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Groundnut rust—its survival and carry-over in India*

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Abstract. Groundnut rust has become an important disease in India, particularly in the South, probably because of extensive and continuous cultivation of the crop. Uredospores present on crop debris in the field, and on pods or seeds in storage at ambient temperatures, lost viability within 6 weeks. They retained viability for long periods when stored at − 16° C. Neither teliospores nor any collateral or alternate hosts were found. Seeds heavily contaminated with viable uredospores and sown in sterile soil gave rise to disease-free seedlings. There should be no risk of spread of rust from properly treated seed samples.

Keywords. Groundnut rust ; survival ; carry-over ; *Puccinia arachidis* Speg. ; *Arachis hypogaea* L.

1. Introduction

Rust of groundnut (*Arachis hypogaea* L.), caused by *Puccinia arachidis* Speg., was reported from Punjab, India, in 1969 (Chahal and Chohan 1971) and now occurs in most groundnut-growing Indian States (Subrahmanyam *et al* 1979). The disease has become particularly important in South India, where groundnuts are grown for much of the year and where conditions favour development and spread of the pathogen. This paper deals with the survival of the rust fungus and presents results of investigations on possible carry-over of the disease in crop debris, on seeds, and on weeds. The biology of the fungus is discussed in relation to distribution of rust and groundnut cropping seasons.

2. Materials and methods

2.1. *Survival of uredospores in crop debris*

Dried haulms of groundnut collected from rust-infected rain-fed and irrigated crops (cv. TMV-2) during 1976–78 were immediately exposed to weather by spreading them in shallow layers in the field at ICRISAT Centre farm. At intervals, uredospores were collected from the crop debris (dried haulms), suspended in sterile distilled water on glass slides, and incubated in the dark at 25° C. After 6 hr, 1000 spores were checked for germination.

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2.2. *Effect of temperature on uredospore longevity*

Uredospores, freshly collectee from infected plants, were placed in glass vials and stored at temperatures of − 16, 6, 25 and 40° C. At intervals, they were sampled and tested for viability as described above.

2.3. *Presence of uredospores on pods and seeds*

Pods were collected from a crop with severe rust and separated into those with no shell damage and those with shells broken during threshing. Undamaged pods were shaken in distilled water to which Tween 80 (1 : 1000) had been added, and washings were centrifuged at 2,000 rev/min for 1 hr. The pellet obtained was examined microscopically for uredospores. Damaged pods were carefully opened and seeds were removed with minimal contact with the outside of the shells. The seeds were washed and the washings examined as described for undamaged pods.

2.4. *Longevity of uredospores on stored seed*

Seeds were dusted with freshly collected uredospores and stored in cloth bags in the laboratory at 25 to 30° C. Samples were removed at 5-day intervals and uredospores washed off the seeds and their viability tested as described above.

2.5. *Carry-over of rust on seed*

Seeds of rust-susceptible cultivar TMV-2 were surface-sterilised by immersion for 5 min in a 0·1% aqueous solution of mercuric chloride to which a small amount of Tween-80 had been added. They were then washed in repeated changes of sterile tap water. Isolation plant propagators (Burkard Manufacturing Company, England) were prepared containing steam-sterilised garden soil in pots which could be watered from below with sterile tap water. Into the pots in one unit, 200 seeds were aseptically sown. In another unit, 200 seeds liberally coated with freshly collected uredospores were sown. A further 200 seeds were aseptically sown in a third unit, and after germination, the seedlings were dusted with freshly collected uredospores. Seedlings were checked for rust infection.

2.6. *Germination of uredospores on germinating seeds*

Two-day-old seedlings of the cultivar TMV-2 were carefully washed, testas removed, and 100 cotyledons and 50 radicles excised. These organs were surface-inoculated with a suspension of uredospores and placed in moist chambers for incubation in the dark at 25° C. Samples were removed after 24 hr, stained, and examined under the microscope. In another test, artificially-contaminated seeds were sown in sterile soil, and resulting seedlings were carefully removed and examined at intervals.

2.7. *Search for teliospores and collateral hosts*

A large number of specimens of rust-infected groundnut from different parts of the country were examined for the presence of teliospores. Some 2,000 entries from the ICRISAT groundnut germplasm collection were also examined at various

stages of development under severe rust infection. Attempts were also made to induce telial production by growing rust-infected plants of the susceptible TMV-2 cultivar under the following combinations of temperature and day length in plant growth chambers.

Treatment	Day temperature (° C)	Night temperature (° C)	Day length (hr)
1	20	10	8
2	30	10	8
3	30	20	10
4	35	25	12
5	40	30	12
6	25	25	12
7	15	15	12

Various common crop and weed plants growing in or near fields of rust-infected groundnuts on the ICRISAT farm and farmers' fields were examined for rust. Some were also subjected to inoculation with uredospores in greenhouse tests ; the groundnut cultivar TMV-2 was used as a susceptible check.

3. Results and discussion

3.1. *Survival of uredospores in crop debris*

The high initial viability of uredospores decreased rapidly with exposure to weather (table 1). This was most marked in uredospores from irrigated crops, probably because of the higher temperatures experienced in May than in the November-to-January period following the rain-fed crop. Invariably, uredospores on exposed crop debris lost all viability within 30 days. Similar work in other parts of India also indicates that uredospores are short-lived in crop debris under field conditions (Lingaraju *et al* 1979 ; Mallaiah and Rao, personal communication).

3.2. *Effect of temperature on uredospore viability*

Spores remained viable for several months when stored at low temperature (– 16° C) while at 40° C they lost viability within 5 days (table 2). At the intermediate temperatures, viability decreased with time of storage and was completely lost within about 2 months. Mallaiah and Rao (personal communication) found that uredospores remained viable for up to 4 weeks when stored at temperatures below 30° C but lost viability within 2 weeks when stored at temperatures above 35° C. It would thus appear that temperature is an important factor influencing viability and longevity of rust uredospores.

3.3. *Carry-over and distribution on seed*

Carry-over and dissemination of uredospores on groundnut pods and seeds have been suggested. Peregrine (1971) indicated that movement of contaminated

Table 1. Viability of uredospores after various periods of exposure to weather on infected crop debris.

Period of exposure (*d*)	Percentage of uredospores viable*			
	Rainy-season crops		Post-rainy-season crops	
	1976	1977	1976–77	1977–78
0	65	90	82	89
6	36	74	9	0
14	1	42	1	1
20	0	26	0	0
22	0	10	0	0
26	0	0	0	0
Period of test	13–12–1976 to 7–1 –1977	7–11–1977 to 2–12–1977	4–5–1977 to 30–5–1977	2–5–1978 to 28–5–1978
RH% 0714 hr	80·7	83·5	60·7	60·7
1414 hr	26·0	46·6	26·9	23·9
Temp. °C : Max.	28·3	28·0	37·6	39·7
Min.	13·4	19·5	24·9	25·6

* 1,000 spores per sample. Figures to nearest whole number.

Table 2. Effects of storage temperature on viability of uredospores.

Storage temperature (°C)	Percentage* of uredospores viable after storage for Days										
	5	13	28	40	48	60	70	78	99	110	120
—16	88	82	89	90	98	88	92	93	92	94	93
6	84	85	82	35	15	4	0	0	0	...	...
25	81	88	80	24	0	0	0	0	0	...	...
40	0	0	0	0	0	0	0	0	0	...	...

* 1,000 spores per sample. Figures to nearest whole number.

seed may have been involved in the spread of rust to Brunei. Pods from a rust-infected crop would be contaminated with spores during threshing and any damage to shells could well lead to contamination of seeds. Seeds could also be contaminated during shelling. Examination of pods from a severely rusted crop showed presence of uredospores on the shells. Where shells were broken, uredospores were found on the seed surfaces.

Table 3. Effects of storage at room temperature (25–30° C) on viability of uredospores.

Percentage* of uredospores viable after storage for : Days											
0	5	10	15	20	25	30	35	40	45	50	55
95	72	30	28	25	28	30	29	39	10	0	0

*1,000 spores per sample. Figures to nearest whole number.

The viability of uredospores on seed stored at room temperature for varying lengths of time is shown in table 3. Viability decreased rapidly with storage time from an initial 95% to zero after 45 days.

Surface-sterilised seeds of cultivar TMV-2 sown in sterile soil in isolation plant propagators gave rust-free seedlings. Seeds similarly treated, but coated with viable uredospores prior to sowing, also gave rise to rust-free seedlings. A 'check' treatment where the foliage of seedlings was dusted with uredospores resulted in severe rust disease within 25 days of sowing. This supports the argument that surface contamination of seeds with uredospores is unlikely to result in rust infection of seedlings.

When excised cotyledons and radicles of germinating seedlings were surface-inoculated with uredospores and incubated in the dark, the spores germinated and appressoria were produced, but there was no development of disease. Examination of seedlings from seeds heavily contaminated with uredospores and sown in sterile soil again showed germinated uredospores with appressoria, but no rust developed.

There would appear to be little danger of rust disease developing, from uredospores carried on sown seed. Also, there is no authenticated report of the rust fungus being internally seed-borne.

Although rust has spread rapidly to most parts of the world in recent years (Hammons 1977 ; Subrahmanyam *et al* 1979), there are still some groundnut-growing areas where it is not present. Plant quarantine authorities and those concerned with distribution of groundnut germplasm are understandably concerned with the possible spread of the disease to these areas through contaminated seed samples. However, the practice of dressing seed with fungicides, the rapid loss of viability of uredospores at ordinary temperatures and their inability to infect seeds or germinating seedlings below ground all indicate that disease spread through properly treated and handled seed samples is extremely unlikely. To obtain successful spread, viable uredospores would have to be carried to the surface of foliage of the susceptible plant under environmental conditions conducive to infection. This is more likely to happen due to long-distance air dispersal or contamination on clothes and baggage of air travellers than on properly treated seed samples.

3.4. *Biology of the rust fungus*

The pathogen is known almost exclusively by its uredial stage. There are a few records of the occurrence of the telial stage on cultivated *Arachis hypogaea* in

South America (Spegazzini 1884 ; Hennen *et al* 1976) and on wild *Arachis* spp. (Guarch 1941 ; Bromfield 1971). In India, Chahal and Chohan (1971) recorded the occurrence of teliospores on groundnut leaves but gave no details of spore morphology and the disease has not recurred in Punjab. There has been no other authenticated report of the occurrence of teliospores of groundnut rust.

We have examined many specimens of rust-infected groundnuts from different parts of India but have found only uredospores. Some 2,000 entries from the ICRISAT groundnut germplasm collection were examined at various stages of development under severe rust infection, but again only the uredial stage of the rust was found.

Attempts were made to induce teliospore production by growing rust-infected plants under various combinations of temperature and day length but were unsuccessful. It is not known if the fungus can produce pycnia and aecia or if any alternate host is involved in the life cycle. It would appear that uredospores are the main, if not the only, means of dissemination of the groundnut rust fungus.

Table 4. Plant species examined as possible collateral hosts of rust.

Leguminous crop plants	*Non-legumes*
Cajanus cajan (L.) Millsp.	*Acanthospermum hispidum* DC.
Canavalia gladiata DC.	*Achyranthes aspera* L.
Cicer arietinum L.	*Aerva monsoniae* (L.F.) Mart.
Crotalaria juncea L.	*Amaranthus viridis* L.
Cyamopsis tetragonoloba (L.) Taub.	*Anisomeles indica* (L.) O. Ktze.
Glycine max (L.) Merr.	*Boerhaavia diffusa* L.
Lablab purpureus (L.) Sweet	*Catharanthus pusillus* (Murr.) G. Don
Lens culinaris Medik.	*Corchorus aestuans* L.
Phaseolus lunatus L.	*Cyperus compressus* L.
P. vulgaris L.	*C. rotundus* L.
Sesbania sp.	*Dactyloctenium aegyptium* (L.) Beauv.
Vicia faba L.	*Digitaria ciliaris* (Retz.) Koeler
Vigna mungo (L.) Hepper	*Eclipta alba* (L.) Hassk.
V. radiata (L.) Wilcz.	*Euphorbia hirta* L.
	Evolvulus alsinoides (L.) L.
Leguminous weeds	*Ipomoea tridentata* Roth
	Lactuca hastata DC.
Aeschynomene aspera L.	*Lagascea mollis* Cav.
A. indica L.	*Leucas lavandulifolia* Sm.
Alysicarpus monilifer (L.) DC.	*Micrococca mercurialis* Bth.
Cassia tora L.	*Mollugo pentaphylla* L.
Indigofera hirsuta L.	*Ocimum americanum* L.
Stylosanthes fruticosa (Retz.) Alston	*Panicum* sp.
Tephrosia hirta Ham.	*Phyllanthus niruri* L.
T. purpurea (L.) Pers.	*Portulaca oleracea* L.
Zornia diphylla (L.) Pers.	*P. quadrifida* L.
	Sida sp.
	Trianthema portulacastrum L.
	Tridax procumbens L.

There is no record of the occurrence of any collateral hosts of groundnut rust outside the genus *Arachis*, and in India wild *Arachis* spp. occur only in research centres and can hardly be involved in perpetuation of the disease. The possible occurrence of other hosts was considered, and various common crop and weed plants growing close to or within fields of rust-infected groundnuts (table 4) were regularly examined for the presence of rust, but no case of infection was found Some of these plants were also subjected to inoculation with rust uredospores in greenhouse tests, but again no case of infection was recorded.

3.5. *Cropping seasons and rust survival and spread*

There is no uniform groundnut growing season in India. In some of the southern states, particularly Andhra Pradesh, Tamil Nadu and Karnataka, groundnuts are grown in some areas throughout the year (figure 1), presenting excellent opportunity for survival of rust. About 90% of the crop is grown in the rainy season, most of the rest is grown in the post-rainy dry season under irrigation. In some places a summer crop is grown.

Rust attack is most severe on the rainy-season crops but can still be noticeable on dry-season crops. The disease has been seen on the summer crop in parts of Andhra Pradesh, but pustules developed very slowly and did not sporulate until the coming of the monsoon rains, when the disease developed rapidly on the maturing crop.

On the rainy-season crop, the disease appears in July and August in South India, in September in Central India, and in October in North India (Mayee *et al* 1977). In Central and North India normally only a rainy-season crop is grown, and it is thought that the groudnut crops in South India may act as a reservoir of rust disease from which spores are carried by the monsoon winds to infect the crops in the north. The present trend towards increased cultivation of groundnuts in southern India, particularly the irrigated dry-season crops, could result in more effective carry-over and spread of rust disease within the country.

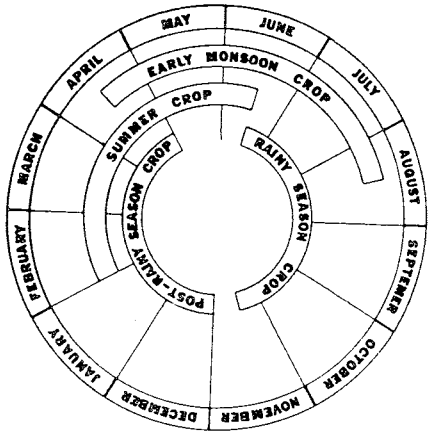

Figure 1. Groundnut cropping seasons in India.

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