IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Review on- Management of cumin wilt caused by *Fusarium oxysporum f.sp.cumini*

Bhavna Jagani[1], Minaxi Parmar[2], Dr. V N Patel[3], Dr. Nutan Prakash Vishwakarma[4]*

[1]Research Scholar, Department of Microbiology, Atmiya University of Rajkot, India
[2]Assistant Professor, Department of Microbiology, Atmiya University of Rajkot, India
[3] Research Scientist, Dry Farming Research Station, Agriculture University of Junagadh, India.
*Corresponding author. Email: nutan.vishwakarma@atmiyauni.ac.in
Principle author: bhulku.shaishav@gmial.com

ABSTRACT

Cumin (Cuminum cyminum L.) is one of the oldest species of spice. Cumin seeds are used as a spice with a distinctive flavor and are traditionally added to chili, curries, and other food preparations. India is the world's largest producer and consumer of cumin. Cumin is an economical cash crop, but cultivar development efforts are limited. Cumin is severely affected by Fusarium wilt caused by the soil-borne pathogens *Fusarium oxysporum*, resulting in yield losses of up to 80% depending on the severity of the infestation. The maximum population of Foc is estimated to be 0–5 cm in soil depth when crops are present. Soil inoculum density increases with each year of cumin cultivation and is directly proportional to disease incidence in the field. This review provides information on cumin cultivation, cumin wilt and management strategies, including soil, climate, seed treatment, time of sowing, sowing method, effective biocontrol agents, organic additives, fungicides for seed treatment, irrigation and harvesting time.

Key wards: Cumin, *Fusarium oxysporum f. sp. Cumini*, wilt, cumin cultivation, nutritional value.

1.INTRODUCTION

India is also the largest producer, consumer, and exporter of cumin. Cumin (*Cuminum cyminum ,L.*), commonly known as jeera, is one of the earliest seed spices used worldwide. Cumin is an annual medicinal plant of the umbelliferae family (Kafi, 2002). Originally grown in Iran and the Mediterranean region, it is now mainly grown in Iran, Uzbekistan, Tajikistan, Turkey, Morocco, Egypt, India, Syria, Mexico, Bulgaria, Cyprus, and Chile. It is the second most popular spice in the world after black pepper. It has different names depending on the country, such as cumin in German, jeera in Hindi, fake anise in French, and comin in Belgium. India's production reaches 100,000 to 200,000 tons per year, making it one of the world's leading producers. The country also has the largest area allocated for cumin production at around 52,500 hectares. The level of cumin production and total planted area has increased significantly in recent years. India exports about 8000 tons of cumin annually. Cumin is a tropical plant grown during the rabbi period when the humidity is low during flowering and seeding. Diseases such as wilting, powdery mildew, and blight are major reasons for low productivity, along with inadequate nutritional management (Dange et al. 1992). Among these all diseases, the greatest loss is caused by wilting. In this review, we look at a variety of cumin-producing countries that have developed over the past many years to help researchers to develop more effective control strategies against wilt disease and intensify efforts to spread them to cumin producers. This review describes the cultivation of cumin, nutritional value of cumin, medicinal importance of cumin, economic importance of cumin, symptomatology, cumin diseases and its management for the production of high yielding cumin crops.

Botany and Morphology of the Cumin Plant:

Cumin is a small bushy plant that is grown annually. It has a thin stem with a diameter of 3-5 cm and a height of 20-30 cm. It is stemless and branched, greenish early in life and grayish at maturity (Hussein and Batra, 1998). Cumin plants thrive with numerous small pink or white flowers on the same stem length and same height. The cumin fruit resembles a cremocarp and grows from the lower part of the ovary. The fruits are light brown or greyish, ovoid or spindle-shaped. The cumin fruit is called the seed, but when it germinates, the pericarp is split open to reveal the true seed. cumin seeds are dried and capsuled and split into two pieces. At maturity, only one seed has grooves in the walls. The seeds are longitudinally curved and brownish in color, similar to other members of the Apiaceae family, but much like caraway seeds (Chandola et al. 1970). It has a wide range of medicinal effects (Singh et al. 2017).

2. CULTIVATION OF CUMIN

Cumin seedlings are very sensitive to salt. Appropriate and improved agricultural practices can increase crop production and productivity. In addition, resources such as seeds, fertilizers, pesticides, and insecticides can be saved, and labor can be saved.

Soil

Soil conditions play an important role in plant productivity. The best soils for growing cumin are sandy to loamy soil with proper drainage, good ventilation, and high oxygen availability. The preferred soil pH range is between 6.8 and 8.3 (Lal et al. 2018). Cumin is mainly grown in light-textured soils that are low in nitrogen and have low water holding capacity. In addition to low organic matter, low microbial counts, and low water-holding capacity, repeated cultivation of susceptible genotypes makes soils conducive to wilt pathogens.

Climate

A warm subtropical climate favors better cultivation. Cumin cultivation requires three to four months of long, hot summers. It cannot withstand high humidity and heavy rain. At low temperatures, the leaves change color from green to purple. High temperatures shorten growth time and induce early maturation. For better growth it needs cool and dry climatic conditions (temperatures up to 25-30°C). It is commonly grown in arid regions such as Gujarat and Rajasthan**.**

Time of sowing

In India, cumin he is sown from October to early December and harvesting begins in February. In Syria and Iran, cumin is sown in mid-November to mid-December (can be extended to mid-January) and harvested in June or July.

Sowing method

Cumin seeds are sown in the first or last weeks of November. The sowing rate is 2-4 kg per acre. The distance between rows is 25 cm and the distance from plant to plant is 10 cm, ideal for growing cumin. Sow the seeds at a depth of 1-1.3 cm and be careful not to go deeper than 1.5 cm.

Manure and fertilizers

For a good cumin yield, fertilizers and fertilizers should be used based on soil surveys. Normally, 20 quintals per acre of cow dung should be applied to the field during tillage. After that, 25 kg of DAP and 4 kg of urea should be added per acre at the time of sowing. At the first irrigation, 3 kg of urea should be given per acre.

Irrigation/Watering in cumin farming

Lightly water the seeds immediately after sowing, and then a second watering 7-10 days after the first watering. Subsequent watering should be done depending on the type of soil and climatic conditions. A final heavy watering should be done at the time of sowing. Watering during seed filling should be avoided as it increases the incidence of rot, powdery mildew and wilt.

Harvesting time of cumin seeds

Harvest time is usually 110-120 days after sowing, depending on the variety selected. Occurs in the first week of March when seeds are sown in November. Seeds can be harvested by tapping the stems on clean ground or can be done in a cumin thresher

3.NUTRITIONAL VALUE OF CUMIN

Among the seed spices, cumin is a high-quality source of various nutrients, vitamins and minerals. Dried cumin seeds contain fat (20–24%), protein (9–11%), fiber (10–12%), and free amino acids (Sowbhagya, 2013). Cumin is also an excellent source of minerals such as copper and zinc, B-complex vitamins, vitamins such as riboflavin, thiamine, niacin, and vitamins A, E, and C and antioxidant (Bettaieb et al. 2011). Cumin seeds are naturally rich in iron, with 1 teaspoon of ground cumin containing 1.4 mg of iron, or 17.5% of the RDI (Recommended Daily Intake) for adults (Ancuceanu et al. 2015). It is also an excellent source of manganese, according to the World's Healthiest Foods rating, which improves the human body's hemoglobin and strengthens the immune system. Cumin seeds contain 2.5-4.0% volatile oils and aldehydes, which are responsible for their flavor and special medicinal properties (Agarwal 1996 & 1950). Seed essential oil contains cumin aldehyde (p-isopropylbenzaldehyde, 25%-35%), perillaldehyde, cumin alcohol, α- and β-pinene (21%), dipentene, p-cymene, β-phellandrene. The seeds contain oil, the main component of which is cuminol, so the seeds have a typical pleasant aroma. Due to the aromatic substances contained in herbs, many researchers are interested in experimentally validating the therapeutic uses of herbs or their seeds.

4.MEDICINAL IMPORTANCE OF CUMIN

It has multiple medicinal properties and is used to treat stimulant, carminative, stomachic, astringent, and restorative properties of diarrhea and indigestion (Malhotra & Vashishtha 2008). It is also used to treat fever, nausea, vomiting, abdominal discomfort, edema, and postpartum discomfort (Johri, 2011 Deepak, 2013; Mnif and Aifa 2015). Cumin oil has been used as a multifunctional glow dye or in topical dressing ointments. Used as a carminative, digestive, astringent, antitussive, analgesic for bronchopulmonary disease and in the treatment of mild digestive disorders (De et al. 2003). It serves as an active reservoir for various bioactive compounds with therapeutic applications (Hajlaoui et al. 2010; Johri, 2011). Cumin plant sprouts are an excellent source of metabolites, fatty acids, phenolic compounds and amino acids. All these properties reveal the plant's therapeutic potential while providing valuable information on the metabolic response to salt stress (Pandey et al. 2015). Many people around the world do not get enough iron on a daily basis diet. As a result, iron deficiency is one of the most common nutrient deficiencies, affecting nearly 20% of the world's population and up to 10 -15 % in the wealthiest countries (Levi et al. 2016). Cumin seeds are naturally rich in iron, with 1 teaspoon of ground cumin containing 1.4 mg of iron, or 17.5% of the RDI (Recommended Daily Intake) for adults (Ancuceanu et al. 2015).

5.ECONOMICAL IMPORTANCE OF CUMIN

India produces 70% of the world's supply and consumes 90% of it (which means India consumes 63% of the world's cumin). Other producing countries are Syria (7%), Iran (6%) and Turkey (6%). The remaining 11% come from other countries. A total of about 300,000 tonnes of cumin are produced worldwide each year. In India, Rajasthan and Gujarat are the main cumin cultivar states, with cumin developed zones covering about 841,940 hectares with an annual production of 546,750 tonnes, contributing about Rs 8.2 billion annually. Gujarat covers an area of about 3,37007 hectares.

6.CUMIN DISEASES AND MANAGEMENT

Wilting, blight and powdery mildew are the main diseases in cumin cultivation. Cumin crops are mainly attacked by three major diseases: blight (Alternaria burnsii), wilt (Fusarium oxysporum f.sp. cumini) and powdery mildew (Erysiphe polygoni) (Dange, 1995).

Extent of damage

Wilt is the most destructive disease of cumin. Gaur (1949) first reported the existence of wilt disease caused by Fusarium species in Rajasthan, India. Patel et al. (1957) identified the pathogen and determined the virulence of the fungus. Since then, it has been exported to Argentina (Gaetan & Madia 1993), Iran (Omer et al. 1997), Egypt (Arafa 1985), Greece (Pappas & Elena 1997), Syria, Afghanistan, Pakistan and Turkey, and worldwide. Restricting cumin production has become a regular issue (Alawi 1969; Champawat & Singh 1972). Studies have revealed losses of approximately 5% to 60% in cumin-producing regions of India (Patel et al. 1957; Patel & Prasad 1963). However, infection rates vary between 25% and 40% and can reach 70% in some cases (Gaur 1949). Yield losses of approximately 40% have been recorded in arid regions of India, where cumin is widely cultivated in winter (Lodha et al. 1986). Producers who have continued cultivation in dry land for several years often have no choice but to give up cultivation.

Symptoms

Plants are affected at all stages of growth, but the severity of wilting increases with plant age. When the plant reaches 2.5 cm to 5.0cm in height, it wilts and dies. In older plants, the leaf color changes from green to yellow, starting with the oldest leaves and moving to the younger leaves. In severe stages, the tops and leaves of the plant fall off, leading to complete plant death. Such plants are easy to pull out of the ground. The roots of diseased plants have dark brown spots. Sometimes only partial wilting is seen. If plants become infected during flowering, they remain sterile (Mathur & Prasad 1964). The seeds formed are thin, small and wrinkled. Seeds are often contaminated at harvest, allowing pathogens to spread to new areas. Partially wilted plants stop growing and the leaves turn pinkish-yellow.

Pathogen

The pathogen *Fusarium oxysporum f. sp. Cumini* grows naturally in both soil and seeds. Patel (1968) investigated the causes of pathogen penetration and emphasized the possibility that fungi are transmitted by endolysis. Later, the role of internal inoculum was established (Singh et al. 1972). The fungus produces abundant white mycelium during cultivation. The microconidia are freely scattered on the 4.8–12.8 μm mycelium. Macroconidia account for about 90% of the conidia produced, mostly 2-3 septa, 34.44 × 3.28 μm. Chlamydospores are terminal or interstitial, globose and smooth, with an average diameter of 8.2 μm, and live in soil for more than 10 years (Mathur & Mathur 1965). Altered hyphal growth and virulence were reported in nine Foc isolates (Champawat & Pathak 1989). Arafa (1985) showed a wide range of pathogenicity for isolates from infested fields in Egypt (Assiut and EL-mina). Foc chlamydospores were severely affected by elevated temperature and exposure time. After 45°C, the time required to completely kill chlamydospores decreased significantly with each 5°C increase.

Management

Incidentally, the genetic resources available worldwide have limited sources of resistance to wilt pathogens. Disease can therefore be managed by cultural, biological, and chemical means. Management strategies have been developed to reduce the incidence of wilt in the field. Integrating cost-effective and practical strategies into specific agroclimatic zones can make cumin cultivation profitable. This goal can be achieved by integrating antipathogen, prohost, and environmental modification methods. package of Practices consisting of a combination of cultural, biological and chemical methods and host resistance can help reduce disease. To achieve meaningful control of pathogens, Critical levels of disease control, all r Components of the disease pyramid need to be managed.

Cultural method

Because the pathogen is host-specific, cumin sowing timing and crop rotation with non-host crops have been found to be excellent methods of controlling field wilt (Mathur et al. 1967). In arid regions of India, alternating use of cumin fields with mustard and pearl millet in the winter and wet seasons, respectively, has been found to reduce the incidence of wilting. Summer tillage significantly reduced disease incidence (Champawat & Pathak 1990). Significantly reduced wilt incidence and improved seed yields were recorded 3 to 1 summer tillage. This method works especially well during the summer months when there is plenty of sunlight and warm soil temperatures. However, in areas with strong summer winds, this method is not recommended as the wind can blow away the most fertile soils of the farmland. Soil solarization has proven to be an effective technique for reducing soil populations plant pathogen density and induced disease in sunny fields irradiance and soil temperature during non-cultivation periods are available (Katan 1981). The use of organic additives such as cakes, residues and compost has proven to be superior Cumin leads to control of wilting in many countries. These changes lead to increased soil microbial populations and activity, along with increasing the population of antagonists to Foc. Soil uptake of cruciferous residues has been shown to reduce the population of soil-borne plant pathogens, the effects of which are primarily due to toxic volatiles such as mercaptans, methyl sulfide and isothiocyanates. (Gamliel & Stapleton 1993). Improved populations of Foc-antagonizing actinomycetes were recorded in the modified soil. This may have also contributed to the reduction in pathogen populations. The effectiveness of cruciferous residues in controlling wilt disease was demonstrated by single irrigation on hot summer days, or during the rainy season, when soils were amended with mustard residues or oil cakes to reduce the occurrence of cumin wilt, led to significant reduction in wilt incidence on cumin (Mawar & Lodha 2002). The reduction in wilt incidence was significantly enhanced when applied in summer compared to when applied in the rainy season. This could be a cumulative effect of biotoxic volatiles released during residue decomposition at elevated soil temperatures (38 °C to 42 °C) and subsequent microbial antagonism.

Chemical methods

The wilting rate was 24.5% at 30 kg N ha-1 followed by 26.8% with 30:10:10 NPK kg ha-1 (Champawat & Pathak 1988a) Increasing doses of K+ reduced the incidence of withering. Pre-sowing application of carbofuran 3G @ 66 kg ha-1 was most effective in reducing wilt incidence followed by phorate 10 G @ 20 kg ha-1 and aldicarb 10G @ 20 kg ha-1 (Champawat & Pathak 1988b). Seed treatment with carbendazim at 3 g kg of seed in combination with spraying with carbendazim (0.1%) or benomyl (0.05%) was effective in reducing the incidence of wilting (Champawat & Pathak 1991a). Soil application of SMDC (Vapam) was effective in suppressing wilting and increasing plant vigor. Application of carbendazim granules one month after sowing cumin was also effective (Jadeja et al. 2002). Seed dressing and soil soaking with thiophanate-methyl Carbendazim reduced the incidence of wilting and increased seed yield. It was discovered that herbicide inhibited the growth of Foc mycelium (Patel & Patel 1993). Aghnoom et al. (1999) studied the effects of fungicides and found that benomyl, carboxim + thiram, iprodione + carbendazim, and captan reduced mycelial growth of Foc. Reduced fusarium infection and increased seed yield of Plant compared to controls was recorded as a result of pre-sowing treatment. A two-day primer combination containing water and T. harzianum appeared to be the best treatment for reducing fungal infections (Tawfic & Allam 2004a).

Biological control

As bioagents have shown potential in various studies in controlling wilt disease, many growers have started using bioagents as a regular practice. Seed treatment with Trichoderma harzianum T2 isolate, reduced disease incidence by 65.4% and was found to be more effective than fungicide seed treatment (Aghnoom et al. 1999). Inoculation of cumin plants with Glomus fasciculatum, G. mosseae, and Aculospora laevis reduced the incidence of wilting (Champawat & Pathak 1991b). Similarly, biocontrol agents such as T. harzianum, Aspergillus flavus, and A. niger inhibited Foc growth in the laboratory (Patel & Patel 1998a). Vyas & Mathur (2002) effectively inhibited Foc growth and/or Lodha & Mawar sporulation in vitro by producing Trichoderma spp.of volatile and non-volatile antibiotics. They also reported that adding T. aureoviride and T. harzianum to seeds and applying them to soil resulted in significantly higher germination rates and reduced disease.

Tea lees have been found to be optimal for large-scale growth of T. harzianum isolates, Antagonizes Foc (Sharma & Trivedi 2005). Three antagonistic bacterial strains, Bacillus subtilis, Pseudomonas fluorescens, and Rhizobium species, sprung on Nutrient Broth, King's Broth, and Yeast Exmanit Broth, respectively. Bioactive substances are increased by using easily decomposable organic substances serves dual function, first as a nutrient base for fungal growth and second as a soil conditioner. The efficacy of peanut husk compost as a carrier for Trichoderma species (T. harzianum, T. hamatum, and T. koningii) in controlling wilt was studied in Egypt (Haggag & Abo-Sedera 2005). Demand for cumin is stable, but wilting is a constant threat to profitable cultivation. A major limitation in the treatment of wilt disease is the lack of resistance in established germplasm worldwide. Large-scale screening of germplasm led to the identification of a few field-tolerant variety, but still in need strengthen joint research efforts. Due to the small flowers, improvement of Umbelliferous plants by classical breeding methods is generally slow, laborious and time consuming (Hunault et al. 1989).

7. REFERNCES

Agarwal S 1996 Volatile oil constituents andwilt resistance in cumin (Cuminumcyminum L.). Curr. Sci. 7: 1177–1178

Aghnoom R, Falahati-Rastegar M & Jafarpour B 1999 Comparison of chemical and biological control of cumin wilt (Fusarium oxysporum f. sp. cumini) in laboratory and greenhouse conditions. Iranian J. Agri. Sci. 30: 619–630.

Alawi A 1969 Fusarium disease of cumin. Plant Dis. J. 5: 92–98.

Ancuceanu R, Dinu M, Hovaneţ MV, Anghel AI, Popescu CV, Negreş S. A survey of plant iron content-a semi-systematic review. Nutrients 2015;7(12):10320-51.

Arafa M K M 1985 Studies on Fusarium wilt ofcumin. M.Sc. Thesis, Assiut University,Egypt

Bettaieb I, Knioua S, Hamrouni I, Limam F, Marzouk B. Water-deficit impact on fatty acid and essential oil composition and antioxidant activities of cumin (Cuminum cyminum L.) aerial parts. Journal of Agricultural and Food Chemistry 2011;59:328-34.

Champawat R S & Pathak V N 1988b Soil application of different insecticides and nematicides for the control of wilt (Fusarium oxysporum f. sp. cumini) of cumin. Indian J. Plant Prot. 16: 195–196.

Champawat R S & Pathak V N 1989 Cultural,morphological and pathogenic varia-tions in Fusarium oxysporum f. sp. cumini.Indian J. Mycol. Plant Pathol. 19: 177–183

Champawat R S & Pathak V N 1990b Management of cumin wilt by summer ploughing. Indian Cocoa Arec. Spices J. 13: 107– 108.

Champawat R S & Pathak V N 1991a Effect of fungicidal seed treatment on wilt disease of cumin. J. Turkish Phytopathol. 20: 23–26.

Champawat R S & Pathak V N 1991b Interaction between vesicular arbuscular mycorrhizal fungi and Fusarium oxysporum. Proc. Indian National Sci. Acad. 57: 59– 62.

Chandola R, Mathur S, Anwer M. A serious weed of cumin crop “zeeri” (Plantago pumila Wild.). Science and Culture 1970;36:168-69.

Dange S R S, Pandy R N & Savalia R L 1992 Dis-eases of cumin and their management -a review. Agri. Rev. 13: 219–224

Dange, S.R.S. (1995). Diseases of cumin (Cuminum cyminum L.) and their management. J. Spices and Aromatic Crops, 4:57-60

Deepak. Importance of Cuminum cyminum L. and Carum carvi L. in traditional medicaments - a review. Indian Journal of Traditional Knowledge 2013;12:300-07.

Gaetan S & Madia M 1993 The presence of cumin(Cuminum cyminum L.) wilt caused byFusarium oxysporum Schl. f. sp. cumini.Patel, Prasad, Mathur and Mathur inArgentina. Boletin-de-Sauidad-vegetal-plagas 19: 503–507.

Gamliel A & Stapleton J J 1993 Characterization of antifungal volatile compounds evolved from solarized soil amended with cabbage residue. Phytopath. 83: 899–905.

Gaur M M 1949 Plant protection work in Ajmer-Merwara in 1948 Plant Diseases. PlantProt. Bull. Govt. India. 1: 20–21.

Haggag W M & Abo-Sedera S A 2005 Characteristics of three Trichoderma species in peanut haulms compost involved in biocontrol of cumin wilt disease. Intl. J. Agri. Biol. 7: 222–229.

Hajlaoui H, Mighri H, Noumi E, Snoussi M, Trabelsi N, Ksouri R et al. Chemical composition and biological activities of Tunisian Cuminum cyminum L. essential oil: A high effectiveness against Vibrio spp. Strains. Food and Chemical Toxicology 2010;48:2186-92.

hampawat R S & Pathak V N 1988a Role of nitrogen, phosphorus and potassium fertilizers and organic amendments in cumin (Cuminum cyminum) wilt incited by Fusarium oxysporum f. sp. cumini. Indian J. Agric. Sci. 58: 728–730.

Hunault G, Desmarest, P & Manoir J D 1989 Foeniculum vulgare Miller: Cell culture. In: Bajaj Y P S (Ed.) Regeneration and production of anethole (pp.185–212), Springer- Verlag, Berlin, Germany.

Hussein M, Batra A. In vitro embryogenesis of cumin hypocotyl segments. Advances in Plant Sciences 1998; 11:125-28.

Johri RK. Cuminum cyminum and Carum carvi: An update. Pharmacognosy Reviews 2011; 5:63-72.

Kafi, M. (2002). Cumin (Cuminum cyminum) Production and Processing. Ferdowsi University of Mashhad press. 195

Katan J 1981 Solar heating (solarization) of soil for control of soil borne pests. Ann. Rev. Phytopathol. 19: 211–236.

Lal G. Scenario, Importance and Prospects of Seed Spices: A Review. Current Investigation in Agriculture Current Research 2018; 8:49-62.

Levi M, Rosselli M, Simonetti M, Brignoli O, Cancian M, Masotti A et al. Epidemiology of iron deficiency anaemia in four European countries: a population-based study in primary care. European Journal of Haematology 2016;97(6):583-93

Lodha S, Gupta G K & Singh S 1986 Crop diseasesituation and new records in Indian aridzone. Ann. Arid Zone 25: 311–320.

Malhotra SK, Vashishtha BB. Package of practices for production of seed spices. Book, Publisher Director, National Research Centre on Seed Spices, Ajmer 2008, 3-19p

Mathur B L & Mathur R L 1965 Metabolites ofFusarium oxysporum in relation tocumin wilt. Indian Phytopathol. 18:335–339.

Mathur B L & Mathur R L 1967 Metabolites of Fusarium oxysporum f .sp. cumini in relation to cumin wilt II. Influence of growth period, pH and dilution. Indian Phytopathol. 20: 42–44.

Mathur B L & Prasad N 1964 Studies on wiltdisease of cumin caused by Fusariumoxysporum f. cumini. Indian J. Agri. Sci. 34:131–137

Mawar R & Lodha S 2002 Brassica amendments and summer irrigation for the control of Macrophomina phaseolina and Fusarium in hot arid region. Phytopath. Mediterr. 41: 45–54.

Mnif S, Aifa S. Cumin (Cuminum cyminum L.) from traditional uses to potential biomedical applications. Chemistry and Biodiversity 2015; 12:733-42.

Omer E A, Nofal M A, Lashin S M & Haggaq W ME 1997 Effect of some growth regulatorson the growth parameters and oil con-tent of cumin with disease incidenceunder two types of soil. Egyptian J.Hort.24: 29–41

Pandey S, Patel MK, Mishra A, Jha B. Physiobiochemical composition and untargeted metabolomics of cumin (Cuminum cyminum L.) make it promising functional food and help in mitigating salinity stress. PLoS One 2015;10(12):15-18.

Pappas A C & Elena K 1997 Occurrence ofFusarium oxysporum f. sp. cumini in the is-land of Chios, Greece. J. Phytopathol.145:271–272.

Patel P N & Prasad N 1963 Fusarium wilt ofcumin (Cuminum cyminum) in GujaratState, India. Plant Dis. Report. 74: 528–531

Patel P N, Prasad N, Mathur R L & Mathur B L1957 Fusarium wilt of cumin. Curr. Sci.26: 181–182.
Patel S M & Patel B K 1993 Evaluation of herbicidal concentrations against Fusarium oxysporum f. sp. cumini causing cumin wilt. In: Proc. Indian Soc. Weed Sci. International Symp. H

Patel S M & Patel B K 1998a Inhibitory effect of different fungal bio-agents on Fusarium oxysporum f. sp. cumini causing cumin wilt. Ann. Plant Prot. Sci. 6: 25–27.

Pruthi, J. S. (1976) Spices and Condiments, National Book Trust, Delhi, India.

Sharma N & Trivedi P C 2005 Microbial bioagents: Economic multiplication and management of fungal nematode complex on cumin. Indian J. Biotech. 4: 419– 421

Singh R D, Choudhary S L & Patel K G 1972 Seedtransmission and control of Fusariumwilt of cumin. Phytopath. Mediterr.11:19–24.

Singh RP, Gangadarappa HV, Mruthunjaya K. Cuminum cyminum – A popular spice: An updated review. Pharmacognosy Journal 2017;9(3):1-5

Sowbhagya HB. Chemistry, technology, and nutraceutical functions of cumin (Cuminum cyminum L): An overview. Critical Review in Food Science and Nutrition 2013;53:1-10

Tawfic A A & Allam A D A 2004a Improving cumin production under soil infestation with Fusarium wilt pathogen: I- Screening of biocontrol agents. Assiut Univ. Bulletin Res. 7: 35–44.

Vyas R K & Mathur K 2002 Distribution of Trichoderma spp. in cumin rhizosphere and their potential in suppression of wilt. Indian Phytopathol. 55: 451–457.
Alawi A 1969 Fusarium disease of cumin. Plant Dis. J. 5: 92–98.