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Resistance of Wild Species of Groundnut to Insect and Mite Pests

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Abstract

While sources of resistance are available in cultivated species of groundnut to some pests such as, thrips, (Scirtothrips dorsalis Hood., Frankliniella schultzei *Trybom., and* F fusca *Hinds), jassids* (Empoasca fabae Harris and E kerri *Pruthi), termites (Odontotermes spp), and southern corn root worm (Diabrotica undecimpunctata howardi Barber), a high level of resistance has yet to be identified for several important pests such as the groundnut aphid (Aphis craccivora Koch.),* Spodoptera *spp,* Heliothis *spp, and mites (Tetranychus spp). Available reports indicate that some wild* Arachis *species have very high levels of resistance to these pests. Species within the section* Arachis *offer the highest potential for rapid utilization of wild germplasm. Future hybridization programs should utilize* A chacoense *as a source of resistance to aphids, thrips, jassids and tomato spotted wilt virus,* A batizocoi *and* A correntina *for jassid resistance,* A chacoense *and* A. stenosperma *for pod-boring insect resistance,* A villosulicarpa, A correntina, *and* Arachis *sp PI 263996 for mite resistance, and* A. correntina *for* Heliothis *resistance*

Résumé

Résistance des espèces d'arachide sauvages aux insectes et acariens nuisibles Les espèces sauvages présentent des niveaux de résistance élevés à divers insectes et acariens et peuvent être utilisées pour l'amélioration des arachides cultivées.

Alors que l'on dispose chez les espèces d'arachide cultivées de sources de résistance à certains ennemis tels que les thrips (Scirtothrips dorsalis *Hood.,* Frankliniella schultzei *Trybom, et* F fusca *Hinds), les jassidae* (Empoasca fabae *Harris et* E. kerri *Pruthi), les termites* (Odontotermes *spp) et* Diabrotica undecimpunctata howardi *Barber, il reste encore à identifier chez celles-ci un degré de résistance élevé à plusieurs ravageurs importants comme le puceron de l'arachide* (Aphis craccivora *Koch),* Spodoptera *spp,* Heliothis *spp et* Tetranychus *spp. Des rapports révèlent que quelques espèces sauvages d'* Arachis *présentent des niveaux de résistance très élevés à ces ravageurs. Les espèces de la section* Arachis *offrent le potentiel le plus élevé pour une utilisation rapide du germplasme sauvage. On devra donc utiliser comme source de résistance dans les futurs programmes d'hybridation,* A chacoense *pour la résistance aux pucerons, thrips et jassidae, ainsi qu'au virus de la maladie des taches bronzées de la tomate, maladie transmise par le thrips;* A. batizocoi *et* A. correntina *pour la résistance aux jassidae;* A. chacoense *et* A stenosperma *pour la résistance au borer des gousses;* A. villosulicarpa, A. correntina *et* Arachis *sp PI 263996 pour la résistance aux acariens et* A. correntina *pour la résistance à* Heliothis.

Introduction

Groundnut is attacked by more than 360 species of insects and mites (Stalker and Campbell 1983) In India the annual losses from five major insect pests have been estimated at Rs. 1600 million (US $160 million) (Amin 1983).

The same pests do not cause damage every year on every farm but in the SAT a number of species are always prominent These are the groundnut aphid *Aphis craccivora* Koch., thrips *Scirtothrips dorsalis* Hood., *Caliothrips indicus* Bagnall, *Frankliniella schultzei* (Trybom), *F. fusca* Hinds, *Enneothrips flavens* Moulton, jassids *Empoasca* spp, armyworm *Spodoptera* spp, and termites *Microtermes* spp, *Odontotermes* spp.

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Aphids, and thrips are usually important as vectors of viruses. *Aphis craccivora* is best known as the vector of rosette virus in Africa but is also the vector of peanut mottle virus (PMV), which is a problem wherever groundnuts are grown. *F. schultzei* is of major economic importance in India because it transmits tomato spotted wilt virus (TSWV), the cause of bud necrosis disease (BND) (Amin et al., 1981).

Until recently, pest control in groundnuts was based on pesticide application. However, the concept of reducing losses by breeding pest-resistant plants is now receiving attention. Wild species are potentially highly resistant to a range of insect pests but in most cases investigations have been limited to the identification of sources of resistance. This is because: pest-resistant varieties of cultivated groundnut are available; there is a limited supply of wild species at research centers; the special breeding techniques required to utilize wild species (Johnson et al., 1977); and the long breeding periods required to remove undesirable characters which have been transferred from the wild species. Dahms (1972) stated that wild species should only be screened for resistance after a thorough search of the cultivated germplasm. However, the rapidly-changing situation created by recent developments in cytogenetic techniques invalidates this view (Sastri et al., 1982).

Resistance of Wild *Arachis* Species to Sucking Pests

Thrips

Of the several species of thrips that attack groundnut only a few are pests. These include *S. dorsalis*, and *C. indicus* in India, *C. indicus* in Sudan (Clinton 1962), *F. fusca* in the USA and *E. flavens* in Brazil.

Frankliniella spp

Stalker and Campbell (1983) screened several wild *Arachis* germplasm collections against *F. fusca* and found 17 accessions to be totally free from injury symptoms. These included; *A. batizocoi*, *A. pusilla*, *A. paraguariensis*, *A. repens*, *A. villosa*, and 12 others.

At ICRISAT, preliminary studies were conducted on the survival and fecundity of *S. dorsalis* and *F. schultzei* by caging five females of each species on individual detached leaflets of wild *Arachis* under controlled conditions of temperature and light (28°C day-time temperature at 700 lux artificial light for 12 h and 21 °C night-time temperature). The survival and fecundity of both thrips species on wild *Arachis* was considerably reduced when compared to those living on *A. hypogaea* (cv TMV 2), indicating a high level of resistance in most wild species tested. *F. schultzei* females survived for 2.7 to 5.7 days on the *Arachis* species compared to 8.7 days on TMV 2 and *Arachis* sp PI 10596. Less than 4.0 nymphs per female were obtained from individual females on wild species compared to 12.2 on *A. hypogaea* (cv TMV 2) and 5.0 on *Arachis* sp PI 10596

High levels of resistance to *F. schultzei* have been identified in cultivated groundnut. They are being utilized in the breeding program at ICRISAT Center and at North Carolina State University, USA. *A. chacoense* has been found to be resistant to TSWV, a trait that has not been located in cultivated groundnuts. This was discovered by exposing seedlings to viruliferous thrips. None of the 20 *A. chacoense* seedlings developed symptoms after 60 days, whereas all the other lines of wild species, the check cultivar TMV 2, and the susceptible host, urd bean, *Vigna mungo* (cv UPU 2) produced symptoms within 10 to 30 days. No viral antigens could be detected in young and old leaves from the *A. chacoense* plants after they had been exposed to viruliferous thrips. The leaves were assayed by the enzyme-linked immunosorbent assay (ELISA) technique.

The mechanism of resistance to TSWV in *A. chacoense* is not known. The reduced survival of *F. schultzei* on *A. chacoense* plants is not responsible for non-transmission of TSWV, because *F. schultzei* adults survived for 2 to 3 days which is long enough to inoculate the plants; the minimum inoculation access period is 5 minutes (Amin, personal observation).

A. chacoense has since been crossed with *A. hypogaea* in the hope of transferring resistance. Several near tetraploid progenies are being evaluated in open field screening

S. dorsalis

The longevity and fecundity of *S. dorsalis* adults were also lower on the wild species and their derivatives than on *A. hypogaea*. Five females of *S. dorsalis* produced 103 nymphs on *A. hypogaea* (cv TMV 2) while no nymphs were obtained from the same number of females caged on *A. chacoense*, *A. duranensis*, and on a hybrid between *A. chacoense* x *A. cardenasii*.

Aphid, *A. craccivora*

It has not been possible to screen wild *Arachis* species for resistance to *A craccivora* in field conditions at ICRISAT Center Screenhouse tests showed that *A chacoense A villosa, A correntina* and *A glabrata* all exhibited high levels of resistance Forty females caged on four plants produced 1050 nymphs on TMV 2 while the same number of females produced no nymphs on *A villosa* and *A glabrata* 2 on *A chacoense*, and 43 on *A duranensis* Progenies of interspecific hybrids involving *A chacoense* and *A villosa* also showed high resistance

Gibbons (1969) reported high resistance to rosette virus in *A repens* and *A glabrata* tested under laboratory conditions in Malawi However, no attempts were made to screen these species for aphid resistance

A craccivora is responsible for the spread of rosette virus between and within crops Therefore, resistance to *A craccivora* in groundnut cultivars selected for African conditions should have characters that combine both nonpreference (to lessen the attractiveness of crop to immigrant alatae), and the reduction of fecundity (to reduce aphid spread within a crop) The latter characteristic has been identified in wild *Arachis* species tested with the Indian biotype of *A craccivora* The former must await the results of field evaluations of wild *Arachis* species and crosses incorporating wild *Arachis* genes under African conditions

Groundnut jassid, *Empoasca* spp

Several species of the genus *Empoasca* are pests of groundnut in various parts of the world They cause similar damage symptoms i e , stunting, vein clearing, and a wedge-shaped yellowing (hopper burn) at the tip of leaflets On very young plants the leaflets wither and die. Stalker and Campbell (1983) reported 21 collections free from jassid injury Four of these, *A correntina, A cardenasii, A duranensis*, and *A villosa* belong to section *Arachis*, three to *Erectoides*, one to *Ambinervosae* and 13 to *Rhizomatosae* The F_1 hybrid of *A villosa* x *A hypogaea*, cv NC Ac 18000-2 was susceptible to jassids while the reciprocal hybrid expressed a high level of resistance

Preliminary experiments at ICRISAT (unpublished) demonstrate that some wild *Arachis* accessions decrease jassid fecundity and were tolerant to jassid attack.

In view of the high level of jassid resistance present in *A hypogaea* there is little need to consider wild *Arachis* spp unless an alternative mechanism of resistance is needed in the future

Mites, *Tetranychus* spp

Mites are important pests of groundnut in the USA They suck sap from the foliage which initially results in leaf stippling, and ultimately in the foliage drying Screening for mite resistance is difficult under field conditions because the mites are unevenly distributed Screening in greenhouses is simpler Leuck and Hammons (1968) reported that *Arachis* sp PI 262841 was highly resistant to *Tetranychus tumidellus* Prichard et Baker, with less than 10% foliar damage *A villosulicarpa, Arachis* sp PI 262841 and *A repens* showed 10 to 25% damage The resistance to mites was attributed to non preference because they failed to establish on resistant plants

Johnson et al (1977) initiated greenhouse tests of several accessions from seven sections of *Arachis* for resistance to *Tetraychus urticae* Koch Most species in section *Rhizomatosae* were highly resistant One accession, *A correntina* PI 331194 in section *Arachis* also had low damage Johnson et al (1980) observed considerable variation in the relative feeding preference on wild species Two species in section *Rhizomatosae*, PI 262286, and PI 262840 were non preferred by *T urticae* with relative preference ratings of 1 8 and 13 3 respectively when compared to *A hypogaea* cv Nc Ac 5 that had a preference rating of 100 For other wild species, PI 262142 (*Erectoides*) and PI 331194 (*Arachis*) the preference rating was 31 9 and 40 6 respectively Fecundity was considerably reduced on two wild species of *Rhizomatosae* but not on single species from both sections *Erectoides* and *Arachis*

It appears that high levels of resistance are only found in section *Rhizomatosae*, but the use of these as resistant sources appears to be restricted unless techniques are developed to hybridize the *Rhizomatosae* species with *Arachis hypogaea*

Resistance to Chewing Insects

Armyworm, *Spodoptera* spp

Lynch et al (1981) evaluated 14 *Arachis* species for resistance to *S frugiperda* by calculating a host suitability index (HSI)

$$HSI = \frac{\text{Pupal wt. (or fecundity)/ Development time}}{\text{Leaf consumption}} \times \text{\% survival}$$

They found that *A. villosa* and *A. burkartii* were totally unsuitable hosts because armyworm larvae did not develop on them at all. Other *Arachis* species with low HSIs were *A. cardenasii* (HSI = 0.09), *A. lignosa* (HSI = 1.3), *A. correntina* (HSI = 1.4), and *A. chacoense* (HSI = 1.6). The remainder had HSIs in the range of 4.6 to 6.5. It is also interesting to note that on *A. villosulicarpa* the survival was low (15%), but the mean pupal weight was high (209 mg) as compared to *A. hypogaea* on which survival was high (75%) and pupal weight low (162 mg).

Heliothis spp

Though various *Heliothis* species attack groundnut in different parts of the world, screening has only been carried out against *H. zea* Boddie in the USA. Stalker and Campbell (1983) evaluated 53 collections and most of them were damaged less than *A. hypogaea*. In section *Arachis*, *A. correntina*, *A. villosa*, *A. chacoense*, and *A. stenosperma* leaf feeding damage ranged from 0.5 to 1.6% compared to 37% in *A. hypogaea* cv Florigiant. An F_1 progeny of *A. villosa* x NC Ac 18000-2 had 38% damaged leaves although the reciprocal hybrid displayed only 4.4% damage. Under laboratory conditions *A. batizocoi* proved to be highly resistant as *Heliothis* larvae failed to survive on this species. When segregates from the interspecific hybrid derivative populations were evaluated, they had a significantly higher level of resistance than their cultivated parent. For example, when *A. hypogaea* PI 261942-3 (with 38.3% damaged leaves) was crossed with *A. cardenasii* (with 2.7% damaged leaves), the progeny had only 4.6% leaves damaged. Similar results were obtained with other crosses involving PI 261942-3 and *A. duranensis*, or with cv NC 2 x (*A. batizocoi* x *A. spegazzinii*).

Conclusion

There is clear evidence that wild species in section *Arachis* have a high degree of resistance to several insect pests. These species are being used in the groundnut breeding program at ICRISAT Center to transfer this resistance to *A. hypogaea*.

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• Potentials of Wild Genetic Resources—Discussion

Rees:
What are the mechanisms of resistance in wild *Arachis* species?

P.Subrahmanyam:
The resistance to rust is dominant when transferred from *Arachis* species to cultivated varieties whereas resistance so far transferred from cultivated *A. hypogaea* is recessive.

Stalker:
The inheritance of genes for resistance has been reported in several cases. For example, Sharief reported that *Cercospora arachidicola* resistance is a multigenic recessive trait. However, in triploid *A. hypogaea* x *A. chacoense* or *A. hypogaea* x *A. cardenasii*, *C.arachidicola* resistance acted as a dominant trait. Further reciprocal differences have been reported for insect resistance where high levels were observed in F_1 interspecific hybrids when *A. hypogaea* was the female parent, but not when the cultivated species was the male parent.

Rees:
These are examples of inheritance of resistance. It is necessary to make efforts to understand mechanisms of resistance.

Amin:
The mechanisms of resistance to insects are only understood in a few cases, e.g., resistance to jassids is ascribed to the density and length of hairs on the leaflets.

Stalker:
Campbell's results show that not only density, or angle but also type and location of hairs at insect feeding, or oviposition sites is very important. Hairiness does not always contribute resistance to pests. In fact, some pests such as *Heliothis* prefer hairy leaves for oviposition e.g. in cotton.

Singh:
Should defoliation in cultivars due to foliar diseases be considered as the most important criterion for susceptibility?

P.Subrahmanyam:
Yes, it is one of the criteria for susceptibility, but other parameters such as smaller and fewer lesions on the leaflets should be also considered important for resistance to the fungal pathogens.

Singh:
Has hairiness any correlation with resistance to jassids in all germplasm lines?

Amin:
In several lines there appears to be a strong correlation between hairiness and jassid resistance.

Sastri:
Does staining hair with Sudan IV have any correlation with resistance?

Amin:
The staining procedure only helps facilitate counting of hairs.

M.V.Reddi:
In your presentation on the sources of rust and leaf spot resistance in wild species, you stated that no morphological characteristic could be attributed as a mechanism of resistance. May the resistance be enzymatic in nature?

P. Subrahmanyam:
Probably, yes. At present we are not investigating these aspects.

Murty:
From your long experience, do you think that the genetic mechanism of resistance to rust in wild species may be different from that in the cultivars of groundnut?

P. Subrahmanyam:
Yes, there is evidence that different genes or alleles are involved.