entomopathogenic fungal isolates on the cotton/melon aphid, Aphis gossypii (Homoptera: Aphididae) Glove

					under different temperature regimes.
	• Addis Ababa University & EARO, Plant Protection Centre, Ambo.	BB	Desert Locust	Adult	• Seneshaw et al. 2003. Evaluation of Ethiopian Isolates of Entomopathogenic Fungi as Potential Biological Control Agent of the Desert Locust.
		CC		Adult	
		DD		Adult	
		FF		Adult	
		GG		Adult	
		HH		Adult	
		AK		Larvae	
	• Alemaya University, Department of Plant Science	BB-01	Spotted stem borer	Larvae	• Tadele T. & Pringle L. 2004. Evaluation of Beauveria bassiana and Metarhizium anisopiae for Controlling Chilo partellus (Lepidoptera: Crambidae) in Maize.
	• Ambo Plant Protection Research Center, Ambo University Department of Plant Sciences, College of Agriculture, Veterinary Sciences, Ethiopian Sugar Corporation, and Showa Research Center	M7A	Pink stem borer	Larvae	• Tesfaye Hailu, et al 2012 Evaluation of some native entomopathogenic fungi against pink stem borer (*Sesamia calamistis* Hampson) (Lepidoptera:Noctuidae) in sugarcane.
		M9C		Larvae	
		M10C		Larvae	
		W2D		Larvae	
		F10A		Larvae	
		F11E		Larvae	