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REVIEW ARTICLE

Association of *Alternaria* spp. with cereals and millets

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Abstract

Cereals and millets (small grains) are the most important sources of food for human being. These crops are affected from the infection of seven species of *Alternaria* causing leaf spots and blight. *Alternaria triticina* and *A. triticola* are especially found associated with wheat crop alongwith causation of black point due to *A. tenuissima.* Stack burn of rice is caused by *A. padwickii,* a serious disease of this staple crop which occurs from seedling to maturity stage of the plants. *A. alternata,* a plurivorous fungus infects jowar (sorghum) Bajra (pearl millet), barely and kodon while *A. infectoria* causes leaf spot/blight and seed discolouration of wheat, barely, oat and rye. The symptomatology of diseases caused by different species of *Alternaria* has been described and the comparative morphological characters of 6 species of *Alternaria* have also been given in this review for their identification and differentiation among them.

Key words-Cereals, millets, *Alternaria* spp. stackburn, leaf spot, blight

Introduction

The cereals constitute as the major food crops of India and there are seven true cereals like wheat, rice, barely, maize, oat, rye and triticale. They contain high percentage of carbohydrates together with a considerable amount of proteins, some fats and even vitamins also. Millets also known as small grains are considered from ancient time the rich source of minerals and other contents for nutrition. Some of the commonly grown millets in India are sorghum (jowar), pearl millet (Bajra), kondon and finger millet. Diseases

caused by *Alternaria* spp. are now appearing seriously on cereals and millets which were considered to be of minor importance in the past. They not only reduce the quantity but also the quality of produce to a greater extent. The species of *Alternaria* infecting cereals and millets (Table 1).

Table 1: *Alternaria* spp. associated with cereals and millets

Crops	Alternaria spp.	References
1. Wheat	*Alternaria triticina*	Prasada and Prabhu (1962), Perello and Sisterna (2006)
	Alternaria tenuissima	Bensassi *et al.* (2009)
	Alternaria triticola	Rao (1964)
	Alternaria hungarica	Toth *et al.* (2011)
2. Barely	*Alternaria alternata*	Dhanraj (1970)
3. Maize	*Alternaria alternata*	Rao (1965), Bhaskaran (1972)
4. Sorghum	*Alternaria alternata* *Alternaria tenuissima*	Mathur and Prakash (1976) Chowdhry (1969) Narain and Saksena (1974)
5. Bajra	*Alternaria alternata*	Gaikward and Rane (1977)
6. Rice	*Alternaria padwickii*	Ganguly (1947) and Ellis (1971)
7. Oat	*Alternaria avenicola*	Simmons (2007)
8. Kondon	*Alternaria alternata*	Gupta *et al.* (1982)
9. Triticale	*Alternaria triticina*	Chaudhuri *et al.* (1976)

Cereals

Many species of *Alternaria viz., A. alternata, A. tenuissima, A. triticina, A. triticola, A. hungarica, A. padwicxii* are associated with cereals like wheat, barely, oats and rice and a critical account of *Alternaria* spp. has been presented by Dugan and Peever (2002) on members of the family Poaceae and by McGee (1995) in general.

Section - *Infectoria* with type species, *A. alternaria* and 4 more species like. *A. graminicola, A. infectoria, A. triticimaculens, A. triticina* affect cereal crops in the field and during storage.One more species, *Alternaria hungarica* has been reported on wheat from Hungary but it is not of much importance from economic point of view (Toth *et al.,* 2011).

Alternaria leaf spot and blight of wheat: The initial symptoms usually appear as small, oval discoloured lesions that are irregularly scattered on the lower surface of leaves. The central portions of the spots are irregular and the border is brownish usually surrounded by a yellow halo. In severe attack, the leaves and leaf sheaths become dry. The lesions are usually dark brown to grey and irregular in shape, which enlarge gradually, resulting in blighting of leaves. The disease is caused by *Alternaria triticina* which was first reported by Prasada and Prabhu (1962) on wheat in India and later on triticale Chaudhuri *et al.* (1976) and also Perello and Sisterna (2006) in Argentina.Another disease of wheat blight due to *Alternaria triticola* was described by Rao (1964) as a new disease and a new species of *Alternaria* from India. This fungus causes fusiform, oval or irregular clear yellowish spots. Otherwise the symptoms are similar to wheat blight caused by *A. triticina.* The differences between the symptomatology and etiology of these two diseases occurring on wheat has been given in Table 2.

Table 2. Differences between *A. triticina* and *A. triticola*

Both the species are found parasitic on wheat

Difference	***Alternaria triticina***	***Alternaria triticola***
Leaf spot	Numerous and tend to run together, brown and sometimes with "yellow halo".	Fusiform, oval or irregular, clear yellowish brown spots.
Conidia		
(i) size	20-90 µm long, 9-30 µm thick	50-170 µm long, 12-35 µm
(ii) Septation	4-7 transverse and several longitudinal or oblique septa.	3-10 transverse and several longitudinal or oblige septa.
Beak	Shorter than or the same length as the spore body.	Much shorter than spore body, often swollen to 7-8 µm at apex.

Leaf blight of triticale is also caused by *A. triticina.* The symptoms are more or less are the same as in leaf blight of wheat caused by the same pathogen (Chaudhi *et al.*, 1976).

Leaf blotch of barley: Barley is infected by *Alternaria alternata* in which the spots are irregular in appearance scattered on whole lamina and sheath also, mostly in the beginning dark brown later brownish black. in advanced cases the spots coalesce, become dry and eventually the leaves fall down (Dhanraj, 1970).

Stackburn disease of rice: The disease is known to occur in many countries of the world (CMI Distribution Map 314). Typical spots on the leaves are large, oval or circular, with dark brown, relatively narrow and distinct margins which, in circle the spots like a ring.

The centre of the spot is at first pale brown, gradually becoming almost white and bearing minute black dots, the sclerotia. The spots vary in size, from 0.3 to 1 cm long and sometimes are surrounded by a second ring. Usually only a few spots on a few leaves are observed in the field.Grains infected by the fungus show pale brown to whitish spots with a dark brown border of relatively large size, on the glumes. The spots bear black dots in the centre. The fungus may penetrate the glumes and invade the kernels causing discouloration or the kernels may even become shrivelled and brittle. The damage caused by the disease usually occurs when the seeds are attacked, the seeds being spotted or discoloured. Heavily infected seeds result in seedling blight or weakening of the seedlings. Leaf spots usually do not cause much damage.The fungus also attacks both the roots and coleoptile of germinating seeds or young seedlings. The spots are dark brown to black and often coalesce to reach several mm in length. As the decay proceeds, small, discrete, black bodies are formed on the surface of the darkened area. Heavily infected seedlings eventually wither and die; those less severely affected may outgrow and recover from the disease (Ou, 1985). The disease is caused by *Alternaria padwickii,* a pathogen in which fruiting bodies sclerotia are formed (Ganguly, 1947).

Leaf spot of Maize: In maize irregular patches are formed on leaves which are straw - coloured with cracked centre and britle in nature the disease is caused by *Altarnariaalternata*(Rao, 1965; Bhaskaran, 1972). In all seven species of *Alternaria* are known to infect nine crops of cereals and millets (Table 1). *A. infectoria* is a single species recorded on barley, oat, rye and wheat to cause the disease of minor importance. Similarly not much information is available regarding the occurrence and damage due to infection of *A. hungarica* on wheat (Toth *et al.,* 2011) and *A. avenicola* on oat (Simmons, 2007). Black point of wheat grains is caused by the fungal pathogens in which *A. tenuissima* (Bensassi *et al.,* 2009) and *A. infectoria* (Perello *et al.,* 2008) are important ones.*Alternaria infectoria* has been recorded on many different plants, especially cereals such as barley, oat, rye and wheat from many countries of the world (Ellis, 1971).

Millets

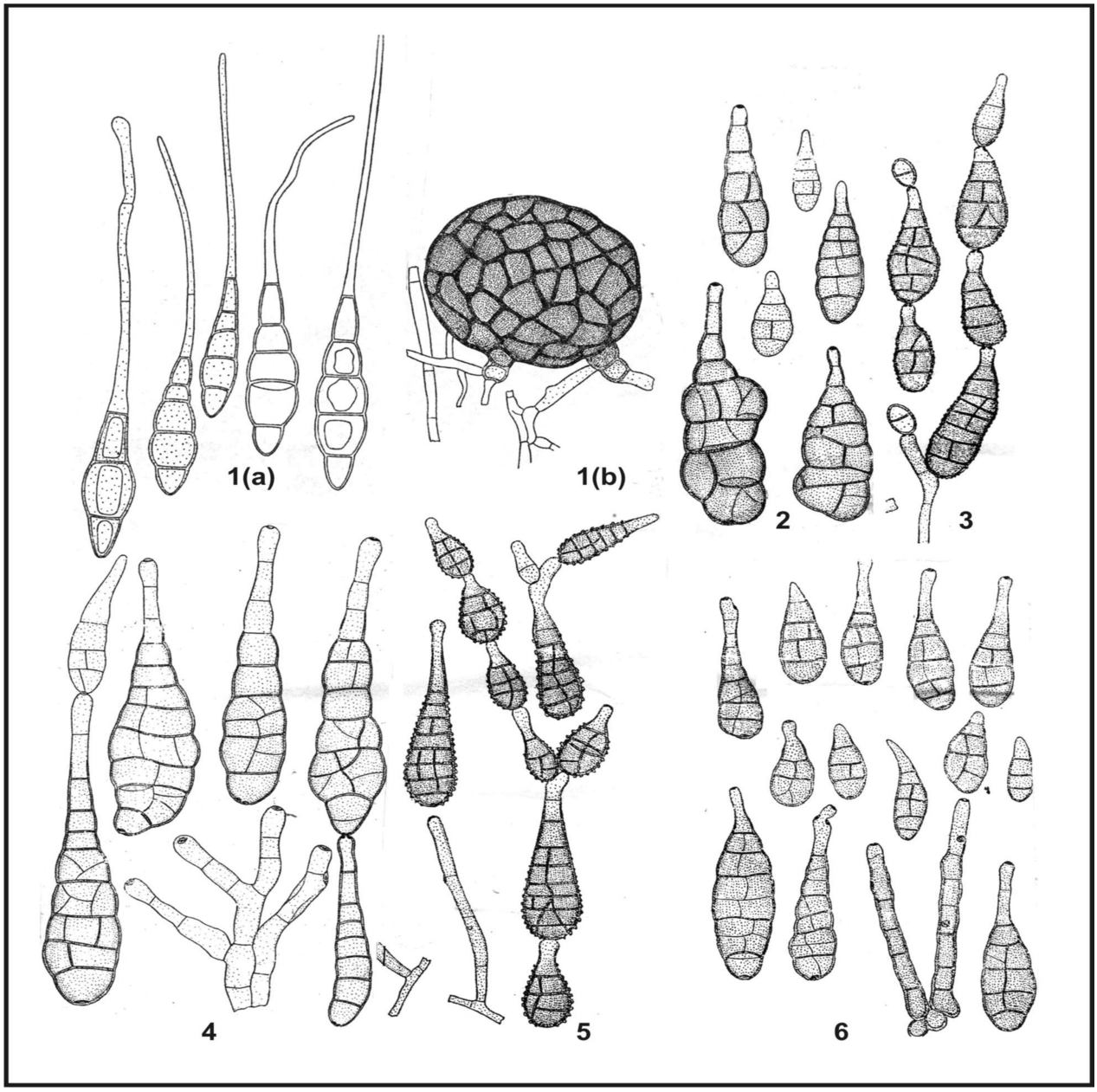
Leaf spot of Jowar: Due to infection of *Altrnaria tenuissima* irregular large, greyish brown patches are formed on leaf margins together involving a major portion of leaf blade in jowar (Chowdhry 1969; Narain and Saksena, 1974). Comparatively spots are smaller in size and scattered in case of *A. alternata* (Mathur and Prakash, 1976).

Leaf blight of Kodon: 'Kodon' (*Paspalum scrobiculatum* L.), a millet crop is attacked by *Alternaria alternata.* The symptoms of disease first appear as small discoloured water - soaked

Table 3: Comparative morphology of *Alternaria* spp.

S.No.	*Alternaria* spp.	Conidiophores	Conidia	Number of septa in conidia		Beak
				Cross	Longi	
.	*A triticina*	Straight and branched, golden or olivaceous brown, upto 30µm long, 9-30 µm thick.	Solitary or in short chain (2-4), obclavate, rostrate, smooth, 20-90 µm long, 9-30 µm thick, constricted at septa.	4-7	Several	Cylindrical, shorter than or the same length of spore body, 3-5 µm thick.
.	*A. padwickii*	Selerotia spherical, black with reticulate wall, 50-200µm diam., conidiophores upto 180 x 3-4µm often, swollen to 5-6 µm at apex.	Straight or curved, fusi form to obclavate and rostrate, 95-170(130)µm long, 11-20 (15.7)µm thick, sometime constricted at septa.	3-5	1 or more	Filiform, long and more than spore body.
.	*A. infectoria*	Often in fascicle, upto 80 x 6 µm, straw coloured or golden brown.	Mostly obclavate, rostrate obpyriform, tapering gradually to a beak, conidia formed in long and branched chain, 20-70 (50)µm long and 9-18 (14)µm wide.	upto 8	Several longi. or oblique septa.	Having swelling, half of spore body, 3-5 µm wide.
.	*A. triticola*	Often emerging in fascicle, simple or branched, straw coloured, upto 100µm long, 5-9µm thick.	Solitary or in chains of 2-3, broadly fusiform to obelavate, rostrate, pale or mid pale golden brown, 50-170 µm long, 12-35µm thick.	3-10	Several longi. or oblique septa.	Much shorter than the spore body, 4-6 µm thick, often swollen to 7-8µm at apex.
.	*A. alternata*	Arise singly or in small groups, olivaceous or golden brown, upto 50 µm long and 3-6 µm thick.	Formed in long often branched chains, polymorphic in shape, simple or verruculose, 20-63(37) µm long and 9-18(13) µm wide.	upto 8	Several longi. or oblique septa.	Pale, 2-5µm thick.
.	*A. tenuissima*	Solitary or in group, simple or branched, straight or flexuous, mid pale brown	In short chains (2-4), straight and cylindrical, pale or mid pale brown, tapering gradually to a beak, frequently swollen at tip 25-95(54) µm long & 8-19 (13.8) µm thick	4 -7	S everal longi. or oblique septa.	2-4µm thick, swollen apex 4-5µm wide.

Morphological fitures of different *Alternaria* spp.



Explanation of figures 1 to 6

Fig. 1: *A. padwickii* (a) Conidia (b) Sclerotium, 2. Conidia of *A. triticina,* 3.Conidiophore and conidia of *A. alternata,* 4.Conidiophores and conidia of *A. triticola,* 5.Conidiophore and conidia of *A. infectoria,* 6.Conidiophores conidia of *A. tenuissima.*

lesions mainly scarred on the middle portion of leaf. Following rains, these spots increase, several of them later coalesce to form large, elongated, irregular necrotic patches which spread longitudinally. In severe infection, a considerable part of the leaf is affected which ultimately dries up prematurely from tip downward and becomes blighted. The heavily infested field presents a blighted appearance visible from a distance. The disease caused by *Alternaria alternata* was fist reported from Kanpur (U.P.) by Gupta *et al.* in 1982.

Leaf spot of Bajra: Pearl millet is also affected by *A. alternata* also which causes leaf spot disease of this millet. The disease is characterized by the appearance of small scattered dark brown spots and the leaf surface, which later increase in size and coalesce also to involve the larger areas (Gaikward and Rane, 1977). The comparative morphology of different species of *Alternaria* associated with cereals and millets has been presented in Table 3 and their morphological features have been depicted in Fig. 1-6. *A. triticina* and *A. triticola* are very much closed to each other and similarly *A. alternata* and *A. infectoria* have much resemblence in their morphological features. *A. tenuissima* is distinct having conidial chains consisting of 2-4 and beak length somewhat equal to the spore body with terminal swellings. Among these six species of *Alternaria* parasitic on cereals and millets, *A. padwickii* is quite different as it produces sclerotia which are spherical or sub-spherical, black with reticulate walls (Ganguly, 1947).

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