



Alternaria leaf blight (*Alternaria* spp.) – an emerging foliar fungal disease of winter-summer groundnut (*Arachis hypogaea*) : A review

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ABSTRACT

Alternaria leaf blight of groundnut (*Arachis hypogaea* L.) is an economic important foliar fungal disease of winter (*rabi*)-summer groundnut. It is not only distributed in India, but also in other groundnut growing countries like Nigeria, Vietnam and Thailand. Its severity increases whenever the crop is facing any biotic and abiotic stresses. This disease significantly affects pod and haulm yield of groundnut causing a reduction in the pod (13–22%), haulm yield (24–63%) and kernel quality. In cultivated groundnut, very limited sources of moderate resistance are available to *Alternaria* leaf blight. Now efforts are being made to identify better and stable sources of resistance in cultivated groundnut germplasm and interspecific derivatives. Although cultural, biological and chemical control measures have been used for the management of *Alternaria* leaf blight but these involve high costs and time. Growing *Alternaria* leaf blight resistant cultivars is the most effective way to protect groundnut crop. However, conventional breeding approaches have been successful for developing moderate resistance groundnut varieties for *Alternaria* leaf blight. This review has made an attempt to consolidate the research developments in *Alternaria* leaf blight and resistance breeding in groundnut.

Keywords: *Alternaria* leaf blight, Cultivar, Groundnut, Resistance

Groundnut or peanut (*Arachis hypogaea* L.) is grown globally in nearly 30.4 million ha with a total production of about 51.5 million tonnes and productivity of about 1696 kg/ha during 2018–2020 (FAOSTAT 2022). India produced 9.0 million tonnes of groundnut annually from an area of about 5.2 million ha area with a productivity of 1718 kg/ha during 2018–19 to 2020–21. Groundnut is a mainly rainfed crop (rainy (*kharif*) season) which accounts an about 85% of the total area and 82.5% of total production with lower productivity of about 1655 kg/ha as compared to irrigated crop 2146 kg/ha (winter (*rabi*)-summer seasons). Winter-summer groundnut is mainly grown in seven major states, viz. Karnataka, Tamil Nadu, Maharashtra, Telangana, Andhra Pradesh, Gujarat and West Bengal which account for about more than 90% of the area and production of the total winter-summer area and production of the country (Anonymous 2022). *Alternaria* leaf blight is an emerging as a major foliar fungal disease in winter-summer groundnut growing states. Thomma (2003) reported that *Alternaria*

species generally attack weakened tissues due to stresses, senescence or wounding. This indicates that saprobic *Alternaria* species opportunistically can become parasitic when they meet a weakened host demonstrating that the distinction between saprophytic and parasitic behaviour is not always evident. Hong and Pryor (2004) also shown that *Alternaria* spp. opportunistically infect plants through mechanical injuries or injuries caused by insects. Moisture deficit stress condition in groundnut increases the incidence of *Alternaria* leaf blight from 5.3–28.6%, hence, moisture deficit stress may predispose the genotypes to *Alternaria* leaf blight susceptibility (Kumar *et al.* 2017).

The genus *Alternaria* was described by Nees (1816) based on *A. tenuis* as the type isolate. Von Keissler (1912) synonymized both *A. tenuis* and *Torula alternata* (Fries 1832) with *Alternaria alternata*. In India, the first report of *Alternaria* was made by Mason (1928) from Pusa (Bihar) on a herbarium material of Brassica species. The appearance of pathogen *Alternaria* spp. was observed by Dey (1948) in Uttar Pradesh. A complete account of distinguishing characters of the Indian species of *Alternaria* has been described by Subramanian (1971).

There are various reported species of *Alternaria* causing leaf spot and blight diseases in groundnut. Bohovik (1936) reported leaf spot disease of groundnut caused by an unknown species of *Alternaria* from the Ukraine region of the USSR. This disease was economically important

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causing severe damage to foliage. A leaf spot disease of groundnut caused by an unknown species of *Alternaria* has been reported in Uganda (Mukiibi 1975) and Nigeria (McDonald 1978). Aulakh (1969) reported a very destructive new disease of groundnut in some parts of Punjab caused by *Alternaria tenuis* Auct. It causes 40–50% damage to groundnut foliage. Kulkarni (1974) first described species of *Alternaria*, *Alternaria arachidis* Kulk. causes necrotic brown leaf spot of groundnut. The most common disease “Alternariosis”, is also leaf blight causing veinal necrosis in groundnut, which is caused by *Alternaria alternata* (Fr.) Keissler, was first reported by Balasubramanian (1979) in the post rainy season in Madras. This disease was later confirmed by many workers (Subrahmanyam *et al.* 1981, Vyas *et al.* 1985, Narain *et al.* 1987). Ghewande *et al.* (1982) first reported *Alternaria tenuissima* (Kunze ex Pers) wilts causing leaf blight of groundnut which was also observed by Patil and Hiremath (1989). Giri and Murugesan (1996) first reported *Alternaria longipes* causing necrotic leaf spots in groundnut.

Keeping the above observations in mind, the objective of this review article is to provide consolidated and updated information on economic importance, distribution, disease symptom, epidemiology, current status as well as progress made so far through groundnut breeding methods, integrated management of *Alternaria* leaf blight of groundnut and identify future thrust areas to combat this disease.

Pathogen

With growing incidences of *Alternaria* leaf blight in winter-summer groundnut, this pathogen is gaining importance. The biology and pathology of this pathogen were studied by Narayanaswamy (1980) and Prasad and Reddy (1986). Growth media composition plays a very important role in fungi growth, nutrition and physiology to obtain a pure culture of the pathogen. Growth and sporulation of *A. alternata* were best studied on potato dextrose agar (Kantwa *et al.* 2015, Reddy *et al.* 2019).

Relative humidity, optimum temperature and pH are very important factors for spore germination, growth and sporulation of any fungi which also influences the occurrence and development of disease. Species, *A. alternata* requires high relative humidity of 85% and above (Chen *et al.* 2000, Reis *et al.* 2006, Kantwa *et al.* 2015, Sharma and Ahir 2018), pH 6.5 (Maheshwari *et al.* 2000, Singh *et al.* 2001, Kumar *et al.* 2012, Gawai and Mangaliker 2018) and optimum temperature range of 25–30°C for maximum mycelial growth and sporulation (Maheshwari *et al.* 2000, Singh *et al.* 2001, Thaware *et al.* 2010, Kumar *et al.* 2012, Kantwa *et al.* 2015, Ginoya and Gohel 2015, Sharma and Ahir 2018). The optimum pH range for groundnut leaf blight caused by *A. tenuissima* was observed between pH 5.4 and 7.8 (Patil *et al.* 1995). Moisture availability in the form of rain, dew or high humidity are essential factors for infection and a minimum of 9–18 h are required for the majority of the *Alternaria* species (Humpherson-Jones and Phelps 1989). Continuous moisture of 24 h or longer

practically ensures infection (Chupp and Sherf 1960). Above findings indicated that majority of the *Alternaria* species requires high relative humidity (85%), medium optimum temperature (25–30°C) and normal pH (6.5) for maximum mycelial growth and sporulation.

Epidemiology

Alternaria is a ubiquitous fungus that shows different kinds of lifestyles ranging from pathogens, weak facultative parasites, saprophytes and endophytes (Thomma 2003). It frequently causes quiescent infections, in which the fungus enters the tissue where it remains dormant until the occurrence of favourable conditions for infection. *Alternaria* species has no known sexual stage or overwintering spores, but the fungus can survive as mycelium or spores on decaying plant debris for a considerable time, or as a latent infection in seeds (Rotem 1994). *Alternaria* species survive as spores and mycelium in infected plant residues or in and on seeds. Spores are carried either by wind or splashing on the surface where infection takes place. For germination and infection, spores must have good moisture. The pathogen infection may take place either through wounds or stomata. Stressed, weak, old, or wounded tissues are more liable to invasion than sound, vigorous tissues (Singh *et al.* 2015). Withholding of irrigation water for four weeks and above, deficiencies of nitrogen, micronutrients (iron and zinc), damage of sucking pests, salinity (4 dS/m) are the predisposing factors for *Alternaria* leaf blight (Anonymous 2019).

Infected seeds with spores on the seed coat as well as inside the seed coat act as major sources of inoculum of *Alternaria* spp. The spores are disseminated through wind, water and by tools and animals. The fungus can survive in susceptible weeds or perennial crops (Chupp and Sherf 1960). Prasad (1991) observed *A. alternata* of groundnut is transmitted from seed source (3.3 to 40%). *A. alternata* of groundnut was able to survive for three months in infected leaves exposed to the natural conditions on the soil surface (Prasad and Reddy 1986). Similarly Prasad (1991) also revealed that *A. alternata* of groundnut was able to survive up to 90 days on the surface of the soil. However at 10, 20 and 30 cm depth of the soil the fungus was able to survive for 60, 50 and 40 days, respectively. Spores of *Alternaria* spp. contributed 5% spores of the total airborne pathogens over the groundnut field at Peravurani, Thanjavur, Tamil Nadu (Rajalakshmi and Shakila 2008). In the groundnut fields at Latur, Maharashtra, 4.92% of the airborne fungal spores reported were of *Alternaria* spp. (Chate and Gaikwad 2019). Volunteer groundnut plants are the primary source of inoculum and secondary spread occurs through conidia. It has several weed hosts including aquatic weeds like water hyacinth (*Eichhornia crassipes*) and pistia (*Pistia stratiotes*). The sources of the inoculums of *Alternaria* leaf blight may come from sesame, sunflower or the weed hosts (Kumar and Thirumalaisamy 2016) and leftover plants of previous season crops especially cotton and groundnut (Kumar *et al.* 2012).

It has been observed that temperature above 37°C,

relative humidity below 60% and withholding of irrigation water after 33–66 days after germination may predispose the groundnut crop to *Alternaria* leaf blight infection (Anonymous 2018–19a). Entry of *A. alternata* into groundnut leaves is either by the formation of appressoria or through stomata or both (Prasad *et al.* 1990). Disease symptoms appeared 12–15 days after inoculation (Kumar *et al.* 2012). The first symptoms of *A. alternata* of groundnut were observed after five days of inoculation as small, isolated, scattered, pale yellow, brown spots first on the lower leaves then progress upward. Full disease symptoms appear after 15 days of inoculation as blighting of leaves (Kantwa *et al.* 2015). Conidial germination and successful infection of *A. alternata* of groundnut occur 48–72 h after inoculation of spores and the development of disease symptoms starts 5 days after inoculation (Mahatma *et al.* 2019). The above findings indicated that high temperature (>37°C) along with low relative humidity (<60%), water stress, damage of sucking pests and nutrients deficiencies are the major predisposing factors for high incidence of *Alternaria* leaf blight in summer groundnut. *Alternaria* leaf blight of summer groundnut generally appears one month after sowing and their incidence reached highest at the time of harvest in May. During harvesting, the temperature is high with low relative humidity which resulting high moisture deficit stress. It is clearly indicated that *Alternaria* is weak and an opportunistic pathogen has positive relationship with high temperature, moisture deficit stress and other prevailing abiotic and biotic stresses.

Symptomatology

There are many species of *Alternaria* which can cause diseases in groundnut (Fig 1). Each species of *Alternaria* produces different symptoms from another. The disease is named according to symptoms produced by the species, viz. *Alternaria* leaf spot and *Alternaria* leaf blight. Bohovik (1936) described *Alternaria* lesions are brown spots with a darker margin and light centre, round or irregular and frequently coalescing. The affected leaves turn chlorotic and dry prematurely. Lesions are mainly found on top leaves.



Fig 1 *Alternaria* leaf blight incidence in field.

Mukiibi (1975) reported light brown lesions starting from the margins of the leaflet and eventually covering half of the surface. Symptoms of a new disease of groundnut caused by *A. tenuis* occur as brown water-soaked translucent blighted areas on leaflet tips (Aulakh 1969). The symptoms produced by *A. arachidis* are brown in colour and irregular in shape and margin surrounded by a yellowish halo (Kulkarni 1974), while the species *A. alternata* (Fr.) Keissler symptoms are orange-brown necrotic spots in interveinal areas extending into veins and veinlets. It causes veinal necrosis in groundnut (Balasubramanian 1979). Subrahmanyam *et al.* (1981) also reported leaf spot and veinal necrosis in post-rainy season in Southern India (Andhra Pradesh, Karnataka and Tamil Nadu) and similar symptoms have been described in Karnataka (Siddaramaiah *et al.* 1983). Leaf spot, veinal necrosis and leaf blight symptoms were also produced by this species (Subrahmanyam *et al.* 1992). They described leaf spot symptoms as small, chlorotic, water-soaked lesions, which may spread over the surface of the leaf (Fig 2). The lesions become necrotic, brown and round to irregular in shape. Veins and veinlets near the lesions also become necrotic. The lesions increase in the area become irregular in shape with brown and dark brown margins, their central portions become pale, dry rapidly and disintegrate. When many lesions are present they may coalesce, giving the leaf a ragged and blighted appearance and subsequently become senescent.

The characteristic symptoms of *A. tenuissima* are blighting of the apical region of leaflets with light to dark brown in colour (Fig 3). The blighted area increased from the tip towards the middle of the leaflets, which results inward folding of the blighted tip area and defoliation of severely affected leaflets (Fig 4) within 1–2 weeks (Ghewande 2002). The symptoms of *A. longipes* are characterized by the production of necrotic leaf spots (Giri and Murugesan 1996).

Geographical distribution and economic importance

Alternaria species are opportunistic pathogen and have been reported having worldwide distribution with wide host range causing plant diseases in nearly about 400 plant



Fig 2 Inward folding of blighted tip.



Fig 3 Blighting of apical region of leaflets.



Fig 4 Leaflet margin surrounded by yellowish halo.

species; in which *A. alternata* alone can infect more than 100 plant species (Simmons 1992, Kusaba and Tsuge 1995, Mirhosseini *et al.* 2015). *Alternaria* leaf blight has more economic importance in India, but it is also distributed in other groundnut growing countries like Nigeria, Vietnam and Thailand (Subrahmanyam *et al.* 1992).

In India, Aulakh (1969) reported a very destructive new disease of groundnut in some parts of Punjab caused by *A. tenuis* Auct. The economic importance of *Alternaria* disease was emphasized by naming it as leaf spot and vein necrosis caused by *A. alternata* in a detailed survey of major groundnut growing states, viz. Andhra Pradesh, Karnataka and Tamil Nadu (Subrahmanyam *et al.* 1981). Siddaramaiah *et al.* (1983) studied the distribution and severity of leaf spots and vein necrosis on groundnut in Karnataka. It has also shown economic importance in the southern states of India like Karnataka, Andhra Pradesh and Tamil Nadu. The intensity of *Alternaria* leaf blight varies from season, generally extent of damage is high in *rabi*-summer than in *kharif* but there are not many differences observed in symptoms.

The intensity of this disease varies from 15–35% generally appears 30–35 days after sowing (Ghewande *et al.* 1982). The field survey of groundnut growing areas around Karlapalem Mandal of Guntur district during the *rabi* season in 1990–91 revealed that the incidence of *Alternaria* leaf spot varied from 30.12% and 37.12% in different areas. The disease starts 30 days after sowing and reached the maximum at 90 days and highest at the time of harvest (Prasad 1991). Recently, it is gaining economic importance and has been observed with a severe incidence of *Alternaria* leaf blight in summer groundnut fields of Junagadh, Rajkot and Kuchchh districts of Gujarat. Kumar *et al.* (2012) observed the severity of *Alternaria* leaf blight in the Junagadh district was relatively more in the cultivars TPG-41 (26.7–66.7%) followed by TG-37A (30–56.7%)

and GG-2 (22.0–33.0%).

A field survey of groundnut fields in Junagadh and Rajkot districts by Pokharkar (2012) revealed disease intensity ranged from 0 to 30%, the highest disease was observed in cultivar GG 2 (30%) followed by TPG 41(10%). At high disease incidence it significantly affects pod and haulm yield of groundnut. Accordingly to Kumar *et al.* (2012) *Alternaria* leaf blight reduced 13–22% pod yield, and 24–63% haulm yield and it also affects kernel quality in groundnut. Pokharkar (2012) studied economic losses in five recommended groundnut varieties of Gujarat (GG 2, GG 6, GJG 31, TG 37A and TPG 41) revealed *Alternaria* leaf blight causes a reduction in pod yield (14.2–57.4%) and haulm yield (24.3–60%). Maximum reduction in a pod (57.4%) and haulm yield (60%) was observed in the cultivar GG 6, which also showed the highest disease severity (65.1%) among the tested cultivars. It is clearly indicated that *Alternaria* leaf blight is an economically important foliar fungal disease of *rabi*-summer groundnut growing countries including India. The intensity of this disease varied from 15–67%. This disease generally appears one month after sowing and reach the maximum intensity at the time of harvest.

Management practices

There are four major components of disease management, viz. host resistance, cultural control, biological control and chemical control.

Host resistance: Host plant resistance is the most desirable, cost-effective and environmentally safest way to manage plant diseases. The development and growing of suitable resistant varieties is an ideal component at no additional cost, compatible with other methods of disease management and free from environmental hazards. Very little information is available on disease resistance responses of groundnut cultivars to *Alternaria* leaf blight. According to

Muthuswamy and Subramanian (1983) most of the progenies from the crosses of Virginia types cultivars were resistant to *A. alternata*, whereas Spanish bunch types were susceptible.

Muthusamy *et al.* (1991) reported groundnut genotypes PI 259747, PI 405132, PI 215696, NcAc 17132, NcAc 17135 and NcAc 17133 RF having resistance to *A. alternata*. Five multiple disease-resistant germplasm accessions, viz. NcAc17149, NcAc927, NcAc17133 (RF), PI 393646 and PI 341879 have been identified as resistant to early leaf spot, rust and Alternaria leaf spot (Ghewande *et al.* 1992). Eight groundnut germplasms, viz. NRCGCS 77, NRCGCS 83, NRCGCS 85, NRCGCS 86, NRCGCS 21, NRCGCS 124, NRCGCS 180, and NRCGCS 222 showed multiple disease resistance to peanut bud necrosis disease, stem rot, late leaf spot, early leaf spot, rust and Alternaria leaf blight (Bera *et al.* 2011a,b,c,d,e,f,g,h). It has also been observed that cultivars TG-37A, ICGS-37, JL-24, AK-159, DRG-12 and TPG-41 were susceptible to Alternaria leaf blight (Kumar *et al.* 2012). Therefore, farmers may replace these varieties with other recommended cultivars to avoid yield losses due to the high severity of Alternaria leaf blight.

Last five years, about 500 groundnut genotypes including cultivars, germplasm, breeding lines and interspecific derivatives have been screened at ICAR-Directorate of Groundnut Research (DGR), Junagadh, Gujarat, India to identify resistance sources of Alternaria leaf blight. Among them four advanced breeding lines, viz. PBS 12190, PBS 22131, PBS 22132 and PBS 22133 and four interspecific derivatives, viz. NRCGCS 176, NRCGCS 180, NRCGCS 196 and NRCGCS 298 found resistance while cultivars, viz. Kaidiri 9, Kadiri Haritendra, ICGV 00348, GJG 17 and ICGS 44 found tolerant to Alternaria leaf blight, therefore these cultivars may be used directly in high Alternaria leaf blight disease incidence groundnut areas (Anonymous 2020). Breeding lines, viz. PBS 22131, NRCGCS 298, NRCGCS 349, NRCGCS 74 and NRCGCS 186 are currently being used in the breeding programme to develop high yielding groundnut cultivars with resistance to Alternaria leaf blight at ICAR-DGR, Junagadh, Gujarat, India. Kumar *et al.* (2020) reported that two advanced breeding lines (PBS 12169, PBS 12190) possess resistance to Alternaria leaf blight in groundnut. They also observed high heritability coupled with high genetic advance for Alternaria leaf blight of groundnut. This indicated presence of additive genetic variance and an adequate amount of genetic variability is available for this disease in the studied material therefore utilizes these breeding lines in breeding programmes and selection would be effective for developing disease-resistant cultivars.

Currently genetic resistance for Alternaria leaf blight is available with moderate level in few varieties and high level of resistance is available in few breeding lines and interspecific derivatives. Most effective and sustainable ways to manage plant pathogens is to grow available moderate disease resistant varieties. Resistance sources can be used in breeding programme to develop high yielding varieties with resistance of Alternaria leaf blight in groundnut.

Cultural control: It also has been reported that a saprophytic *Alternaria* species can become parasitic when they encounter a weakened host. Therefore, recommended agronomic packages and practices should be followed for raising the healthy crop. Cultural practices involve manipulation of the crop environment through intercropping, crop rotation, field sanitation, removal or burial of infected crop debris, organic amendments of soil, manipulation of sowing dates etc. These all cultural practices make it less favourable to organisms by disrupting their reproduction cycles, eliminating their food sources and encouraging their natural enemies. Generally plants weakened by any biotic and abiotic stresses are more prone to *Alternaria* infections as compared to healthy plants.

Biological control: Bio-agents are an alternative to fungicides for the suppression of pathogens. As seed is a source of inoculum of *A. alternata* in groundnut (Prasad 1991). Therefore, seed treatment with biocontrol agents may be the best approach to control the primary source of inoculum of *A. alternata* in groundnut. Phyllosphere or epiphytic bacteria can be used as potential biological control agents for foliar fungal pathogens. Five-time foliar spraying of epiphytic bacteria *Bacillus amyloliquefaciens* 9S2 at 15 days intervals was found effective in reducing Alternaria leaf blight of groundnut (Anonymous 2019).

Application of talc-based formulation of *Trichoderma* through seed treatment @10 g/kg seed along with foliar spray could be used for managing the incidence of Alternaria leaf blight in groundnut (Chitra *et al.* 2006). Application of *Trichoderma aureovide* (70.25%) followed by *T. harzianum* (67.8%) significantly reduced mycelial growth of *A. alternata* in groundnut (Pokharkar 2012). Chaudhary *et al.* (2018) observed that *T. viride* was found most effective in controlling Alternaria leaf blight of groundnut during *kharif* 2016 (31.9%) and summer 2017 (40.1%). To have environment-friendly agriculture, herbal extracts and natural products in disease control are being encouraged as bio-fungicides. The use of neem and its products could be used as an economically viable alternative to fungicides for the management of *Alternaria* leaf blight in groundnut. Application of 1–5% aqueous neem leaf extract reduced growth of *A. alternata*, *A. tenuissima* and *A. raphani* by 77.8–95.7%, 70–95%, 88.5–92.4%, respectively (Nandagopal and Ghewande 2004). Spraying of neem oil (3%) at the appearance of disease and 15 days later was significantly effective against the *A. alternata* causing leaf blight of onion (Ramjegathesh *et al.* 2011). Kantawa *et al.* (2014) observed that garlic clove (46.6%) extract irrespective of the concentration was most effective in inhibiting the mycelial growth and sporulation of *Alternaria alternata* of groundnut followed by neem (43.3%) and Datura leaf extracts (40.3%). It means the application of bio-pesticides or green pesticides not only effectively manages the disease by creating an unfavourable condition for the growth of fungus but is also safe for humans and the environment. These bio-pesticides are economical and serve as very good alternatives to chemical fungicides.

Chemical control: It is the last resort in disease management. *Alternaria* is a foliar fungal airborne disease so application of fungicides gives effective control of this disease in groundnut but the effectiveness of fungicides depend upon the method and time of application, optimum dose and weather factors. Though *Alternaria* leaf blight of groundnut is mainly a foliar disease but it may also transmit through seed, therefore, seed treatment will be very effective to manage this disease at primary level of infection. Seed treatment with tebuconazole 2Ds @1.5 g/kg seed followed by two foliar sprays of tebuconazole 50% + trifloxystrobin 25%-75 WG @ 1.32 g/l (0.035%) at 40 and 65 days after sowing effectively reduced disease incidence of *Alternaria* leaf blight of groundnut (Anonymous 2018-19b).

Two sprays of pyraclostrobin 5% + metiram 55% @0.98% (Cabrio Top) and tebuconazole 50% + trifloxystrobin 25% @0.01% (Nativo) at 45 and 60 days after sowing found equally most effective for controlling severity of *Alternaria* leaf blight incidence in groundnut (Anonymous 2012-13). Application of propiconazole and hexaconazole reduced *Alternaria* blight of groundnut (Bhaskar 2012). Five years (2011-2015) pooled results indicated three sprays of Mancozeb @ 0.2% (22.95%) followed by difenconazole @ 0.025% (24.47%) and propiconazole @ 0.025% (24.98%) at 35, 50 and 65 days after sowing proved most effective fungicides, which significantly reduced disease intensity of *Alternaria* leaf blight in groundnut (Anonymous 2016). Mancozeb at 1000 ppm revealed complete inhibition of mycelial growth and sporulation of *Alternaria alternata* of groundnut (Kantawa *et al.* 2014). Kapadiya (2017) recorded three sprays of mancozeb (0.2%) at 35, 50 and 65 days after sowing was highly effective and economical in reducing *Alternaria* leaf blight of groundnut with minimum disease incidence (22.95%), maximum pod (1873 kg/ha) and haulm yield (4648 kg/ha). Chaudhary *et al.* (2018) have shown two sprays of hexaconazole 5% EC (1ml/l) at 45 and 65 days after sowing was found highly effective and controlling 52.4% and 58.7% *Alternaria* leaf blight of groundnut during *khariif* 2016 and summer 2017, respectively. It has also recorded maximum pod (2767 kg/ha) and haulm yield (8749 kg/ha) during summer 2017. Shinde (2019) reported that among systematic fungicides, carbandazim (0.15%) and non-systematic fungicides, mancozeb (0.15%) was found to be most effective to inhibit the growth of *Alternaria alternata*. It is concluded that all fungicides have been successful in controlling *Alternaria* leaf blight but most of study revealed that application of mancozeb in different doses was found effective and economical in reducing incidence of *Alternaria* leaf blight in groundnut.

Conclusion

Success of any breeding program depends on the availability of diverse sources of resistance. Lack of high levels of resistance to *Alternaria* spp. in the cultivated groundnut cultivars that ceiling on the progress made through the conventional breeding approach. Now resistance sources for *Alternaria* leaf blight of groundnut have been identified

and are currently being used in breeding programs but still, there is a need to identify more very good sources of resistance to *Alternaria* leaf blight. In addition, screening techniques should be further standardised to produce reproducible results. Information on the inheritance/genetics of *Alternaria* leaf blight is either lacking or limited. There is a need to understand the genetics of this disease to devise better strategies for breeding programmes. *Alternaria* leaf blight of groundnut is effectively managed through seed treatment with biocontrol agents and seed treatment and spraying of recommended fungicides.

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