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STRATEGIES OF BIO CONTROLLING THE *FUSARIUM* WILT DISEASE OF BANANA IN NORTH BIHAR

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ABSTRACT

Wilt disease of banana is an important destructive disease caused by *Fusarium oxysporum* f.sp. *cubens* (Foc). It is one of the most important disease found in North Bihar. Bio control of the destructive disease by the use of antagonists as biocontrol agent (BCAs) against Foc, constitutes an effective role for the management of the disease. These effectiveness depends on range of biological, physio –chemical factors including the type and properties of bio chemical agent, the obstacles to the initial colonization of antagonist as well as the variation factors after initial colonization. Various strategies can be opted to minimize the bio control efficacy, such as the user of endophytes from banana plants as BCAs (favourable *Bacillus* sps), the development of water retaining agent, the application of proper carrier for BCA, the restoration of soil bio diversity and combined management of nematodes disease and *Fusarium* wilt. In this review, elements effecting the biocontrol efficacy of *Fusarium* wilt are analysed in detail and also to search for promoting the biocontrol effects.

KEYWORDS

Strategies, Biocontrol, *Fusarium* wilt disease of banana, *Fusarium oxysporum* f. sp. c*ubens*, Antagonistic strain, *Bacillus* sp., Bio control agent and Endophytes.

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INTRODUCTION

Fusarium wilt is one of the important destructive fungal disease of banana for cultivators which destroys rudely to banana crops of North Bihar. Wilt is an important disease which is caused by *Fusarium oxysporum*. The disease is ranked as one of the top six important plant diseases in world (Ploetz and Pegg 1997)[1]. It is also called Panama disease. In terms of crop destruction it can be compared with the

devastating disease such as Wheat rust and Potato blight disease.

The Panama disease was firstly reported epidemic in Panama in 1890. Now it is spread in several countries like Central and South Americas, Parts of Africa, Sri Lanka, Burma, Thialand, Malaysia, Indonesia, Hawaii, Figi, Philipines, Australia, Newzealand and India. (Bastasa and Blia, 2005, Moore, Plegg and Bentley 1999, Ploetz, 2000, Herbeart and Marx 1990). Specially in India, these diseases also spread in North Bihar which affects the Banana crops. The Panama disease was first discovered at Eagle farm, Brisbane, Queensland, Australia in 1876 in banana plants by Bancroft, The fungus Foc is the soil born hypomycete is one of more than 100 formae specials of *F. oxysporum* that causes vascular wilts of flowering plants (Domesch *et al*, 1980, Anna and Dubery 2000, Nelson *et al*, 1983). The Fungus in facts the roots of banana plants colonizing the vascular systems of the rhizome and pseudostem and inducing characteristic wilting system mostly after 5-6 months of planting and symptoms are expressed both externally and internally (Wardlaw 1961, Stover 1962, Ayadurai *et al*., 2006)[2].

The fungus infect banana plant through the roots and invades the vascular tissue causing external symptoms like gradual wilting, progressive yellowing of banana leaves, eventual collapse at the petiole and longitudinal splitting of the outer leaf sheath in the pseudo stem (Yin *et al*., 2011). The internal symptoms of the disease is the typical discoloration of vascular tissues (in roots, corm, pseudo stem, fruit stalk) varying from light yellow to dark brown which extends up to the pseudo stem (Ploetz, 2006). Eventually, the disease leads to the death of banana plants. *F. oxysporum* is a soil born fungus surviving in the soil for several decades by producing spores known as chlamydospores which will re-infect the susceptible banana plants (Stover1962). Due to survival of spores in several decades so the difficulty arises for disease controlling management.

As *Fusarium* survives in the soil many microbes such as bacteria, viruses, nematodes and protozoa enhance the ability of the infection through invading root system. So it is necessary to develop suitable biocontrol agents for disease management.

Huang *et al*, (2012) reported that the crop rotation of banana is an efficient way for cotrolling banana *Fusarium* Wilt disease. But it is not suitable due to the environmental conditions. Some chemicals and pesticides are also tried by soil producing infection but these chemicals and pesticides are not beneficial to human health concern. Due to fumigated soils with chemicals can be re-infected in two or three years in the field. It is also tried to develop resistant banana variety against the disease for solving this problem (Stover and Buddennhagen, 1986, Hwang and Ko, 2004). Considering the needs of the cultivators it is tried for managing *Fusarium* wilt involves the biological control and important component of integrated disease management programmes. Hence in this case it requires naturally occurring antagonists and active substances like viruses, bacteria, fungi and active substances of natural origin as biocontrol agents (BCAs) for disease management. The use of BCAs is proved to be an ecologically safe for disease management. The enormous effects should be still contributed to the development of effective and safe BCAs for commercial application.

ELEMENTS RESPONSIBLE FOR THE BIO CONTROL OF FUSARIUM WILT

For obtaining the ideal result it is necessary to work systematically for using biological agents to control Fusarium wilt of banana. The initial colonization of antagonist have been effected as well as the variation factor after initial colonization properties of the biocontrol agents. Firstly it is necessary to discover effective bio control is to find out the suitable bio control agents. A primary concentration in the selection of antagonist as BCAs for field application as their types and properties which directly or indirectly effect the efficacy, the production process, the post processing as well as storage and the transportation. It is reconsider that the production methods for biocontrol agents must be at low cost and yield viable, highly effective propagules of high concentration. Some workers Yilmaz *et al*, 2005, Bertangnolli *et al*., 1996, Szczech and Shoda, 2004,

Farhana *et al* 2011, Govindasamy *et al*, 2011, Tan *et al*., 2013)[3] also considers that viable *Bacillus* spp. serves as ideal for controlling the disease as an BCAs agents. These *Bacillus* spp. strains are advantageous as biological agents due to its high tolerant in adverse environmental stages by producing endospores. At present variety of strain of *Bacillus* sps. Have been extensively applied as biocontrol agents against soil born plant diseases of *Fusarium* wilt (Schisler *et al*, 2002, Sun *et al*, 2011). They also proved that the *Bacillus* sps. Having high biocontrol efficacy which are easy to control and the storage and transportation condition needed could be easily fulfilled. On the other hand the application of the other micro organisms as BCAs such as non pathogenic *F.oxysporum* (Nel and Steinberg, 2006), *Trichoderma* spp. (Thangavelu *et al*., 2004), has been demonstrated to result in high cost of production storage and transportation.

OBSERVATION AND DISCUSSION

It has been observed that the antagonistic microbe how far can be colonized the biocontrol efficacy of the biocontrol agents largely depends on the ability of antagonists microbes to colonize the plant root and rhizosphere and to produce substances which inhibits pathogens.

The colonization of antagonistic microbes is hampered by several obstacles at the initial colonization which refers to the initial set of natural barrier encountered by antagonistic microbes after the application of BCAs. It has been also observed that some protozoan, some microbes which inhibits the exudates of indigenous microbe or plant roots (Bolwerk *et al*, 2003, Ekelund *et al*, 2001, Chao *et al*, 1986).

Normally, influenced by these barriers, the population of most antagonistic microbes reduced drastically in the first two to three days after the application of the BCAs. However BCAs usually maintaining a certain population of the antagonistic microbes to obtain a certain level of disease suppression (Wang *et al*, 2011)[4]. Thus in order to achieve satisfactory biocontrol efficacy, appropriatre measure should be taken to help the antagonistic microbes to get desired results. One of the alternative is to increase the original population of the antagonistic microbes in the BCAs found that a considerable part of population survive this adverse phase under the regulation of environmental factors.

Bird *et al*., 2003[5], Ingham *et al*., 1985 also revealed that the protozoa in the soil to some extent act as regulator of the population of soil bacteria and Fungi. They prey selectively on certain bacteria and fungj which exert an effect on the population and diversity of their prey.

Besides this the nature of soil also helpful for the predator–prey relationship. Certain soil structure are beneficial for survival of bacteria. Study revealed that well aggregated soil is found to be a very desirable habitat for bacteria (Wardlaw, 2006). Bacteria tend to accumulate inside soil aggregates which establish micro-ecological sites that are not accessible to certain protozoa. Thus to some extent protect the antagonistic microbes from the prey of indigenous predatory protozoa, thus conserving a substantial number of microbes.

During study a substantial amount of certain exudates of indigenous microbes and plant root exert an inhibitory micro organism (Quintana *et al*., 2009[6], Hirsch *et al*, 2003). On the colonization of the heterologous antagonistic microbes in banana plant exert strong negative influences. Hence to overcome these difficulties it is necessary to isolate active antagonistic microbes from the endophytic strains of the healthy banana plant (Lian *et al*., 2008)[7].

When the BCAs have to be applied in soil, to overcome the inhibition from indigenous microbes and plant roots or the "induced systemic resistance" mentioned above, a recommended option is to introduce a cover for the antagonistic microbes which shelters the microbes for antimicrobial agents and environmental stress by acting as a physical barrier.

Obstacles to the long term colonization of antagonists:

After the initial colonization the variation factors effect the long term colonization of antagonist. *Fusarium* wilt is a typical soil-born disease. To achieve the ideal bio control efficacy, the antagonist must colonize the rhizosphere soil and sustainedly occupy favorable ecological sites in the environment.

The rhizosphere bacteria exist in the bio film (Webb *et al*, 2003)[8]. A biofilm is "a structured community of microorganism in encapsulated within a self – developed polymeric matrix and adherent to a living or inert surface" formed by an aggregate of microorganism in which cells adhere to each other. In nature, bio film constitute a protected growth modality allowing bacteria also survive in hostile environment (Rinaudi and Giordano, 2010)[9]. Hence biofilm is the best mode for antagonist to occupy heterogenous habitats.

SOIL MOISTURE

Soil moisture effects the structure of soil aggregate for banana plantation which significantly related to soil erosion, temperature entropy and pH. Banana plants require plenty of water and fertilizer for growth. It requires high humidity (50% or more) and require regular requirements of fertilizer. The yield of banana plant depends largely on the rational management of fertilizer and water. For banana cultivation it is suitable in dry slope, platform, plateaus or plains in short of water. The large scale banana plantation are mostly required water through well irrigation. These irrigation means to solve the water shortage problem to some extent for satisfy the sustained demand of banana plant. The continuous water supply helps in banana plantation specially in the vegetative stage flowering and fruit ripening stages. Water logging reduces yield and plant size, restricts root growth, causes shallow root system and stops the active uptake of nutrients (Aguilar *et al*., 2008) and consequently microbial community of soil microbes decreased.

There are two types of water retaining agents. One is chemical and the other is bioactive. Poly - y-glutamic acid (Zeng *et al*, 2013), y-PGA acts as a new kind of bio active water retaining agent in agriculture and environmental application. It is a bio degradable water soluble amino acid polymer. It is normally composed of about 5000 glutamic acid molecules or mono units, with a free Carboxyl group on the alpha carbon atom of each repeating unit. The y- PGA is in low concentration which shows ideal material for super absorbent soil water. Hence y-PGA as a water retaining agent can be used to change soil aggregates structure and maintaining soil moisture and conserve fertilizer in soil. In our study we have found several y- PGA producing strength that are antagonistic against Foc under the application for a patent.

Other factors which help to improve the bio control efficacy against *Fusarium* Wilt of Banana

Nematodes constitute another major threat to banana production all over the world which causes yield losses up to 30% to 60% in many countries (Roderick *et al*., 2012)[10]. The fundamental reason that leads the nematode disease and *Fusarium* wilt due to the loss of biodiversity in soil. Banana plants that are infected with nematodes tend to have enhanced susceptibility to *Fusarium* wilt which shows *Fusarium* tolerance or resistance (Ammar 2007)[11]. Thus the two diseases could be control jointly and combined management efforts which save the crops of banana.

Nonpathogenic *F.oxysporum* strains can be develop as biocontrol agents. They are able to compete for nutrients in the soil which effect the rate of chlamydospore germination of the pathogen. They can also compete with the pathogens for infection sites on the root which trigger plant defense reactions, inducing systemic resistance.

Some secondary metabolites are also used as potential viable biocontrol agents.

CONCLUSION

The antagonistic strain that are tolerant to avoid strain of environmental condition have greater market potential as biocontrol against Foc. In other words the advantageous and competitive microbes have greater chance to colonize heterogeneous habitats and become "indigenous inhabitants "in this environment which is heterogeneous habitats known as "host indigenous microbes". The most typical feature of *Bacillus* strain that form spores to get through adverse environmental condition which enable them to survive in broad range environmental condition. The utility of *Bacillus* strain as bio control agents cannot only obtained subtend colonization in banana plants but also facilitate the post processing, storage and transportation.

Therefore antagonistic strain from *Bacillus* sps. Are a recommended choice as a biocontrol agent in field application.

Crop rotation is also require and water management is also helpful to controlling the diseases.

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CONFLICT OF INTEREST

We declare that we have no conflict of interest.

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