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Diseases of Marigold (Tagetes erecta) and their management: A Review

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Abstract

Marigold belongs to family Asteraceae and is extensively used for making garlands, beautification and other purposes i.e. pigment extraction, oil extraction and therapeutic use. Both leaves and flowers of marigold plant are important as medicine due to phenolic and antioxidant activities. Inspite of insecticidal, fungicidal, bactericidal, larvicidal properties of marigold, it is affected by various pathogenic microoganisms such as fungi, virus and bacteria thyat cause diseases and damage to the plant which resulted yield loss. In the present review, a brief introduction to various diseases of marigold, their symptoms and management strategies are discussed.

Keywords: *Tagetes erecta*, eco-friendly management, diseases, Marigold

1. Introduction

Marigold is one of the commercially exploited ornamental flower crops which belong to genus *Tagetes* and family Asteraceae. It has wide spectrum flowers with attractive colour, shape, size which grab the attention of various flower growers. Flowers of marigold are extensively used for religious and social purposes (Bos and Yadav 1998). They are a group of perennial herbs of varying habit and exhibit both type of pollination, self and cross pollination. Out of the 33 species of marigold, Two popularly grown species of marigold are African or Mexican marigold (*Tagetes erecta* L.) and French marigold (*Tagetes patula* L.), which originated in Mexico and South Africa, respectively. Although the origin of *T. erecta* (African marigold) is Mexico, but due to its adaptability, popularity and wide cultivation in India, it is presumed to be of Indian origin (Desai, 1967, Asif, 2008). It is majorly grown in Madhya Pradesh while Himachal is at ninth rank in area and production of marigold (Shukla and Thakur, 2018).

The plant has economical importance due to its showy flowers, tagetes oil and anti-nematicidal properties (Usman *et al*., 1972). Flowers of marigold are sold as loose flowers in the market, highly suitable as a bedding plant and it is also used for beautification.

Both leaves and flowers of marigold plant have phenolic and antioxidant activities due to which they are used for medicinal purposes (Tripathy and Gupta, 1991, Khalil *et al.*, 2007). Leaves paste is used externally to treat boils and carbuncles and leaf extract of the plant is good for ear ache. Extract of its flower is used as blood purifier, as a cure for bleeding piles and for treatment of eye diseases and ulcers (Bos and Yadav, 1998). Marigold plants have anti-nematicidal activity (Olabiyi and Oyedunmade, 2007) and found most effective against the nematode species *Pratylenchus penetrans*. The flowers are used to make food pigments as they are rich in carotenoid pigment. The powder of flower petals are used in poultry feed which ensure a good colouration of egg yolks and broiler skin (Shukla and Thakur 2018).

Inspite of insecticidal, fungicidal, bactericidal, larvicidal properties of marigold it is affected by various pathogenic microoganisms such as fungi, virus and bacteria that causes diseases and damage to the plant which resulted yield loss. Marigold suffers from various fungal, bacterial, viral and nematodal diseases and a brief introduction to these diseases and their management strategies are being discussed in the present review.

2. Major Diseases of Marigold and Their Management

2.1 Fungal diseases

Marigold is one of the most important commercial flower crops of India in terms of cultivation and utilization. Though having repellent property, marigold is also affected by number of fungal diseases. Some of the important fungal diseases of marigold are flower blight (*Alternaria zinniae*), wilt and stem rot (*Phytophthora cryptogea*), Collar Rot (*Phytophthora* sp.; *Pythium* sp.), damping Off (*Pythium* sp.), *Alternaria* leaf spot, *Fusarium* wilt (*Fusarium oxysporium*) and *Cercospora* leaf spot (*Cercospora megalopotamica*) (Sohi, 1983; Pawar, 1971). Out of these leaf spot and flower blight incited by *Alternaria tagetica* is the most serious, prevalent all over the country. Shamsi and Aktar (2017), isolated a total of 20 species of fungi from *Tagetes erecta* and *T. patula*, out of which *Aspergillus fumigates*, *Alternaria alternata*, and *Curvularia*

lunata were found to be pathogenic to *Tagetes erecta* and *T. patula.*

2.1.1 Alternaria Leaf Spot

The disease is incited by *Alternaria* spp. The favourable temperature for germination of conidia of *Alternaria helianthi* is 25°C to 28°C and the presence of free water on leaf surface (Allen *et al.* 1982) and exposure to high moisture conditions for long time increased the severity of *Alternaria tagetica* (Hotchkiss and Baxter, 1983). According to Cotty and Misaghi (1985) growth, sporulation, zinniol production and number of lesions formed by *Alternaria tagetica* infection was found to be affected by light.

The fungus growth is also affected by both continuous and alternating light. The fungus grows optimally at 25°C and the growth was almost inhibited at a temperature of 35°C (Yu and Lee, 1989). Mazumdar (2000) studied the effect of various meteorological factors on the development of leaf blight of African and French marigold caused by *Alternaria dianthi* and found a significant correlation between rain fall, temperature and humidity which were suitable for the development of leaf blight in marigold. In alternaria leaf spot, brown necrotic spots formed on leaves, which increases in size during later stage of infection and the entire foliage gets damaged by the infection and results in poor vegetative growth. According to an estimate the disease resulted in a loss of flower yield upto 55-60% (Cotty and mishaghi, 1985) in northern Madhya Pradesh. The leaf spot and flower blight disease (*Alternaria tagetica*) has become a major biotic constraint in the full exploitation of high yielding scented marigold varieties. The infection can lead to premature defoliation and finally death of the plant. *Alternaria zinnae* cause inflorescence blight of marigold in which elongated lesions are formed on inflorescence. Light tan to dark brown, large irregular blotches appears on the leaves with zonation. Dithane M-45 (0.2%) and Carbendazim (0.05%) spray can be used to control the disease at regular intervals (Aktar and Shamsi, 2015, Singh *et al*., 2012, Bharnwal *et al.* 2002). Some plants and plant products are also found to be useful in controlling *Alternaria* infection (Mamgain *et al*., 2013). Dubey (2001) also reported that *Azadirachta indica* in different forms is effective against *Alternaria* spp. while according to Gupta (2005) volatile oils from *A. indica* and *Eucalyptus* sp. were found effective against *Alternaria tagetica* (Chandel *et al.*, 2010).

2.1.2 Septoria leaf spot

The disease is caused by fungal pathogen of *Septoria* sp. Septoria leaf spot is commonly occurred on chrysanthemum (Waddell, 1959, Magie and Overman, 1960, Chandel and Chandel, 2010). Earlier this disease in marigold was reported from Florida (Changsri, 1958). However, Shukla and Thakur (2018) firstly reported the septoria leaf spot of marigold from Himachal Pradesh, India. Symptoms of the disease mainly appear on leaves but these can also develop on petioles, stem and calyx. Small, water-soaked circular spots appear on older leaves of the infected plants. The centre of these spots turns into gray colour and margins into dark brown colour as the disease progress. In the tan centres of spots, there is some readily visible dark brown, tiny dot like structures appear which are known as Pycinidia. After appearance of many spots, the affected leaves turns yellow in colour and then turn brown, become shrivelled and ultimately drop off (Shukla and Thakur, 2018).

The disease have a severity of about 30-70% in Marigold growing area of Himachal Pradesh, India and under favourable conditions it may reach upto 100 percent (Shukla and Thakur, 2018). For control of the disease the crop should be sprayed by 0.2% Dithane M-45 fungicide at regular intervals after appearance of first disease symptoms (Aktar and Shamsi, 2015, Bharnwal *et al.*, 2002). Hussain *et al.* (2013) used 33 plant extracts against leaf spot of ground nut and all extracts found effective against the pathogen but leaf extract of *A. indica* found more effective in comparison to others. Foliar spray of aerated compost tea reduced septorial leaf disease of tomato by 26.3% (Gangaiah *et al.*, 2004).

2.1.3 Cercospora Leaf Spot

Cercospora leaf spot is caused by fungus *Cercospora megalopotamica* which causes the economic losses in term of yield and quality parameters of marigold crop. In Cercospora leaf spot, circular spots (Diameter of about 1/8 inch) with ash gray centres and dark brown or reddish-purple borders appear on leaves. To reduce the effect of fungus and to get high flower production, usage of fungicides in excess lead to resistance in the pathogens against fungicide (Gangavane, 1981, Arora *et al.*, 1992, Waghmare *et al.*, 2011). Bavistin and captan gave the best control against the Cercospora leaf spot of the marigold (Barbetti, 1987, Veena *et al.*, 2013; Chandel and Kumar, 2017). A combination of the bio-formulation (garlic extract, cow urine, soap nut) was found effective in controlling the disease (Venkataramana *et al*., 2009, Chandel and Kumar, 2017). Uddin *et al.* (2013) used six plant extracts (Neem leaves extract, Garlic cloves extract, Biskatali leaves extract, Alamanda leaves extract, Arjun leaves extract and Debdaru leaves extract) against Cercospora leaf spot of mungbean and suggested the use of neem leaves extract for controlling the pathogen as it minimize the incidence and increased the yield of mungbean. Farrag (2011) firstly observed Cercospora leaf spot disease in Okra plant and reduced the disease

incidence by foliar application of Topsin M-70WP and lemongrass oil in different concentrations.

2.1.4 Wilt and Stem Rot

It is caused by the fungus *Phytophthora cryptogea* which infect the collar portions of the plants. In nursery, the infection resulted in damping-off which is aggravated by soil moisture while infected plants showed wilting in the field. French marigold and dwarf varieties of marigold are found less susceptible to the disease in comparison to African types of marigold. The disease can be controlled by treating the soil with Captan, Metalaxyl Mancozeb and Fosetyl-Al. (Kumar, 2012). Strains of *Pseudomonas fluorescens* can be used as biocontrol agents against *Phytophtora cactorum* that causes root rot of strawberry (Agusti *et al.,* 2011). Aqueous and acetone extracts of *Allium sativum* and *Azadirachta indica* were found effective against *Phythopthora infestans* (Ngadze, 2014). In a study conducted by Yanar *et al.* (2011), out of 26 plants, *Xanthium strumarium*, *Lauris nobilis*, *Salvia officinalis* and *Styrax officinalis* were showed potent antifungal activity by completely inhibiting the mycelial growth of *P. infestans*. Acetone, methanol and hexane extracts of *Terminalia bellerica* and acetone extracts of *Psoralea corylifolia* showed complete inhibition of mycelia growth of P. Infestan (Rani *et al.,* 2015).

2.1.5 Collor Rot

It is caused by a number of pathogens *viz*. *Rhizoctonia solani*, *Phytophthora* sp. and *Sclerotium rolfsii*. The occurrence of disease in nursery stage or in grown up plants depends upon type of soil, moisture content and other environmental factors (Sohi, 1984). In this disease black lesions developed on the main stem and rotting at the collar regions causes plant death.

The disease can be reduced by soil sterilization and controlled watering (Anonymous, 2012). Captan, Thiram and Manzate at 0.3% concentration can completely inhibit the growth of pathogen. Blitox-50 can also control the pathogen at 0.3 and 0.5 % concentration (Rout and Mishra, 2008). Plant extracts of *Rauwalfia serpentine* can be used against the pathogen and similarly biological antagonist (*Streptoverticillium* sp., *Trichoderma* sp. and *Gliocladium virens)* can also be used to significantly control the pathogen (Rout and Mishra, 2008). In studies carried out by Siddique *et al.* (2018), Chemical fungicide, leaf extract of Neem, Poultry manure and *Trichoderma harzianum* found effective in controlling *Sclerotium rolfsii* that causes foot and root rot disease of eggplant.

2.1.6 Powdery Mildew

The causal organisms are *Oidium* sp. and *Leveillula taurica* which produces whitish, tiny, superficial spots on leaves and later on whole aerial parts of plant is covered with whitish powder which contains conidia and conidiospores of the pathogens (Grover, 1952, Sreeramula, 1953). The disease can be controlled by spraying Sulfex (3g/litre of water), 0.5% Karathane (40 E.G.) or by dusting with sulphur powder at regular intervals (Anonymous, 2012). Cell-free culture filtrate and biomass of *Ampelomyces quisqualis*, *Trichoderma harzianum* and *Saccharomyces cerevisiae* were found effective against powdery mildew of grape (Singh et al., 2017). Singh *et al.* (2015), evaluated aqueous extracts of leaves of *Azadirachta indica*, *Melia azedarach*, *Melothria perpusilla*, *Phlogacanthus thyrsiflorus*, *Vitex trifolia* and rhizome extract of *Acorus calamus* and *Zingiber officinale* against powdery mildew of oak tree (*Quercus serrata*). Out of these plants, rhizome extract of Zingiber officinale (at 15% concentration) was found to be most effective in disease control.

2.1.7 Flower Bud Rot

The causal agent for the disease is *Alternaria dianthi.* During the disease young flower buds shrivel, turn deep brown in colour and dry up while symptoms of the disease on mature buds are less prominent but these buds also fail to open due to the effect of pathogen (Mondal and Chaudhari, 1976). The pathogen also infects leaves of the plant causing blight and brown necrotic spots on margins and tips of older leaves. Spraying of 0.2% Mancozeb and 0.2% Dithane M-45 effectively controls the infection of flower bud and leaf (Singh *et al*., 2012). The antagonists like *Chaetomium globosum, Trichoderma harzianum, T. koningii, T. viridae, Bacillus subtilis* and *Fusarium* spp. found effective against different species of *Alternaria* (Vananacci and Harman, 1987, Babu *et al*., 2000). The extracts of *Canna indica, Convolvulus arvensis, Cenchrus catharticus, Mentha piperita, Allium cepa, A. sativum, Argemone mexicana, Datura stramonium* and *Clerodendron inerme* were effective in preventing the germination of *A. brassicae* isolated from leaves of cauliflower (Sheikh and Agnihotri, 1972, Mamgain *et al*., 2013).

2.1.8 Damping Off

The causal agent of the disease is *Rhizoctoina solani* and the disease is more frequent at the seedling stage. Necrotic spots and rings develop on the young seedlings and cause pre-emergence mortality in seedlings while appearance of water soaked, brown, necrotic ring on lower part of hypocotyl are post-emergence symptoms and due to these post emergence symptoms seedling collapse (Singh *et al*., 2012). It causes cconsiderable loss if seedlings are not properly looked after and root system of the infected seedling appears partially or fully decayed (Subramanyan *et al.,* 1975). Damping off disease of

marigold caused by *Ceratobasidium* sp. on *T. erecta* was first reported in India by Saroj *et al*., 2013. Soil sterilization by Formalin (2%) before sowing, spraying with Dithane Z-78 (0.2%) and soil drenching with 0.3% Brassicol and 0.1% Carbendazim are found effective in controlling the disease. Also a Proper drainage should be provided in the nursery bed to control the spread of the pathogen and 3-4 years crop rotation should be followed (Singh *et al*., 2012).

Sanaullah *et al.* (2018) evaluated extracts of cinnamon (*Cinnamomum verum*), moringa (*Moringa oleifera*) and clove (*Syzygium aromaticum*) in various concentrations against *R. solani* that cause damping off of tomato. Out of these, clove leave extract showed highest antifungal activity and inhibited complete mycelial growth.

2.1.9 Botrytis blight or Gray mold

The Causal agent of the disease is *Botrytis cinerea.* Disease symptoms appeared as dead blotches on leaves, flowers, and stems. Rotting of stems may cause plants to collapse, flower buds may fail to open and diseased flowers that open become decayed and drop prematurely. A covering of gray fuzzy fungal growth and spores appears on infected plant tissue (Anonymous, 2012).

The disease can be controlled by removing plant debris after appearance of disease symptoms, by providing proper air circulation, maintaining dry foliage and avoiding overhead watering. Other than these sanitary practices, use disease-resistant cultivars and replacement of susceptible plant material with tolerant cultivars can reduce the disease. Fungicides can also be used to control the pathogen (Dhiman and Arora, 1990, Anonymous, 2018a). *Pseudomonas* strain (QBA5) isolated from healthy tomato plant significantly inhibited the conidia germination and mycelial growth of *B. Cinerea* (Gao *et al.,* 2018). The aqueous extract of *Asteriscus imbricatus* has inhibited completely the growth of *B. cinerea* (Senhaji *et al.,* 2014). Fielding *et al.* (2015) evaluated eight plant extract against *B. cinerea* and out of them *Galenia africana* and *Elyptropappus rhinocerotis* extracts showed maximum inhibition.

2.2. Bacterial diseases

2.2.1 Bacterial Leaf Spot of Marigold

Bacterial leaf spot of marigold is caused by *Pseudomonas syringae* pv. *tagetis*, the disease is seed borne and very destructive in immature marigold plants. It was observed for the first time in the United States (1978) in the field of Wisconsin (Styer *et al.*, 1980) and also found in greenhouses in North Carolina during 1983 and 1984.

The symptoms of the disease are appearance of black spots on cotyledon of seedlings, necrotic spots on leaves surrounded by chlorotic tissues in an irregular pattern, chlorotic and distorted apical growth and in some cases the disease cause mortality of the infected plant. Shane and Baumer (1984) reported that the pathogen that causes bacterial leaf spot of marigold also causes diseases of zinnia, common ragweed, sunflower and Jerusalem artichoke. In the starting of infection symptoms appear under the leaf surface as tiny, watery, dark-green spots and then appear on upper leaf surface after one or two days as a brownish diffuse discolouration (Hellmers, 1955).

As bacteria causing the leaf spot of African Marigold is seed borne and to control the pathogen healthy seeds should be used. To control the pathogen spray of 'Mercusan' (0.1%) or 'Midol-special-Mercuri' (0.75%) should be used (Hellmers, 1955). Verma and Agarwal (2015) found that plant extract of *Allium sativum* and *Terminalia chebula* effective to control *P. syringae* pv. *pisi.* Ethanolic and methanolic extract of *Lantana camera* found effective against bacterial leaf spot disease of papaya (Hossain *et al.,* 2018). Mougou and Boughalleb-M'hamdi (2018) studied the antibacterial potential of *Bacillus* species and garlic extracts against *P. syringae* and found them effective in controlling the pathogen.

2.3. Viral diseases

Some of the marigold plants affected by viral disease and their symptoms comprises of yellowing, mosaic, vein chlorosis and mild curling. The infected plants were stunted and yielded poor number of twisted and deformed flowers and the reduction in growth appeared as the production of small leaves clustering around the main stem. Growth ceases and necrosis at the top observed in the severely infected plants. Marigold plant is naturally attacked by three different viruses viz. *Cucumber mosaic virus* (CMV) (Hanson *et al*., 1951), *Marigold mosaic virus* (MMV) and *Marigold mottle virus* (Naqvi *et al*., 1981).

CMV is identified as a member of cucumovirus which is transmitted by *Aphis gossypii, A. craccivora* and *Myzus persicae* and it was found to be seed transmitted in case of marigold plants. Naqvi *et al*. (1981) reported a potyvirus causing mosaic disease in marigold and they named it as *Marigold mosaic virus*. The thermal inactivation point of the virus was 55°C with dilution end point of 1:6000 (Sang and Varma, 1975). Elbeshehy *et al.* (2014) recommend the use of *Thuja* extract (6 g/L) to decrease the infection caused by *watermelon mosaic potyvirus*. Glycoprotein from the roots of *Boerhaavia diffusa* acts directly on viruses to effectively control their growth (Awasthi *et al.*, 2016).

2.3.1 Aster yellows

It is Caused by Aster yellows phytoplasma and infected leaves become discolored (light green, yellow, white, red or purple) and stunted; flowers are small and deformed with improper coloration; Stems become weak and may form a clump (witches

broom). Infected plants cannot be recovered so to control the spread of the pathogen infected plants should be completely removed and destroyed as well as nearby perennial weeds should be removed as they can be a source of inoculums (Anonymous 2018a).

2.4 Nematode diseases

Marigold plant as described earlier has nematicidal activities but all *Tagetes* varieties are unable to resist all types of nematodes. For example, Cracker Jack marigold can control the southern root-knot nematode but this variety serves as a host for other nematodes such as stubby-root and reniform nematodes and other nematodes like Sting and awl nematodes can increase on *Tagetes* species (Rhoades 1980).

Kanwar and Walia (2002) have reported efficacy of *Chenopodium* and neem in the management of root-knot nematode in tomato. Extract of tobacco, clove, betelyine and sweet flag found most effective against the root knot nematode (Wiratno *et al.,* 2009). Aqueous extract of mint have nematicidal properties against the root knot nematode (Caboni *et al.,* 2013).

3. Conclusion

From the above review, it can be concluded that Marigold plant belonging to the Asteraceae family, is extensively used for various purposes such as for making garland and for beautification purposes. Marigold plant is medically important and also used to control the nematodal diseases of other plants. Marigold plant suffers from various diseases (Fungal, bacterial, viral and nematodal) and affected majorly by fungal pathogens. Some of the important fungal diseases of marigold are flower blight (*Alternaria zinniae*), wilt and stem rot (*Phytophthora cryptogea*), Collar Rot (*Phytophthora* sp.; *Pythium* sp.), damping Off (*Pythium* sp.), *Alternaria* leaf spot, *Fusarium* wilt (*Fusarium oxysporium*) and *Cercospora* leaf spot (*Cercospora megalopotamica*). These diseases resulted in yield loss and can be controlled by chemical treatment as well as with the help of various plant extracts and antagonist such as *Bacillus* sp., *Trichoderma* sp. and *Pseudomonas fluorescens.*

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