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Impact of Tikka Disease of Groundnut and Its Management

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ABSTRACT

Groundnut Arachis pintoi L., is a worldwide valuable oilseed and food legume which sustains the livelihood of millions of smallholder farmers, especially in the tropics and subtropics. Among the different biotic constraints that affect its productivity, tikka disease caused by Cercospora arachidicola (early leaf spot) and Nothopassalora personata (late leaf spot) is the most economically important foliar disease. This review covers the present knowledge of the biology, symptoms, epidemiology, and economic importance of tikka disease, and critically assesses the current management practices such as host resistance, cultural management, biological control and fungicide application. Special focus on limitations of chemical control, fungicide resistance, and the need for integrated disease management (IDM). In summary, the review suggests that a holistic approach to lowering the amount of losses to this disease will be achieved through a combination of resistant cultivars, timely cultural practices, and judicious fungicide use which is backed up by disease forecasting.

Keywords: *Groundnut, nutrition, nitrogen, symptoms, tikka disease and fungicide.*

Introduction

Groundnut or peanut is a crop that is grown in over a hundred countries and is one of the major oil seed crops in the world that contribute significantly to the supply of vegetable oil, protein nutrition and rural income generation in Asia, Africa and the America [1]. It is a major source of both edible oil and domestic food in most of the emerging economies with its seeds having an approximate of 45 to 50 percent oil and 25 to 28 percent protein content. In addition to its nutritional benefit, groundnut enhances soil fertility due to biological fixation of nitrogen, a fact that gives it an additional agronomic significance in cereal-legume systems of crop production. Although it is important, the productivity of groundnut is limited by various biotic stresses, with foliar fungal diseases being some of the most intractable. Tikka disease, which is commonly referred to as the groundnut leaf spot disease in South Asia, is a disease that is caused by two different pathogens that occur regularly but often together and attack the foliage, diminishing photosynthetic activity, and promoting senescence. The disease is found in practically all areas where groundnuts grow, and has been reported to result in yields being reduced up to 70 percent when not controlled [2]. Tikka disease remains a topic of continued research due to its widespread distribution, as well as the frequently challenging nature of attaining full control. This review discusses the causal organisms, symptomatology, disease cycle, economic impact, and management of tikka disease, focusing on how to combine the existing evidence into a cohesive, critically reviewed narrative.

Tikka Disease of Groundnut

Tikka disease is caused by two taxonomically distinct related fungi which form the early and late leaf spot disease complex. *Passalora arachidicola* (Hori) U. Braun causes early leaf spot, and Nothopassalora personata (Berk. and M.A. Curtis) U. Braun causes late leaf spot, which were formerly known as *Cercosporidium personatum* [3].

Both pathogens have been reclassified to new genera with molecular taxonomic revisions in the last 20 years based on DNA sequence data, although older names based on Cercospora remain widely used in applied plant pathology literature and most fungicide recommendation systems. The two causative agents often infect the same crop and even though they cause similar necrotic lesions on the same crop, there exist many diagnostic differences between them. The lesions which are caused by early leaf spots usually occur earlier in the growing season, have the circular shape, reddish-brown to dark brown on the upper leaf surface, and are usually surrounded by a yellow halo. By contrast, late lesions of leaf spot usually appear later in the crop cycle, are darker, almost black, more angular in shape, and usually do not exhibit the strong yellow halo of early leaf spot [4]. The lesions caused by late leaf spots are also more common on lower surface of the leaf where sporulation occurs and early leaf spots sporulates occur on upper leaf surface. These differences, although helpful in field diagnosis, are not always so straight forward in mixed-infection, the more typical field circumstance in the majority of groundnut-growing tracts.

Symptoms, Disease Cycle and Epidemiology

The symptoms of tikka disease are initially seen as small, chlorotic to necrotic flecks on the lower leaves which increase to round or subcircular lesions in one to two weeks. Sporulation is seen as the lesion matures appearing as a greyish and powdery lesion on the surface of the lesion, especially on the abaxial surface of the leaflet. Severe infection leads to coalescence of lesions, large-scale necrosis, and early yellowing of the foliage. At advanced stages, the affected leaflets abscise earlier than the normal senescence and this effectively reduces the effective photosynthetic period of the crop. Lesions can also appear on the petioles, stipules and stems, but foliar symptoms are the most predominant and most destructive sign of the disease.

Tikka disease has a polycyclic disease cycle whereby it is infected and released back into the soil in the same season of crop rotation. Both pathogens have been reported to overwinter as mycelium or conidia on infected crop debris in the field of origin and conidia and ascospores dispersed on this debris tend to initiate primary infection. The crop is primarily spread by airborne conidia with rain splash and wind being the main agents of spread. Since the two pathogens need free moisture to germinate their spores and infect humans, the environment conditions determine the intensity of diseases decisively. Research into the conidial production by the late leaf spot pathogen has demonstrated that sporulation is optimised at high relative humidity, usually above 90 percent and moderate temperatures in the range of about 20 to 25 degrees Celsius and that several hours of constant leaf wetness is normally necessary prior to successful infection [5]. Long intervals of leaf wetness, be it due to dew, rain or irrigation overhead, thus have a close relationship with disease epidemics, and epidemics are likely to be worsened during the rainy season or in crops grown under moist conditions by irrigation. Temperature and moisture play their role in epidemic development: both pathogens may infect over quite a wide temperature range, but, sporulation and lesion growth are particularly sluggish at hot and dry climates, making this one of the reasons why disease pressure tends to decrease near the end of a hot, dry growing season with no active control.

Impact on Groundnut Production

Tikka disease decreases yield primarily by the destruction of photosynthetically active leaf tissue. With the further increase and merge of lesions, the useful amount of leaf area to be used in carbon assimilation decreases and early defoliation only exacerbates the reduction by taking away leaves altogether. Since pod filling is largely limited by current photosynthate, and not by stored photosynthate, any disturbance of canopy photosynthesis during the reproductive period is directly proportional to a decrease in the number of pods, a decrease in kernel size, and a decrease in shelling percentage. Defoliated crops are also prone to secondary stresses, such as soil borne pathogens that infect via exposed pegs, and lodging, which makes harvest more difficult and more pods lost in soil. The economic loss of yield to tikka disease has widely differing estimates based on cultivar susceptibility, disease pressure, and the level of management intervention, however, losses are always large. In cases of uncontrolled, severe infection, up to 70 percent yield losses have been observed [6], and in the unprotected scenario, where fungicides were not used, more moderate yet still economically significant losses of between 40 and 50 percent are typical of late leaf spot alone [7]. In addition to direct yield loss, the disease also reduces the quality of fodder, as defoliated haulm is less valuable as livestock fodder, which is of particular concern in mixed crop-livestock systems where groundnut haulm is a valuable dry-season fodder source. Combined with decreased pod yield, decreased haulm value, and the repetitive nature of fungicide application costs, tikka disease is among the most economically impactful limitations on groundnut production globally.

Management Strategies

Several management options are available for tikka disease, but none are magic bullets and all have their compromises that should be carefully weighed before being used.

Host plant resistance is considered to be the most economically and environmentally viable long-term method. Sources of resistance have been identified in wild Arachis species and introgression into cultivated backgrounds has identified several interspecific lines with significantly reduced disease scores and improved pod and haulm yield when compared to susceptible checks [8]. But, challenges exist: the durable high-level resistance is polygenetic and may be accompanied by undesirable agronomic traits from the wild relatives; and resistance to early leaf spot is not always the same for late leaf spot, as the two pathogens respond somewhat independently to the host defence mechanism [9]. Therefore, most released resistant cultivars do not provide complete protection and yield advantage under disease pressure, is the realistic breeding goal. Cultural practices add another element of control, mainly of interrupting the pathogen's survival and dispersal. Deep ploughing to bury crop debris, crop rotation with non-host cereals over two or three years and the use of pathogen-free seed all help to decrease primary inoculum load at the beginning of a season as both fungi overwinter on crop debris that is infected. Indirect measures to suppressing sporulation include wider plant spacing and avoiding excessive nitrogen fertilisation which helps to produce a 'open canopy' microclimate that is less conducive to prolonged leaf wetness. They are low cost and widely available to smallholder farmers, but, in general, their impact on disease severity is incremental rather than determining, and should be considered as a base on which to build other practices. Biological control has increasingly garnered research attention as a more environmentally friendly alternative or supplement to chemical fungicides. Some rhizobacteria and entomopathogenic or antagonistic fungi have demonstrated the ability to induce systemic resistance, or to directly reduce the leaf spot pathogens under experimental conditions; mixtures of plant growth-promoting rhizobacteria in particular have been demonstrated to induce systemic resistance against multiple leaf spot pathogens in a variety of crops [9]. Biological control agents hold potential for managing GLS in groundnut but have yet to be used on a large scale, and efficacy is frequently inconsistent amongst environments and generally lower than synthetic fungicides when disease levels are high, making their use at present more a component of GLS management rather than an effective control option.

Botanical extracts including neem-based extracts have also been tested for in-vitro and under limited field trials for their antifungal activity against pathogens of tikka disease with moderate inhibitory activity in general. They are cheap, locally available and less toxic than synthetic chemicals, but currently, there is a lack of standardisation and large-scale field validation due to the variability of the active compound concentration among the plant material. Under high disease pressure, fungicide application is the most consistently effective and is the most commonly used chemical control method. The systemic triazole and strobilurin fungicides (tebuconazole and pyraclostrobin) and protectant fungicides (chlorothalonil and mancozeb) have consistently proven to be effective in reducing disease severity and maintaining yield when applied preventatively at the onset of disease [10]. Seed treatment with fungicides suitable for the purpose can further reduce the early seedling infection risk but only for the establishment phase and should not replace foliar protection during the growing season. Although fungicides are effective, they have significant drawbacks.

However, populations of leaf spot pathogens have been documented to be less sensitive to fungicides in some groundnut-growing areas due to repeated use of the same class of chemicals, which could make chemical control less reliable in the future [7]. The list of options is further constrained by the regulatory discontinuation of chlorothalonil in certain areas due to environmental and health issues. Cost is also limiting, as at least three to five timed sprays per season are needed for adequate control, often too high a price for resource poor farmers, and environmental and human health consequences of repeated fungicide use further support the idea that fungicide use alone should not be used as a strategy.

Integrated Disease Management

Integrated disease management (IDM) has been found as most sustainable approach in the control of tikka disease given the limitations of any single management strategy. Based on local disease pressure and available resources, IDM integrates moderately resistant cultivars, proper cultural management (including residue destruction and crop rotation), timely management of fungicide use based on need, and, if possible, biological/herbal inputs into a coordinated programme. Disease forecasting and monitoring are an integral part of this strategy as relative humidity, leaf wetness duration, temperature and other environmental factors are key determinants of the infection risk [6]. Models developed from these parameters enable fungicide sprays to be timed based on actual disease risk as opposed to a fixed spray schedule, which not only diminishes the number of applications made but also provides similar control levels. This can also help to decrease the selection pressure that leads to the development of fungicide resistance and to cut input costs for farmers. However, the implementation of IDM in practice is not uniform. However, timely information from weather forecast stations is not readily available to smallholder farmers and extension services are often lacking, and the technical skills to make informed decisions on the timing and consistency of the spraying recommendations are lacking, so that calendar based spraying or simply relying on cultural practices are common. To bridge this gap requires investment in extension services and in simpler, locally-tested forecasting tools, not in any further elaboration of the basic biological knowledge which is already reasonably complete.

Future Prospects

A number of research directions have the potential to enhance the management of tikka disease in the near future. Innovations in molecular markers have made it possible to identify quantitative trait loci and single nucleotide polymorphisms associated with leaf spot resistance, which provides a pathway to breeding more durable and multi-pathogen resistant cultivars more quickly and precisely without the extended backcrossing that has been long needed to eliminate unwanted wild-relative phenotypes (Janila *et al*., 2016). The characterisation of the population structure of the pathogen population and fungicide sensitivity will also need to be continued in order to support the resistance management approach as well as inform the rotation of the mode of action of fungicides. Increasing the evidence base of biological control agents in different field regimes, as well as trying to make disease prediction tools more accessible by providing mobile-based extension systems, can significantly decrease reliance on calendar-based chemical spraying by farmers. All of these combine to form the best future direction, which is not a one-time technological advancement but gradual convergence of recalcitrant genetics, precise use of chemicals, and localised cultural practice in an actual integrated system.

Conclusion

Tikka disease is still one of the most intractable and costly limiting factors in groundnut production globally and it can lead to serious losses in yield and quality by causing rapid defoliation and decreased photosynthetic ability. None of the management tactics can provide total protection: host resistance is not complete, cultural practices are progressive, biological and botanical solutions are not well-proven at large scale, and chemical control, though efficient, is questioned more and more by resistance development and cost. A combination of moderate-resistance cultivars, good agronomic practices, controlled use of fungicides under the guidance of disease prediction and sustained investment in extension delivery would provide the most realistic and sustainable path to reducing the effects of this disease on groundnut yield and the livelihoods of the farmers.

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