DISEASES OF RABI GROUNDNUT IN INDIA

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INTRODUCTION

India is the world's largest producer of groundnut and in 1983/84 some 7.64 million hectares were planted and 7.28 million tonnes of dried pods were harvested (Anon. 1984). The states of Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra contribute approximately 85% of the country's production. About 75% of the crop is produced in the kharif season (rainy season) and the remainder in the Rabi season (postrainy season). In the 1983/84 Rabi, groundnut was grown on over 1.2 million hectares and 1.9 million tonnes were harvested. The average yield of groundnut is much higher in the Rabi (1544 kg/ha) than in the Kharif season (838 Kg/ha). The major Rabi groundnut producing states are Andhra Pradesh, Tamil Nadu, Gujarat, Maharashtra, Karnataka and Orissa (Table 1). The area under Rabi groundnut cultivation is rapidly increasing.

In this paper we review the literature on fungal and nematode diseases of Rabi groundnut in India. Symptoms of the major diseases are described, and their distribution and

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relative importance in the various Rabi groundnut growing areas of India outlined. The information was obtained largely from our disease surveys of Rabi groundnut in March of 1978, 1979, 1981 and 1982, in April 1981, and in July 1979 (summer crop), in south Indian states. Information was also extracted from the All India Coordinated Research Project on Oilseeds (AICORPO) Rabi/summer Annual Progress Reports (Anon.1982 and 1985a). Disease management strategies are reviewed and future research needs indicated.

LEAFSPOTS

Causal organisms: Early leafspot = Cercospora arachidicola Hori

Late leafspot = Phaeoisariopsis personata (Berk. & Curt.) v. Arx

(formerly known as Cercosporidium personatum (Berk. & Curt.) Deighton)

Symptoms: Leafspots symptoms are strongly influenced by host genotype and environmental factors. Lesions caused by C. arachidicola are sub-circular and 1 to over 10 mm in diameter. They are dark brown on the adaxial (upper) leaflet surface where most sporulation occurs and a lighter shade of brown on the abaxial (lower) leaflet surface. Lesions caused by P. personata tend to be smaller, more nearly circular, and darker than those of C. arachidicola. On the abaxial surface where most sporulation occurs the

lesions are black and slightly rough in appearance. A chlorotic halo is often present around C. arachi-icola lesions, but its presence and prominence is strongly affected by varietal and environmental factors, and similar halos may be found around P. personata lesions on some cultivars; therefore, the halo is not a good diagnostic character (Subrahmanyam et al. 1982). The colour of the lesion on the abaxial leaflet surface, light brown for C. arachidicola and black for P. personata, and distribution of fruiting structures, randomly over the adaxial lesion surface for C. arachidicola and in concentric rings on the abaxial lesion surface for P. personata, are useful characters for distinghishing between the two leaf spots. In addition to causing lesions on leaflets, the two pathogens also produce lesions on petioles, stems, and pegs. When disease attack is severe, the affected leaflets become chlorotic, then necrotic, and lesions often coalesce, resulting in shredding of leaflets. Severe defoliation can also be indured.

Distribution and importance: Both leafspots are commonly present wherever groundnut is grown, however, the incidence and severity of each disease varies between localities and seasons, and there can be both short and long-term fluctuations in their relative proportions. In India, late leafspot is currently predominant both in Kharif and Rabi seasons. Late leafspot is present in almost all Rabi groundnut growing areas in India. The disease was

particularly serious in Guntur, Prakasam, Nellore, Chittoor, Krishna, East Godavari, Kurnool, Nalgonda, Cuddapah districts of Andhra Pradesh; North Canara, Bangalore and Raichur districts of Karnataka; in almost all Rabi groundnut growing districts of Tamil Nadu, and in the Union Territory of Pondicherry. Extensive damage to the foliage due to combined attacks of late leafspot and rust was observed in many locations in Kurnool district served by the Cuddapah-Kurnool canal which originates from the river Thungabhadra, and in Nalgonda district where groundnut is grown under the Nagarjuna Sagar left canal area in paddy fallows. Late leafspot in conjunction with rust and Alternaria leafspot and veinal necrosis was serious in coastal districts of Andhra Pradesh, Tamil Nadu and Karnataka, probably because of the warm and humid climatic conditions. Late leafspot was present in Nizamabad, Karimnagar, Khammam, Anantapur, Mahaboobnagar, Rangareddy districts of Andhra Pradesh and in Kolar, Hassan and Shimoga districts of Karnataka but did not cause any appreciable damage to the foliage. Although, late leafspot is not usually a major disease problem in Raichur district of Karnataka, extensive damage from the disease was observed in the Gangawathi area of Raichur district during the 1981 Rabi season. The diseae was also reported to be serious in Mandya (1981/82 Rabi) and Dharwad (1982/83 and 1983/84 Rabi) districts of Karnataka, in Chiplima (1983/84) in Orissa, and in Jagityal (1983/84) in Andhra Pradesh (Anon. 1982 and 1985a). The Rabi groundnut growing areas in India where

late leafspot is serious are shown in Figure 1.

Leafspots damage the plant by reducing available photosynthetic area by lesion formation and by stimulating leaflet abscission. Worldwide, pod yield losses range from 10 to over 50% but vary considerably from place to place, and between seasons. Yield losses are generally substantial when the crop is attacked by both leafspot and rust. In India, leafspots and rust normally occur together and yield losses as high as 70% have been attributed to their combined attack in the Kharif season (Subrahmanyam et al. 1984). Losses in haulm (hay) yield are even greater, and this is important in areas where high quality fodder is scarce in the Rabi season and livestock populations are high. Although abundant information is available on yield losses from leafspots in the Kharif season, there are only a few reports of yield losses from leafspots in the Rabi season. Trials conducted at various AICORPO centers indicate that yield losses from foliar diseases in the Rabi season are substantial in Aliyarnagar and Vridhachalam in Tamil Nadu and in Digraj in Maharashtra. Although yield losses from foliar diseases during the 1983/84 Rabi season were substantial in Chiplima, Orissa state, no significant yield losses were observed there during the 1984/85 Rabi season (Table 2). No yield losses were observed during the 1984/85 Rabi season at Junagadh (Gujarat), at Dharwad and Raichur (Karnataka) because the disease severity was low (Table 2).

FIG. 1
GROUNDNUT GROWING AREAS WHERE LATE LEAFSPOT IS SERIOUS IN THE RABI CROP

Disease management: Eradication of volunteer groundnut plants and 'ground keepers', and removal or burial of infected crop debris is important in reducing the source of infection. Crop rotation is of great importance in reducing early season infection. Depending upon length of the growing season and cultivars grown, the time of sowing may be adjusted to avoid infection of the crop from outside sources and to avoid environmental conditions conducive to disease build-up.

Control of leafspots with fungicides has proved to be effective and economical when used by farmers in developed countries where it has been widely adopted. Fungicides have been evaluated extensively in different parts of India for control of leafspots in Kharif groundnuts. Foliar applications of sulphur dust, wettable sulphur, Bordeaux mixture and copper oxychloride were found useful in controlling leafspots. In recent years several new fungicides, including systemic fungicides such as benomyl and carbendazim compounds, have been found effective for control of leafspots. Both these compounds are ineffective against rust. Chlorothalonil was found useful in controlling both leafspots and rust. Based on several years of trials at various AICORPO centers, it was found that spraying a mixture of carbendazim (0.05%) and mancozeb (0.2%) at 2-3 week intervals starting from 4-5 weeks after planting was effective for controlling leafspots and rust during the kharif season. The cost:benefit ratio ranged

from 1:14.8 to 24.4 (Anon. 1985 b). There is no specific information available on chemical control of leafspots in the Rabi situation. However, the chemicals recommended for control of the disease in the Kharif should also be effective in the Rabi. Under the high input, low risk conditions of Rabi groundnut cultivation, the yield potential is so great that controlling even relatively low levels of foliar diseases may well prove economical.

At present, there is no agronomically acceptable groundnut cultivar with resistance to leafspots. Screening for resistance to leafspots has been intensively carried out by many workers and a number of sources of resistance have been reported. At ICRISAT Center, a world collection of over 10,000 germplasm lines was screened in the field for resistance to late leafspot and several sources of resistance were identified (McDonald *et al.* 1985). Some of these germplasm lines are also resistant to rust. Research is in progress at ICRISAT and in various research centers in India aimed at incorporating the leafspot resistance into agronomically acceptable cultivars.

RUST

Causal organism: *Puccinia arachidis* Speg.

Symptoms. Rust can be easily recognized when the orange-coloured pustules appear on the abaxial surfaces of

leaflets and rupture to release the reddish-brown urediniospores. The pustules appear first on the abaxial leaflet surface, and in susceptible cultivars the original pustules may be surrounded by colonies of secondary pustules. Pustules may later be formed on the adaxial surface of the leaflets opposite those on the lower surface. The pustules, which develop on all aerial plant parts except flowers, are usually circular and range from 0.5 to 1.4 mm in diameter. Pustules may also form on shells of developing pods. In contrast with the rapid defoliation associated with leafspots, leaves infected with rust become necrotic and dry up, but tend to remain attached to the plant (Subrahmanyam and McDonald, 1983).

Distribution and importance: Rust is a destructive disease of groundnut on a world scale. In India, rust was first reported from the Punjab in 1969 (Chahal and Chohan, 1971) and now occurs in most groundnut growing states (Mayee et al. 1977; Subrahmanyam et al. 1979). The disease has become particularly important in the southern states, where groundnut is grown for most of the year and where environmental conditions favour development and spread of the pathogen (Subrahmanyam and McDonald, 1982). Yield losses from rust are substantial in the Kharif season, damage being particularly severe if the crop is also attacked by leafspots. Field trials conducted in India in the Kharif season using fungicides with differential disease controlling abilities, showed that rust can cause yield

losses of around 50% (Subrahmanyam et al. 1983; Ghuge et al. 1981).

Rust is present in almost all Rabi groundnut growing areas in India. It is particularly serious in Guntur, Prakasam, Nellore, Chittoor, Kurnool, Nalgonda and Cuddapah districts of Andhra Pradesh; in North Kanara and Raichur districts of Karnataka; in all Rabi groundnut producing districts of Tamil Nadu, and in the Union Territory of Pondicherry. Rust was observed in Nizamabad, Karimnagar, Khammam, Krishna, East Godavari, Anantapur, Mahaboobnagar, Nalgonda, and Ranga Reddy districts of Andhra Pradesh and Bangalore, Kolar, Hassan and Shimoga districts of Karnataka, but did not cause any appreciable damage to the foliage. Rust was reported to be serious in Chiplima (Orissa) and Jagityal (Andhra Pradesh) areas in the 1983/84 Rabi, but occurred only sporadically in Junagadh district of Gujarat (Anon. 1984). Rust in conjunction with late leafspot and Alternaria leafspot and veinal necrosis caused serious damage to Rabi groundnut in coastal districts of Andhra Pradesh, Tamil Nadu and Karnataka states. The Rabi groundnut growing areas in India where rust is serious are shown in Figure 2.

In some parts of Andhra Pradesh, Tamil Nadu and Karnataka States groundnut is also grown in the summer season (March to July) under irrigation. During our survey trip in July 1979, small patches of summer groundnut (sown in March to April) were seen in many parts of Kurnool and

FIG 2

GROUNDNUT GROWING AREAS WHERE RUST IS SERIOUS IN THE RABI CROP

Anantapur districts, scattered among the vast areas of Kharif groundnut (sown in June). Mild infections of rust were noticed on the summer groundnut in some parts of Kurnool and Anantapur districts of Andhra Pradesh and in the Mysore district of Karnataka. In some areas extensive rust infections were noticed on the summer crop following monsoon showers. It was disturbing to see the Kharif crop being sown adjacent to summer groundnut fields showing serious rust attack.

In the Pollachi tract of Coimbatore district in Tamil Nadu, groundnut is grown extensively in the summer under rainfed conditions because of the unique topography and rainfall patterns. The crop is sown in April (summer) with the onset of the southeast monsoons and is harvested in August. During our disease survey in July 1979, we observed extensive damage to groudnut crops due to rust and late leafspots. Rust was observed on seedlings at the 3-4 leaf stage in this area where climatic conditions favoured infection and spread. We feel that summer groundnut in Andhra Pradesh, Tamil Nadu and Karnataka, and early monsoon groundnut in the Pollachi tract may play a significant role in the perpetuation of groundnut rust in southern India by providing a source of rust inoculum for the Kharif crop.

Disease management: Overlapping of groundnut cropping seasons should be avoided, and there should be a break of at least a month between successive groudnut crops to minimize

early season infection.

Several fungicides and their combinations have been tested for control of rust or, more often, for control of rust and leafspot together. Some of the fungicides already in use for control of leafspots have given a certain measure of rust control, chlorothalonil being particularly effective. The structurally related systemic fungicides benomyl and carbendazim have no positive effect in controlling rust and, in some cases, their application has apparently increased the severity of rust attack. Research on fungicidal control of groundnut rust has recently been intensified in India, and the fungicides mancozeb, tridemorph, carboxin, oxycarboxin, Baycor and chlorothalonil have been found effective. It is obvious that any fungicide treatment applied for rust control must also be effective against leafspots (Smith and Littrell, 1980). Recommendations for fungicidal control of combined attacks of rust and leafspots are discussed under "leafspots".

Prior to 1976 there were few reports of research on genetic resistance to groundnut rust, however, the rapid spread of the disease in the early 1970's, and increasing costs of chemical control, have stimulated work in this field. Screening for resistance to rust has been intensively carried out by many workers and a number of sources of resistance have been reported. At ICRISAT Center, some 10,000 groundnut germplasm lines were screened for resistance to rust. Previous reports of resistance were

confirmed and several new sources of resistance were identified (Subrahmanyam et al. 1985). Research is in progress in India and other countries aimed at incorporating rust resistance into agronomically acceptable cultivars.

ALTERNARIA LEAFSPOT AND VEINAL NECROSIS

Causal organism: Alternaria alternata (Fr.) Keissler

Symptoms: The disease first appears as small, chlorotic, water-soaked lesions spread over the surface of the leaf. The round to irregular lesions become brown and necrotic. Veins and veinlets adjacent to the lesions become chlorotic. The lesions increase in area and their central portions become pale, rapidly dryout, and may disintegrate. Affected leaves show chlorosis and in severe attacks become prematurely senescent. When many lesions are present they may coalesce, giving the leaf a ragged and blighted appearance. Profuse sporulation occurs on the adaxial surfaces of mature lesions.

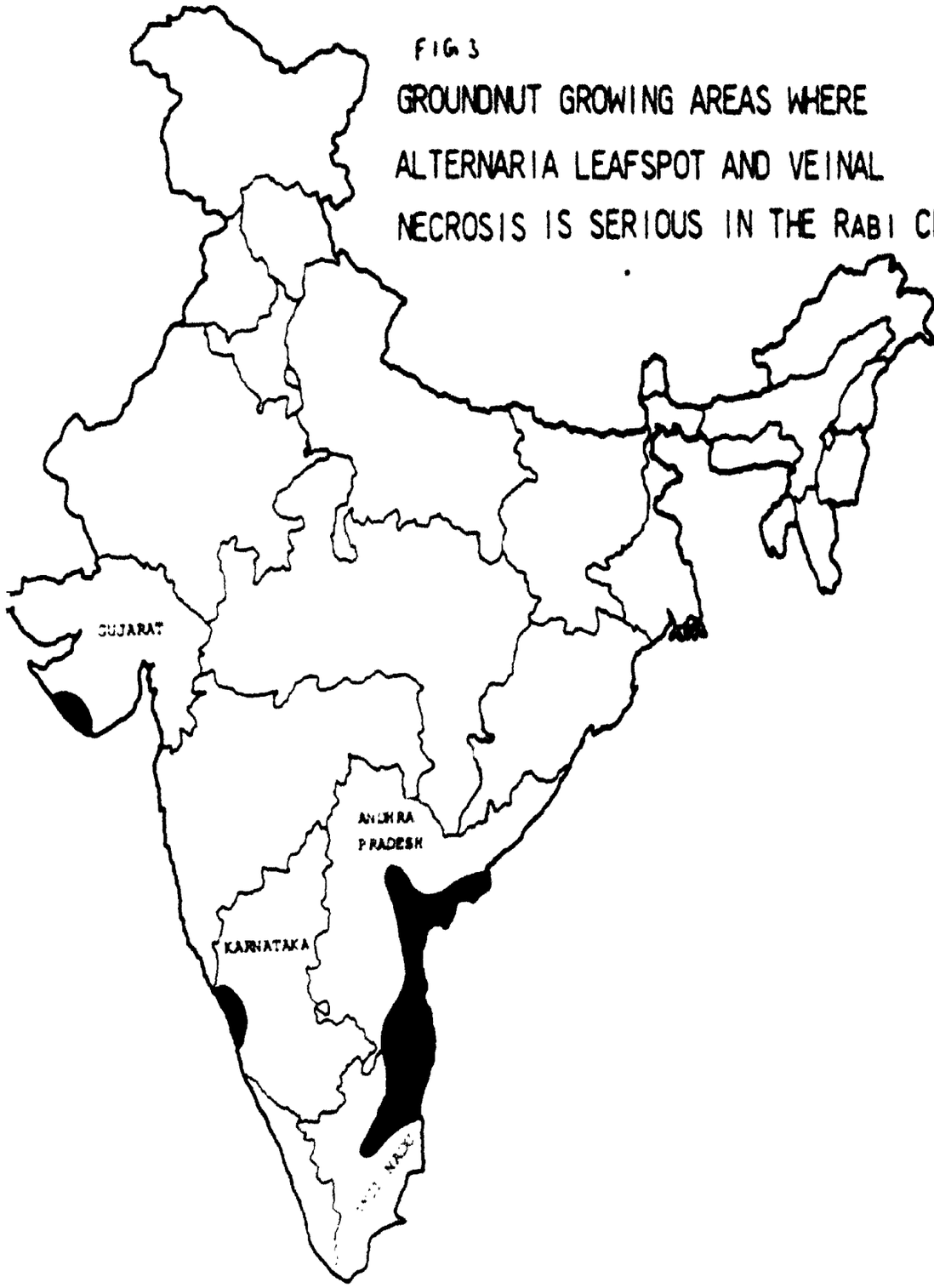
Distribution and importance: Alternaria leafspot and veinal necrosis disease was first reported on spanish-type groundnuts grown in the 1978 Rabi season near Madras (Balasubramanian, 1979). Surveys were made by ICRISAT on Rabi groundnut during the years 1977 to 1981 to collect data on the extent and severity of the disease in the south Indian states of Andhra Pradesh, Karnataka and Tamil Nadu,

and the Union Territory of Pondicherry. The disease was observed in Chittoor, Nellore, Guntur and Nalgonda districts of Andhra Pradesh in the 1977/78 Rabi season, and subsequently in the 1978/79, 1979/80, and 1980/81 Rabi seasons. In the 1978/79 and 1979/80 Rabi seasons, the disease was found in Cuddapah, Prakasam, Krishna and West Godavari districts of Andhra Pradesh, in the Dharwad, North Kanara and Bijapur districts of Karnataka, and in the Coimbatore district of Tamil Nadu. In the 1980/81 Rabi season, the disease was observed in Shimoga district of Karnataka, in Madurai, Ramnad, Pudukkottai, Tiruchirapalli, South Arcot, Cuddalore, Chengalput, and North Arcot districts of Tamil Nadu, and in the Union Territory of Pondicherry. The disease was not found in Hyderabad, Mahaboonnagar, Kurnool or Anantapur districts of Andhra Pradesh, nor in Raichur, Hassan, Tumkur, Mysore or Bangalore districts of Karnataka during the 1977-1981 surveys of Rabi crops (Subrahmanyam et al. 1981). During the 1981/82 Rabi season, the disease was observed in Tumkur and Bangalore districts of Karnataka (Anon.1982). The disease was also found to be serious in Junagadh district of Gujarat during 1981/82, 1982/83, and 1983/'84 Rabi seasons (Anon. 1982 and 1984). The Rabi groundnut growing areas in India where the disease is serious are shown in Figure 3.

Alternaria leafspot and veinal necrosis was found on plants of all ages. The disease generally occurred in combination with late leafspot and rust, causing extensive

FIG 3

GROUNDNUT GROWING AREAS WHERE ALTERNARIA LEAFSPOT AND VEINAL NECROSIS IS SERIOUS IN THE RABI CROP



damage to the foliage. It is therefore difficult to assess its individual effect upon the crop. By analogy with other foliar diseases, the mild attack was not expected to reduce yields by more than 5%; however, severe attack probably caused losses comparable to those from rust and late leafspot diseases.

The disease has not been reported on Kharif season groundnuts.

Disease management: There are no reports of cultural or chemical control of Alternaria leafspot and veinal necrosis disese. The reaction of groundnut varieties to this disease is also not known.

SEED ROT AND SEEDLING DISEASES

The fungi that are commonly associated with seed rot and seedling diseases include: Aspergillus niger van Tieghem, A. flavus Link ex Fr., Macrophomina phaseolina (Tassi) Goid., Sclerotium rolfsii Sacc., Rhizoctonia solani Kuhn., Botrydiplodia theobromae Pat. Rhizopus spp., Pythium spp. and Fusarium spp. Seed rots and seedling diseases may develop from fungi already established in the seed before sowing, or may result from direct invasion of seed by the soil inhabiting fungi.

Pre-emergence seed and seedling rots: In wet soils, seeds may be invaded immediately after sowing, leading to

pre-emergence rotting. Infected seed and seedlings are reduced to a dark brown or black spongy mass of rotted tissue covered with sporulating mycelium which varies in colour depending upon the species involved. Decay is most rapid when infected seeds are planted, as the seed-borne fungi revive and become active as soon as the seed absorbs moisture.

Post emergence seedling diseases: Collar rot (A niger) and "aflaroot" (A. flavus) are the most common post-emergence seedling diseases of groundnut in India. The commonest symptom of collar rot is the rapid wilting of the emerged seedlings due to rotting of hypocotyl tissues. The infected tissues become water-soaked and light brown, and are covered by sporulating mycelium. Symptoms of "aflaroot" include the presence of necrotic lesions on the cotyledons which usually terminate at or near the cotyledonary axis, stunting of seedlings, reduction in size of leaves which become chlorotic with vein-clearing, and poor development of the root system (Chohan and Gupta, 1968).

Distribution and importance: Collar rot and 'aflaroot' are the most commonly observed seedling diseases of Rabi groundnut in India. However, at the present time, no information is available on yield losses. During our survey in the 1979 Rabi, both diseases were commonly observed in parts of Kurnool, Cuddapah, West Godavari and Visakhapatnam districts of Andhra Pradesh. The incidence of 'aflaroot'

was high (about 10%) in some fields near Kalahasti in Andhra Pradesh. Both diseses were commonly present in almost all Rabi groundnut growing areas of Tamil nadu and Karnataka but not causing appreciable reduction in plant stand.

Disease management: Remove crop debris by burning or by deep ploughing to reduce inoculum carry-over from season to season. Use good quality seed for planting. Treat the seed with Thiram @ 3 g/kg seed or with Bavistin @ 2 g/kg seed (Anon. 1985b). Avoid deep planting as etiolated seedlings are very susceptible to the pathogens.

KALAHASTI MALADY

Causal organism: Tylenchorhynchus brevilineatus Williams 1960.

Symptoms: Small brownish-yellow lesions appear on the pegs, pod stalks, and on young developing pods. The margins of the lesions are slightly elevated because of the proliferation of host cells around the lesions. Pod stalks are much reduced in length and in advanced stages of the diseases the entire pod surface becomes discoloured. Kernels from such diseased pods are apparently healthy. Discolouration is also observed on roots, however, this is less prominent than that on pods. Affected plants that are stunted and have greener than normal foliage appear in patches in the field (Reddy et al. 1984).

Distribution and importance: At the present time, the disease occurs in Chittoor and Nellore districts of Andhra Pradesh, and is especially serious in the Kalahasti area of Chittoor district.

Disease management: Trials conducted in Kalahasti area during the 1981/82 Rabi season showed that application of Carbofuran @ 4 to 8 kg a.i./ha was efficient in decreasing nematode populations in the soil and in increasing the pod yields (Reddy et al. 1984).

OTHER DISEASES

Stem rot (Sclerotium rolfsii) and root rot (Macrophomina phaseolina) were commonly observed in Guntur, Chittoor, Kurnool, districts of Andhra Pradesh, in Dharwad and Raichur districts of Karnataka, in Junagadh district of Gujarat and in several locations in Tamil Nadu, but were not causing appreciable damage to the crop. Pod rot caused by a variety of soil fungi was found to be serious in parts of North Arcot in Tamil Nadu in the 1980/81 Rabi season, and in North Kanara district of Karnataka in the 1981/82 Rabi season. A "pod-knot" disease (aetiology unknown) was also serious in North Kanara district in the 1981/82 Rabi season. Pepper spot and leaf scorch (Leptosphaerulina crassiasca (Sechet) Jackson & Bell), anthracnose (Colletotrichum sp.) Pyllosticta leafspot (Phyllosticta sp.) and Drechslera leafspot (Drechslera spicifera (Bain.) von Arx) were also

recorded on Rabi groundnut in India, but at the present time, they are not considered to be economically important.

RESEARCH NEEDS

Research needs should be considered in relation to the economics of Rabi groundnut production. This is a low risk, high input, high value crop and even small losses in yield or quality are important. Improvements in agronomy could easily bring about an increase in average yield of farmers' groundnut crops from the present level of around 1,500 Kg/ha to at least 4 t/ha. At these production levels a yield loss of 10% is definitely of economic significance.

The yield losses caused to Rabi groundnut crops in the coastal areas of the southern States are considerably in excess of 10%, and from the results of fungicide application trials on the Kharif crop it is clear that economic returns could be expected from fungicide use. Under the low or no rainfall conditions of the Rabi it should be possible to get good control of foliar diseases with only a few fungicide applications. However, trials are needed to determine optimal spray regimes.

Diseases that are specific to the Rabi such as Alternaria leafspot and veinal necrosis should be further investigated to determine distribution, losses caused, and possible control measures.

Surveys should be carried out to determine the occurrence and economic importance of diseases of seeds and seedlings, stem rot, and of pod rots under Rabi conditions. Surveys should also be made to determine the extent of the aflatoxin problem in the Rabi crop. It is known that soil type, drought stress, and fluctuations in soil moisture can exert considerable influence upon incidence and severity of pod rots and on seed invasion by the toxigenic Aspergillus flavus. These factors merit investigation.

Growing groundnut in a multiple cropping system where the soil does not dry out over an extended dry season may well lead to the appearance of new disease problems, e.g., nematode diseases and possibly bacterial wilt. The latter disease caused by Pseudomonas solanacearum is important in several southeast Asian countries where groundnut is grown in rice-based cropping systems. Rabi groundnut crops should be carefully monitored to ensure that any new disease is quickly recognised.

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Table 1. Area, production, and average yields of groundnut in India in the 1983/84 Rabi season

State	Area ('000 ha)	Production ('000 tonnes)	Yield (Kg/ha)
Andhra Pradesh	325	476	1465
Tamil Nadu	277	323	1166
Gujarat	200	400	2000
Maharashtra	199	308	1548
Karnataka	130	225	1731
Orissa	114	189	1658
All India	1245	1922	1544

Table 2. Yield losses from foliar diseases in different locations in India during the 1981/82 to 1984/85 Rabi seasons (Anon. 1982 and 1984).

Location and state	% loss in pod yield from foliar diseases			
	1981/82	1982/83	1983/84	1984/85
Aliyarnagar, Tamil Nadu	28	3	11	21
Vridhachalam, Tamil Nadu	-	27	-	37
Dharwad, Karnataka	-	-	0	0
Raichur, Karnataka	-	-	-	0
Chiplima, Orissa	-	11	29	0
Digraj, Maharashtra	21	17	-	-
Junagadh, Gujarat	0	-	0	0

Key:

- = Trial not conducted

0 = No significant yield loss