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Case Study

Fusarium Corm Rot of Gladiolus and its Eco-Friendly Management

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ABSTRACT

Gladiolus is one of the top cut flowers in the international market and the demand for gladiolus flowers among the consumers is increasing every year due to its magnificent, unrivaled beauty, striking colours, different sizes, and shapes of flowers with long-lasting spikes. Apart from the flowers the planting material i.e., the corm is too in high demand. But Gladiolus are susceptible to many diseases and one of them is Fusarium corm Rot and its occurrence has become a major drawback in production and the pathogen is soil-borne, so it is difficult to control. *Fusarium oxysporum f. sp. gladioli* is a soil-borne fungus that persists in soil and plant debris as chlamydospores and can endure in the absence of gladiolus for several years. Infected corms show tissue discoloration. The corms become softer, crumpled, and dried out in storage. Despite many attempts to control this disease, the problem still occurs worldwide. The management practices include resistant cultivars, chemical applications, cultural practices, and biotechnological approaches. However, eco-friendly management measure provides a better opportunity to manage this disease in long term and helps to eliminate synthetic chemicals, decreasing environmental hazards, improve soil conditions. In this review, the major measurement taken up to control Fusarium corm rot in gladiolus species through eco-friendly management have been discussed.

Key words: Gladiolus, Fusarium, Bio-control, Essential oil, Integrated management, Plant extract, Cut flower

Gladiolus is a major crop in the global florist industry due to its high economic value [1]. It occupies the top position among the bulbous crop for commercial cut flowers which are in high demand in both the domestic and international market. The popularity among the consumers is due to its magnificent, unrivaled beauty, striking colours, different sizes, and shapes of flowers with long-lasting spikes. Gladiolus is susceptible to many diseases incited by fungal, bacterial, and viral pathogens such as Fusarium wilt, Botrytis blight, dry or neck rot, Curvularia leaf spot, bacterial scab, grey mold, storage rot, etc. Pathological problems, particularly diseases caused by fungal pathogens, heavily damage the plant stand, quality, and yield.

Fusarium corm rot is the most common fungal disease on gladiolus cultivars. The disease occurs wherever gladiolus is grown and can be lethal on certain cultivars. The characteristic symptoms for Fusarium corm rot were first reported in 1912, but it took an additional 16 years for the disease and the pathogen to be properly described. The fungus *Fusarium oxysporum* f. sp. *gladioli* are the pathogen that dwells in many soils as different biotypes. As a result, the disease occurs wherever gladiolus is still growing in soil, due to resident populations of the pathogen, and due to dormant corm infections, that are frequently present. About 60–80% annual losses were noted in India [2].

Maximum studies have been performed towards fungicidal control of corm rot of gladiolus and various synthetic chemicals are used [3]. But these chemicals, to be degraded completely take long duration thus causing heavy toxicity to the human being, domestic animals, etc. As a result, there is a crucial need to developed a safer antifungal agent which are expected to be renewable, non-petrochemical, eco-friendly, and easily accessible. The possibility of introducing a variety of combined treatments (cultural, physical, biological, and botanical) i.e., integrated management may provide for an even wider spectrum of disease control.

Characteristic symptoms of the disease

Due to the wide diversity in the pathogen populations, symptoms can be diverse and may include stunting and chlorosis and in severe cases, wilt and death. Along with the rotting of corms, the disease can cause

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vascular discoloration. The corm rot is a dry corky rot that stays confined until the entire corm becomes infected.

Fusarium corm rot of gladiolus showing wilt and death (Wade Elmer [4])

Bology and epidemiology

The most common means for long-distance dissemination is via latent infections on the corms and cormlets. However, once the pathogenesis is established in the soil, the fungus survives well as persistent chlamydospores and as mycelium on plant debris. The fungus can persist in the absence of gladiolus for many years. The fungus can also endophytically colonize the roots of non-symptomatic plants. New infections result from hyphae that emerge from soil inoculum consisting primarily of chlamydospores or mycelium. The fungus invades roots intercellularly causing root rot as it advances toward the corm. The corm may be able to compartmentalize invasion, or the infection continues becoming systemic in the vascular tissues.

Management

1. *Biological control*

Biological control includes total or partial destruction of a pathogen population by other microorganisms. *Fusarium oxysporum* thrives well and causes several diseases in conducive soils. While in Lateritic clay soil, known as suppressive soil, it develops much less and causes much milder disease. The suppression of disease is due to the presence of microbiota especially *Streptomyces spp*. in lateritic clay soil that suppresses infection [5]. To prevent disease occurrences sanitation should be highlighted as the most significant approach. Gladiolus need a well-drained soil type with a pH of around 6.5, as acidity promotes Fusarium corm rot. Soil tests should routinely be performed and soil limed appropriately to achieve a soil pH of around 6.5–7.0. Hot water treatment of corms and cormlets (30 min at 57°C/135°F) followed by biological and inorganic amendments at planting can be effective [6].

Inoculation of freshly harvested cut corms with an isolate of *F. monliforme*, controlled Fusarium corm rot [7-8]. Growth inhibition of pathogen by *Trichoderma harzianum, T. viride, and T. virens* has been reported by Sharma and Chandel [9]. This inhibition can be attributed to antibiosis. Similar antagonistic activity of *Trichoderma spp*. was reported by Dennis and Webster [10]. While Mishra *et al.* [11] use an isolate of *Trichoderma virens* Miller, to evaluate the control of gladiolus corm rot caused by *Fusarium oxysporum f.sp. gladioli* in glasshouse and field experiments. It was found to be good for controlling corm rot in all experiments. According to Sharma and Chandel [12], the soil placement method was better than the corm dip method while *T. harzianum* in comparison to *T. viride* achieved better control against Fusarium corm rot pathogen which resulted in leaser disease incidence in addition to the improvement in growth and flowering parameters of gladiolus. Bhardwaj *et al*. [13] AM (*Arbuscular mycorrhiza*) fungi (*Glomus mosseae* and *G. etunicatum*) were used to manage the disease under pot culture and reported that plants inoculated with *Glomus mosseae* resulted in maximum disease reduction followed by *G. etunicatum*. Kulkarni *et al*. [14] reported screening biocontrol agents and cultivars. The maximum reduction in colony size was observed in *T. harzianum* (76.08) and proved to be better overall other bio-agents tested and was followed by *T. konigii* (72.48%), *T. viriens* (66.30%), and *T. viride* (61.44%). Hashmi *et al*. [15] conducted a field experiment and examine the prospects of two isolated bacteria *Bacillus subtilis*, *Pseudomonas florescence*, and one fungal isolate *Trichoderma harzianum* to evaluate corm rot *by Fusarium oxysporum*. At seedling stage, suspensions of these agents individually and in the combination of two were applied to the plants. *P. fluorescens* inhibited the maximum disease severity to 1.26% followed by 1.33% in treatment *B. Subtilis* and 1.53% in treatment *T. harzianum*. And mixing the two biocontrol agents gave disease severity ratings of 1.13% in treatment (Baci+Pf), 1.06% in both (Baci+Tr) and (Pf+Tr) as compared to 3.66% in the control treatment. According to an experiment conducted by Walid *et al.* [16] *Trichoderma harzianum* and *Aneurinobacillus migulanus* when tested against corm rot separately and in combination using soilless culture Perlite as the substrate, *Trichoderma harzianum* was found to be more effective than *A. migulanus* for managing diseases, improving plant growth, as well as for boosting flower production and quality. The effectiveness was estimated based on vegetative, root growth, and flowering parameters [17]. Corm rot incidences are reduced by 46.1%, in field condition and 54.8% reduction in greenhouse, in comparison to the non-treated control, when Talc-based formulations that mixed two plant growth-promoting rhizobacterial strains (*Bacillus atrophaeus* and *Burkholderia cepacia*) are used.

2. *Using plant extract*

Plants are composed of biochemicals i.e., polyphenols, flavonoids, condensed tannins, crude saponins, carotenoids and alkaloids that can be used as pesticides and are proved to be more environmentally safe than chemical alternatives [18]. So, to inhibit various phytopathogenic fungi plants can be utilized as Plants are the reservoirs of biodegradable secondary metabolites.

Antifungal activity of different concentrations (2, 4, 6, and 8% w/v) of leaf extracts of wheat, maize, sunflower, chilies, onion, and marigold (*Tagetes erectus*) was studied [19]. It was reported that extracts of marigold, sunflower, and chilies were highly efficient, and significantly reduced fungal biomass by 54-79%, 33-85%, 45-57% respectively. The different phytoextracts of *Azadirachta indica*, *Ocimum sanctum*, and *Allium sativum* were found to inhibit the growth of mycelial in fungus [20]. When two pot experiments were conducted to check the effect of different plant materials, to manage the Fusarium corm rot disease of gladiolus using the leaves of five allelopathic plant species viz. *Syzygium cumini* (L.) Skeels, *Eucalyptus citriodora* Hook, *Coronopus didymus* (L.) Smith, *Chenopodium album* L. and *Cyperus rotundus* L. which were incorporated into the soil @ of 2, 4 and 6 g 100 g^{-1} of soil for the first experiment. And the second experiment, using the leaves of five plant species *Azadirachta indica A. Juss*, *Alstonia scholaris* (L.) R. Br., *Parthenium hysterophorus* L., *Ageratum conyzoides* L., and *Allium cepa* L. @ 4 g 100 g^{-1} of soil, which were spread on the surface of the potting soil [21]. The disease incidence and the number of infection lesions on corms were drastically reduced in all the treatments. Incorporation of all the dosages of 2 – 4% of *C. rotundus* significantly enhanced shoot biomass. Similarly, 2% *Eucalyptus citriodora* and 4 – 6% *Cylindrocarpon album* application also enhance shoot biomass significantly over Fusarium corm rot control. Different plant extract against fusarium invitro and concluded that complete inhibition of mycelial growth was achieved at 10 percent Jatropha followed by Soapnut, Neem seed kernel extract, Cassia extract, Neem leaf extract, and bulb extract of Garlic. While Clove, Castor, Nilgiri, Cinnamon, and Sarpagandha were found least effective against the fungus. plant extracts [22]. When aqueous extracts of six plant species, namely *Azadirachta indica* A. Juss, *Alstonia scholaris* (L.) R. Br., *Lawsonia alba* Lam., *Allium cepa* L., *Allium sativum* L., and *Zingiber officinale* Roscoe are used, it was found that all the test plant extracts succeeded in controlling the corm-rot disease to some extent [23]. The aqueous bulb extracts of *Allium sativum* and *Allium cepa* and the rhizome extract of *Zingiber officinale* showed better control over the disease.

3. *Using essential oil*

Essential oils are complex volatile compounds, and they have been utilized as biological agents due to their therapeutic activity and toxicity against insects as well as plant pathogenic fungi [24]. The essential oils of *Cinnamomum zeylanicum*, *Syzygium aromaticum* and *Thymus vulgaris* was found to inhibit the mycelial growth of *Fusarium oxysporum* f. sp. gladioli. The compounds like carvacrol, geraniol, and trans-cinnamaldehyde provide an effective antifungal activity against Fusarium fungus [25].

4. *Integrated management*

Control of plant diseases is most successful when all available information regarding the crop, i.e., pathogen, environmental conditions, control measures, growing time, and their costs are taken into account for controlling the disease. Studied integrated management of Fusarium yellows of gladiolus under pot culture and polyhouse conditions and reported that integrated approach using pots treated with neem cake, carbendazim, and *Trichoderma harzianum* revealed the highest disease control [26]. After storing for 4 and 12 weeks followed by integrated treatments of hot water (55°C for 30 min), UV-C (dose 4.98 kJ m^{-2}), and essential oil (0.8 μL cm^{-3}) for 2 weeks were found promising to control fusarium rot than their treatments alone. In an integrated management approach, which include treatment of corms with moist hot air coupled with the dipping of corms in carbendazim and planting in solarized plots augmented with *Trichoderma harzianum* followed by soil drenching after planting at 70 and 90 days recorded the minimum Fusarium corm rot incidence of 2.77% [27].

CONCLUSION

As gladiolus is one of the most important commercial cut flower bulbous crops which is regarded as a “Queen of bulb”, it fetched high returns profit to the growers both in national and international markets. But the occurrence of Fusarium in devastating form, has become a major drawback in production and the pathogen is soil-borne, so it is difficult to control. When Chemicals are used to control the pathogen, it is associated with many side effects like resistance to the pathogen, new races of the pathogen, depleting of soil fertility, hampering beneficial microbes, and negative effects on the environment as a whole. So, as a result, alternate eco-friendly management practices are utilized to control Fusarium corm rot which helps in sustainability production. And use of eco-friendly management including Integrated management is proven to be better than chemical control methods as it drastically decreases the side effects caused by chemicals thereby decreasing environmental hazards and improve soil conditions. The use of eco-friendly management has minimized the use of synthetic chemicals.

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