STUDIES ON THE TIKKA DISEASE OF GROUNDNUT

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C E R T I F I C A T E

Certified that this Thesis is a bonafide record of work done by Sri V.Rama Krishna during the period of 1962 -'64 at the College of Agriculture, Rajendranagar, Osmania University, Hyderabad and that the Thesis has not formed, in whole or in part, the basis for the award of any Degree, Diploma, or other similar Degree or Distinction.

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INTRODUCTION

Among the many diseases recorded on ground nut, tikka disease caused by two species of Cercospora { C. personata (Berk. & Curt.) Ell.& Ever. and C. arachidicola Hori. } is perhaps the most destructive - the loss in pod production some times amounting upto 50% (Smartt, 1960). In India the disease appears to have been first reported by Butler (1914) from Bombay presidency and since then was reported from almost all parts of the country wherever ground nut is grown. Reliable estimates of losses due to this disease are lacking; but it is certain that the heavy defoliation caused by the disease results in considerable reduction in yield of ground nuts in our country. Indeed Butler (1918) attributed the fall of exports of ground nuts during the close of the last century, in part, to the ravages of tikka.

The symptomatology of this disease was studied by Butler (1918), Woodroof (1933) and Jenkins (1938). Both the fungi produce conspicuous spots on the leaves with occasional lesions on petioles and stems. Although it is difficult to distinguish between the two species during the early stages of infection, as the spots mature they can be differentiated. C. arachidicola produces irregularly circular to often confluent spots varying in size from 0.1 to 1 cm. in diameter, surrounded by a bright yellow halo blending into the green leaf. While in the initial stages the spots appear as yellowish specks, when mature they are dark brown to almost black on the upper surface and light brown on the lower surface. Spots produced by C. personata tend to be circular, 1 - 7 mm. in diameter with bright yellow halos around mature spots on the upper surface. In both the spots halo is

either wanting or faintly present on the lower surface.

Although known under one name the disease is caused by two distinct species. Cercospora personata was first described by Berkely (1875) as Cladosporium personatum. Ellis and Everhart transferred it to the genus Cercospora. Later on many workers (See review of literature) described the two fungi under several names and synonyms. Woodroof (1933), after a laborious observation of herbarium specimens and descriptions, set a seal to this taxonomic contraversy by concluding that C. arachidicola and C. personata are the two valid species causing leaf spots on ground nuts. Jenkins (1938) obtained the perfect stages of the two fungi from the fallen leaves of ground nut and described them as Mycosphaerella berkeleyii (= Cercospora personata) and Mycosphaerella arachidicola (= Cercospora arachidicola).

Butler (1914) illustrated and described the inter cellular nature of the mycelium and lobed haustoria of C. personata. Woodroof (1933) reported that the mycelium of C. arachidicola is both internal and external and inter and intra cellular, while in the case of C. personata the mycelium was only internal and inter cellular. She also observed branched haustoria in the case of C. personata in palisade and spongy mesophyll.

Jenkins' (1938) description was very similar to that of Butler and Woodroof. He also described the histopathological effects caused by C. arachidicola. There was a collapse of the lower epidermal cells which lost contact with the mesophyll cells in the initial stages. The inter-cellular mycelium, later on as the spot matures, became intra-cellular. One significant observation made was that while the

cells are killed in advance of the mycelium in the case of C.arachidicola there was no such advance killing in the case of C. personata.

A certain degree of difference in varietal responses to the attack of these two fungi had been reported. Reyes and Roma Santa (1940) classified five of the thirteen varieties they have studied as highly susceptible, six as intermediate and two as highly resistant. Hemingway (1957) observed certain histological differences between the resistant varieties Kanyoma and Mwitunde and the susceptible variety Natal Commons. In general, bunch varieties are more susceptible than spreading varieties (Clinton, 1961).

Although two distinct species of fungi are involved and the host-parasite relationships in the two species show considerable differences, enough information is not available to make a clear distinction between the diseases caused by the two species. Much emphasis has been placed by several workers (Woodroof, 1933 and Jenkins, 1938) on the time of appearance of the halo in differentiating the symptoms due to the two species. This criterion however cannot be applied to a mature spot where halo develops in the case of both the fungi. Nor is the shape of the lesion so definite as to serve as a differentiating character.

There is no information about the presence of the mycelium in the region of the halo. Jenkins (1938) suggested that there is a killing of cells in advance of the mycelium in the case of C.arachidicola. Now that the role of toxins in the physiology of pathogenism is well known (Ludwig, 1960) it is not presumptuous to postulate that the halo is a result of one or more toxins. That the production of toxins

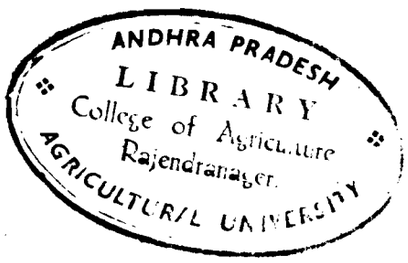
is dependant on the available nutrients has been well established (Ludwig loc. cit.). In the light of this, placing too much emphasis on halo production as a criterion for differentiating the two species does not appear to be sound. Indeed, it has been observed by the author that halo may not develop even around mature spots in some varieties.

Based on the time of incidence of the disease due to the two species, Woodroof (1933) designated the disease caused by C. arachidicola as early spot and that of C. personata as late spot. In our country precise information on the relative periods of incidence of the two fungi is lacking.

In the present investigation an attempt has been made to study the detailed symptomatology and host - pathogen relationships of the disease caused by the two fungi on several varieties with varying degrees of susceptibility and resistance. Such a study, it is hoped, would provide a basis not only to define clearly the symptoms caused by the two fungi which will facilitate ready identification of the spots, but also throws light on the histological mechanism of resistance, if any.

Besides the above, certain factors influencing the epidemiology of the disease, like those influencing spore germination, the age of the ground nut plant in relation to susceptibility to disease, and the relative incidence of the disease due to the two species, were studied.

REVIEW OF LITERATURE



The salient features of work done on this disease is reviewed below:

Distribution:-

Known under different names as Brown spot, Black spot, Chestnut spot, Peanut leaf spots, Cercospora leaf spots etc; the disease has a wide distribution. It appears that the disease is present in almost all parts of the world except, probably, the Soviet Union. Leaf spots have been reported from several states of the U.S.A; as causing severe destruction to ground nuts (Wolf, 1914; Woodroof, 1933; Jenkins, 1938; Ken knight, 1941, Waterson, 1941 and Martin, 1944). It has also been reported from Brazil, (Chevalier, 1934), Peru (Rada, 1939), Argentina (Frezzi,1960), Saupaulo Brazil (Cruz et al, 1962), Columbia (Barcenas, 1962), in the South American Continent and North America (Hunt, 1946). The widespread nature of the disease was reported from West Africa (Maublanc, 1924), Gambia (Brooks, 1923), French West Africa (Mallamaire, 1931), Uganda (Hansford, 1934), Transval (Pole Evans, 1939), Mozambique (Cardoso, 1940) and Nyasaland (Corbett, 1962). Other countries where the occurence of ground nut leaf spot is reported are Maritius (Anonymous, 1925) and Hopkins, 1960), Burma (Rhind,1924), Dominica (Ciferri, 1925), Peurto Rico (Tucker, 1924), Germany (Nagormy and Eristavi, 1928), Italian Somaliland (Petri, 1931), Nanking:China (Teng, 1932 and Tai, 1936), Gautamela (Palm, 1932), Phillipines (Welles, 1924), Ghana (Anonymous, 1957) and Queensland (Purss, 1962).

In India tikka disease was reported by Butler (1914), as existing in the Bombay presidency area. Subsequently it was reported from the Central Provinces(Pearl, 1923), Assam (Choudhary, 1944) an

and from almost all parts of the country where ever ground nut is cultivated (Vasudeva, 1961).

Nature of Damage:-

Severe leaf spotting, followed by defoliation, is the principal damage caused by C. arachidicola and C. personata (Butler, 1914; Woodroof, 1933 and Jenkins, 1938). Stem lesions, though common, do not attain much severity. It is generally observed that lesions are restricted to the aerial organs mentioned above. However it has been reported that C. personata does appear on the 'Pegs', directly obstructing the conveyence of elaborated nutrients required for the normal development of the pods (Reyes and Romasanta, 1940).

Butler (1918) estimated the losses due to C. personata ranging from 33% to 50%. Brooks (1925), Mallamaire (1931) and Rogers (1935) reported heavy losses from the attacks of C. personata. However, Woodroof (1933) observed that both the leaf spots were equally destructive. Wherever both species occur together, the major damage is due to C. personata (Chevaugeon, 1952; Hemingway, 1955 and Anonymous, 1957 b). Cole and Hunter (1944) observed C. arachidicola to be the major pathogen in Georgia. Smartt (1960) estimated 50% losses due to C. arachidicola and C. personata put together.

Symptomatology:-

The most conspicuous symptoms are observed on the leaflets. However, symptoms are also observed on the rachis, petiole, stipules and stems etc. late in the season.

C. C. personata: Butler, (1918) described symptoms on leaves as dark spots surrounded by a bright yellow ring. Woodroof (1933) described them as circular spots 1 - 7 mm. in diameter with bright yellow halos on mature spots. Similar descriptions were made by Jenkins (1938) and Mundkur (1949). Vasudeva (1961) differed from the above workers in that he described the spots to be darker in colour on the upper surface and lighter brown on the lower surface,

C. arachidicola: Butler (1918) reported it as only another species of Cercospora. He described the spots as less regular than C. personata, lighter in colour and not as sharply defined. According to Maffei (1922) the spots are roundish oval, dark chestnut brown in colour without a lighter centre or concentric markings. Woodroof(1933) described them as irregularly circular, 1 mm. to 1 cm. in diameter, surrounded by a bright yellow halo blending into the green leaf, which is prominent only on the upper surface. Jenkins (1938) described similarly. Vasudeva (1961) agreed with Woodroof in all aspects but for this description of a darker colour of the spot on the lower surface and a lighter colour on the upper surface.

Morphology:-

C. personata: The mycelium of C. personata is internal, strictly inter cellular with characteristically branched or lobed haustoria(Butler, 1918; Woodroof, 1933 and Jenkins, 1938). Jenkins (1938) clearly demonstrated the presence of botryose type of haustoria in apparently healthy cells. Similar descriptions were given by other workers (Mundkur, 1949 and Vasudeva, 1961). Sporulation is most commonly observed on the lower surface though it is not uncommon on

the upper surface also. Conidiophores are thick (6u), unbranched, short, non septate and are marked by pronounced angular bends,each of which represents the point of attachment of a spore. The spores are irregularly cylindrical, straight or curved, rounded at the free end, and slightly flattened at the base; ashy grey to light brown in colour, 3 - 8 celled; measuring 20 - 55 x 6 - 8u (Butler, 1918). According to Woodroof (1933) they measure 24.3 - 54 x 2.7 - 8.1u; continuous or 1 - 2 septate; subjeniculate; developing from stromatic mycelium beneath epidermis, frequently in spaces beneath stroma. Conidia are obclavate, cylindrical, 18 - 60 x 5.4 - 10.8u and 1 - 7 septate. Jenkins (1938) described the conidia as obclavate 1 - 8 septate pale brown, olivaceous, measuring 18 - 60 x 5 - 11u.

C. arachidicola: According to Woodroof (1933) the mycelium is internal and external and inter and intra cellular without haustoria. Conidiophores are formed exclusively on the upper surface in young lesions, which later become amphigenous with age. Conidiophores first emerge directly through a stoma forming a small fascicle. Secondly the mycelium grows in between epidermal cells or through a stoma and continues to develop under the cuticle, and from this mycelium fascicles of conidiophores are formed. Thirdly conidiophores form from mycelium growing in the epidermal cells, which are later ruptured by the developing conidiophores. Conidiophores are subgeniculate, ~~21.6~~ 21.6 - 40.5 x 3.2 - 5.4u, yellowish brown and continuous or 1 - 2 septate. The scars marking the point of attachment of conidia are plainly vissible. Conidia colourless to pale olivaceous, obclavate, measure 37.8 - 108 x 2.7 - 5.4u and are 4 - 12 septate. Maffei(1922) previously described conidiophores measuring 40 - 47 x 4 - 5u; conidia

with 8 - 12 septa and measuring 50 - 110 x 4 - 7u. Jenkins' (1938) descriptions were similar to those of Woodroof.

Ascigerous stages:-

Jenkins (1938) obtained the ascigerous stages of both C. arachidicola and C. personata in nature and on the basis of the morphological characters the two organisms are referred to the genus Mycosphaerella and named as M.berkeleyii (= C. personaata) and M. arachidicola (= C. arachidicola). Perithecia of M. berkeleyii are scattered erumpent, amphigenous, ovate to nearly globose with a slightly papillate ostiole and measure 47.6 - 84 x 44.4 - 74u in diameter (occuring mostly along the margins of the lesions). Asci cylindrical, clubshaped, short, stipitate, fasciculate, eight spored and measure 27 - 37.8 x 7 - 8.4u. Ascospores uniseriate to biseriate, two celled, slightly curved, hyaline and measure 7 - 15.4 x 3 - 4u.

The general morphology of the perithecia of M. arachidicola is very similar to the above. The size of perithecia is 84 - 140 x 70-112u; of the asci 30 - 40 x 4 - 6 u and of ascospores 10.9 - 19.6 x 2.9 - 3.8u. In both species the formation of perithecia is initiated in autumn (Jenkins, 1938).

Taxonomy:-

Berkely (1875) first described the causal organism of ground nut leaf spot as Cladosporium personatum. Ten years later, Ellis and Everhart (1885) renamed the fungus as Cercospora personata. Atkinson's (1891) collections agreed with those of Ellis and Everhart, except for the amphigenous nature of the conidiophores (opposed to the hypophyllous nature according to Ellis and Everhart). Hennings (1902)

described Cercospora arachidis as a new species, which, other workers later on relegated it to the status of a synonym to Cercospora personata. Raciborski (1899) described Septogloeum arachidis and Zimmerman (1902) studied the same spot, and later on it was proved, Septogloeum arachidis to be the same as Cercospora personata (Woodroof, 1933). Bancroft (1910) reported both Cercospora personata and Septogloeum arachidis. Heald and Wolf (1912) described Cercospora personata as producing long, slender obclavate conidia. Butler (1914) also reported both Septogloeum arachidis and C. personata on ground nut. Wolf (1914) considered C. personata synonymous with Cercospora arachidis. Reinking (1918) described short thick abruptly obclavate or cylindrical conidia of a leaf spot on ground nut which he considered as Septogloeum arachidis. Wolf (1919) however referred to C. personata and stated that a further study would reveal it as a species of Septogloeum.

Sawada's (1927) illustrations of C. personata are similar to those of Zimmerman (loc.cit.), Butler (loc.cit.) and Reinking (loc.cit.) for Septogloeum arachidis, and of Maublanc (1924) and Bal (1921) for C. personata. His illustrations of C. arachidicola are similar to those of Welles (1917), Heald and Wolf (loc.cit.) and Wolf (loc.cit.)

A second species of Cercospora on ground nut was identified by Hori (1917) who termed it as Cercospora arachidicola. Maffei(1921) described a second leaf spot on ground nut as being caused by C. arachidis var macrospora. Both meant the same fungus, but, by virtue of priority Cercospora arachidicola is the valid name and hence is retained.

Woodroof (1933), compared a number of herbarium specimens and descriptions of Saccardo (1902), Maublanc (1924), Ciferri(1925), Wakefield (1921), Mason (1928), Solheim and Stevens (1931) and Curzi (1931) etc. and finally concluded that C. personata with short cylindrical spores and C. arachidicola, with long slender spores are the two valid species causing leaf spots on ground nut.

Chupp (1953) followed the nomenclature of Woodroof (1933). In a very recent paper, however, Khan and Kamal (1961) have shifted Cercospora personata to the genus Passalora,based on the short,0 - 3 septate conidia borne from stromatal conidiophore tufts and accordingly renamed the fungus as Passalora personata (Berk and Curt) Khan and Kamal.

Host Range:-

So far no alternate or collateral hosts outside the genus Arachis. have been found to be associated with either Cercospora personata orCarachidicola. However Chevalier (1934) found C.personata on several wild species of Arachis indigenous in Brazil. Chupp (1953) opines that, the reports, implicating Cassia sp. as a host of C.personata are erroneous.

Cultural Characters:-

No perfect stage was observed in culture for both the fungi. Satisfactory cultures were obtained in several agar media. Both conidial and ascospore cultures almost behaved similarly. Jenkins (1938) studied the cultural characters of the two species and the following account is based on his work.

Mycosphaerella arachidicola: After 3 days of single spore (conidial) isolation, sharp, whitish, pulvinate colonies were visible to the naked eye which sporulated in 56 to 72 hours at room temperature. They assumed olivaceous colour in 4 to 7 days and produced spermogonia in 3 to 4 weeks. Ascospore cultures behaved similar to conidial cultures except for the fact that the latter had a slow initial growth.

Mycosphaerella berkeleyii: Single and multispored isolates of conidia were obtained easily. They were visible only after 4 to 7 days. From the time the mycelium is visible in culture, the hyphae are distinctly pigmented; at first the colour is pale buff but as the colonies age it became tawny or even reddish. Growth was always sparse. The culture differed in many aspects from M. arachidicola. After 7 - 10 days or some time longer, conidia were produced. In all respects spores were similar to those on ground nut leaves except that they were uniformly longer because of constant moisture supply. After 4 weeks colonies became stromatic and produced conidia. Ascospores cultures were visible after 7 - 8 days. They were similar to conidial cultures, but for their slower initial growth. They produced conidia in 7 to 12 days which were identical with those produced in conidial cultures. Spermogonia were produced in 3 - 4 weeks but there was no further development in culture.

Physiology:-

The reluctance of the two fungi to grow and sporulate profusely in artificial media is probably one of the reasons, for the very little knowledge on the physiology of C. personata and C. arachidicola. Jenkins (1938) obtained sporulation on many culture

media. Roldan and Querijero (1939) failed to get a culture of C. personata. Miller (1949) obtained cultures from material collected in different geographic regions of the U.S.A. He found these cultures to behave differently in growth as well as in the green house inoculations. Shantha (1956) obtained good sporulation of C. personata on Czapeck's Agar with yeast extract. She found the fungus to be partially deficient for thiamine and inositol. In addition to thiamine, pyridoxine and biotin were necessary for good sporulation of the fungus. Quite recently Narayanaswamy (1961) reported that, leaves heavily infected by C. personata produced a volatile substance, probably ethylene.

Host-Parasite relations:-

It was Butler (1914) who first illsstrated the presence of haustoria in the leaf cells of ground nut infected by Cercospora personata. He described the mycelium as chiefly inter-cellular, sending characteristic haustoria (Woodroof, 1933). He also described the formation of stromata on both the surfaces, but chiefly on the lower surface. Woodroof's (1933) description of C. personata tallied with that of Butler. She also described, an internal and external, inter-cellular and intra-cellular mycelium without haustoria, in the case of C. arachidicola. Jenkins (1938) confirmed this. He observed, in leaves infected with Cercospora arachidicola, the collapse of lower epidermal cells which lost contact with mesophyll, when the spot just appeared. He observed the mycelium to be first inter-cellular and later on intra-cellular, in the cells which have been killed in advance of the mycelium.

Hemingway (1957) observed histological differences in the

resistant Kanyoma and Mwitunde varieties, and attributed, the slower rate of lesion growth on these varieties, to the extra thickness of the palisade tissue.

Epidemiology:-

Butler (1918) was of the opinion that spores can remain long enough in the soil to infect the succeeding crop. He also stated that the disease was chiefly spread by wind, though insects also carried spores on their body and in their alimentary canal. Mallamaire (1931) proved the seed borne nature of this disease and suggested burning of diseased husks and seed disinfection as measures of control. Wilson (1950), however, argued that the evidence for seed transmission is not adequate.

Roldan and Querijero (1939) concluded that the organisms persist in the soil from one season to another in the dead refuse of diseased ground nuts. Certain wild species of Arachis indigenous in Brazil which are hosts to Cercospora personata (Chevalier, 1934) may also be playing a part in the epidemiology of this disease. Where the perfect stages are known to occur as in the U.S.A. (Jenkins, 1938) the primary infection is by ascospores.

Like many other diseases tikka disease is also highly influenced by environmental factors. Maublanc (1939) indicated the probability of heavy rainfall influencing the spread of Cercospora personata. The prevalance of C. personata in Gambia, was attributed to the lighter and less frequent rainfall during 1925 (Line,1926). This is evidenced by the fact that C. personata

fructifies well in more humid regions (Rogers, 1935). Magnesium deficiency in soils is also suspected to be responsible for the susceptibility of the plants to C. arachidicola. (Blessoe et al, 1946). Shantha (1961) observed that plants were infected by C. personata under conditions of high relative humidity or prolonged low temperatures . In another experiment she observed that application of nitrogen and phosphorous markedly increased disease incidence while potassium decreased the incidence slightly.

Varietal resistance and susceptiblity:-

Varying degrees of resistance and susceptibility is exhibited by different varieties of ground nut towards the two leaf spot fungi.

Brooks (1931) reported the presence of C. personata on all varieties of ground nut tested by him, out of which only one variety known as Phillipine Pink succumbed. Well marked differences, in 13 varieties of ground nut, were observed with regard to infection on 'Pegs' (Reyes and Romasanta, 1940). In the same work, five varieties were classified as highly susceptible, six as intermediate and two as highly resistant, on the basis of leaf spotting. Nandi (1941), from Assam, found the ground nut varieties, Shaw (Magura),Cawnpore No.23 and M 30/38, to be resistant to C. personata. According to a report from Georgia (Anonymous,1951),a wild species; Arachis diogoi is immune to C. personata and C. arachidicola. Similarly Arachis rasteiro among the spreading types and A.H.45 (HG-1) among the bunch types appear to be showing some resistance to C. personata (Anonymous, 1953 and John, 1949). Hemingway (1957) studied resistance and susceptibility in 29 varieties. According to him

Kanyoma and Mwitunde varieties showed some degree of resistance. Clinton (1961) reported that the upright varieties Natal Commons and Barberton were more susceptible. Late varieties were observed to be more resistant than early ones by Rothwell (1962).

Control:-

Mallamaire (1931) suggested burning of diseased husks to control Cercospora personata. Shelling the seed before planting was recommended by the Georgia experiment station (Anonymous, 1933). In another report of the Georgia experiment station (Anonymous, 1945) better yields were obtained by digging undusted plots 109 days after sowing and dusted plots 116 days after sowing. Smartt (1961) recommended destruction of volunteer crops for the successful control of this disease. It was reported from Mozambique that best control of C. arachidicola was secured by shortening the length of rows (Vasudeva, 1961).

Although Butler (1918), Brooks (1925) and several others recommended the use of resistant varieties for controlling the tikka disease, very few such varieties appear to be available. Work on evolving resistant varieties had been reported to be under way at Georgia experiment station (Anonymous, 1938). Perhaps the most outstanding success in this field was that of Cooper and Gregory (1960) who developed resistant lines by radiation induced mutations.

Work done in Madhya Pradesh (Anonymous, 1936) revealed that C. personata and C. arachidicola could be effectively controlled by Bordeaux Mixture (2 - 2 - 50) containing linseed oil or Agrar I

as spreader. Dastur (1939) reported increased ground nut yields as a result of applying Bordeaux mixture against tikka. Mcdougall (1941) confirmed this report. Results obtained at Georgia experiment station revealed Bordeaux mixture to be probably more effective than sulphur dusts. Addition of magnesium oxide increased the efficacy of Bordeaux misture. (Anonymous 1943, 1946). Trials conducted at Madras had resulted in an average increase in yield of 31% of ground nuts due to Bordeaux mixture sprayings (Anonymous, 1953a). Lynn (1959) reported an increase in yield of 800 lbs per acre by spraying Bordeaux misture against Cercospora personata.

Results of Georgia experiment station (Anonymous, 1941) revealed an incrased yield of 329.5 lbs of ground nuts per acre, by dusting copper containing preparations. Maximum increase in yield of nuts and foliage was observed by Van Hoof (1950) by the application of copper oxychloride (0.5% Kopper Kalkwieko). According to reports from Nyasaland (Anonymous, 1955) perenox, sprayed at 6 lbs per acre in 100 gallons of water, controlled both the leaf spots on Gambia variety resulting in a 70% increase in yields. Increased yields of 20 - 30% were however obtained by successful control of C. personata after using 0.75% copper naphthalene (Seman Goen, 1959).

Sulphur dust enabled to retain leaves, ultimately resulting in an increased yield of 5 - 77% (Average 18%) (Higgins 1938). Woodroof and Higgins (1939) reported satisfactory control of leaf spots by dusting sulphur (40 - 45 lbs. per acre, 325 mesh) at

fortnightly intervals. Miller (1940, 1942) similarly observed an increase in yeild upto 23.5% valued at $ 18 per acre, by sulphur dusting. With tha similar dusting schedule Higgins (1941) reported satisfactory control of C. personata and C. arachidicola, with a resulting increase in yield of 16 - 20%. At the North Carolina Agricultural experiment station (Anonymous, 1943) effective control was obtained by dusting sulphur not later than 8 days after inoculation. So extensive was theuse of sulphur for controlling ground nut leaf spots, in U.S.A. that, as much as 7% of the total sulphur used in U.S.A. in 1947, was applied against tikka (Mcnew et.al, 1951). Mehta et.al (1955) reported 40% increase in yields by dusting sulphur (16 lbs per acre) at 10 days interval. Bates (1959) obtained successful control of C. arachidicola by 3 applications of sulphur dust, with 12% increase in yield.

Johnson (1960) reported control of C. arachidicola with Maneb and Zineb resulting in an increased production of 750 lbs per acre. Low volume application of oil sprays was reported to give slight control of C. personata (Calpouz et.al,1961). Of a number of modern organic fungicides tested Brestan VP 19 - 40 was reported to give good control (Ter Horst, 1961).

Good control of leaf spots of ground nut was obtained by three applications of either Bordeaux mixture (8 - 12 - 100), Lime sulphur (2 in 100 with or without catalytic sulphur or 4 in 100) or four proprietory sulphur dusts (98 - 100% through 325 mesh); two of Bordeaux followed by one of wettable sulphur (6.5 in 100) and one of Bordeaux followed by two of wettable sulphur(Miller, 1939).

Results with Burgandy mixture, copper and sulphur dusts at three weekly intervals were unsatisfactory (Simmonds, 1947). Mehta and Mathur (1954) reported successful control with sulphur dusting (6 applications at weekly intervals) or spraying with 0.15% cupravit, 0.15% perenox or 2 - 2 - 50 Bordeaux misture (All these sprays were used with linseed oil as sticker). Cooper (1961) found that, TC-90 spray (experimental liquid copper @ 1.5 - 2.5 gallons per acre) was effective at weekly and biweekly intervals and Dithane (1 - 2.5 lbs) and cyprex (0.5 - 0.75 lbs) were effective at weekly intervals. Staples (1958) obtained good control of C. arachidicola by the application of copper oxychloride, Maneb and sulphur dust. Red copper oxide combined with sulphur gave best control of C.personata (Shantha, 1961).

Shaw and Herbert (1941) obtained practical control of ground nut leaf spots, by four applications of copper - sulphur dusts at fortnightly intervals. Woodroof (1942) recommended the use of sulphur (93% through 325 mesh) or copper - sulphur (10 - 90) on the first appearance of spots on the basal leaves, at the rate of 15 - 20 lbs per acre; 3 or 4 times. Results of the Georgia experiment station (Anonymous, 1944) revealed copper-sulphur dusts to be most effective. It was reported from Texas Agricultural experiment station (Ken Knight et.al, 1945) also that copper-sulphur dusts were superior to sulphur alone. Further experiment at Georgia experiment station revealed that 20% mixtures of Zerlate or Fermate with talc were inferior to sulphur and copper - sulphur (10 - 90). Fermate-sulphur and Zerlate-sulphur (20 - 80) showed some superiority to sulphur alone, but were less effective than copper - sulphur combination (Anonymous, 1949).

MATERIALS AND METHODS

The Host:-

Unless otherwise stated, the variety of groundnut used was Spanish Improved - a bunch variety highly susceptible to tikka disease. For inoculation experiments groundnut plants were raised in 9" x 5" pots filled with a soil-farm yard manure mixture. In general two seeds were sown in each pot. All the plants raised in pots were maintained in the green house.

The Pathogen:-

Inoculum: As the fungus does not sporulate freely on artificial media, inoculum was always obtained from infected host plants. The following procedure was adopted for obtaining the inoculum free from contaminants.

Tikka affected leaves were collected from the field and well developed spots of Cercospora arachidicola and C. personata were separately cut into bits. (It is quite possible to differentiate spots produced by C. arachidicola and C. personata, by the external appearance of the spot). The leaf bits, with spots thus obtained, were thoroughly washed in sterile water to remove any saprophytic fungi or any other contaminant. The washed bits were pressed dry between filter papers and kept in a petriplate moist chamber for 48 hours (Shantha, 1956).

Abundant sporulation of both the species of fungi occured, without any microscopically visible contaminants, after 48 hours of incubation. The spots of C. arachidicola and C. personata were separately transferred to tubes with 5 ml. of sterile water. The

tubes were thoroughly shaken to obtain a heavy suspension of the spores. The spore load in the suspension was always maintained, by dilusion with sterile water, to contain 15 to 20 spores per microscopic field (x100 maginification). The spore suspension was immediately used for inoculations.

Inoculations:-

Inoculations of C. arachidicola and C. personata were always conducted separately on different plants.

Prior to inoculations, the plants were wetted by a fine spray of sterile water with a small nozzle sprayer. The plants were then thoroughly shaken, to remove all excess water, and inoculated by spraying the spore suspension with an atomizer. (separate atomizers were used for the two species to prevent possible contamination) Inoculations were always conducted in the green house, late in the afternoon. All inoculations were done on 30 day old plants.

Incubation:-

The inoculated plants, were covered with polythene bags whose open end was sealed by tying to the pot with a thread.

The controls were sprayed only with sterile water and then covered with polythene bags as usual.

Polythene bags had been removed 3 days after the plants were inoculated.

Host - parasite relations:-

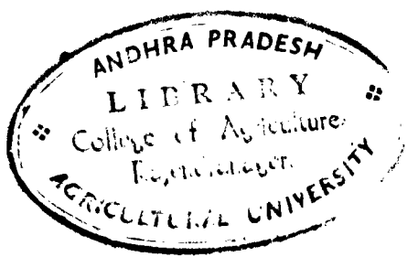
Fixing: From the time the first symptoms were observed, spots of C. arachidicola and C. personata were fixed on alternate days until the spots were mature. Formalin - acetic acid - alcohol (F.A.A.) of the following formula was used as fixing medium.

Formalin (40%)	5 c.c.
Glacial acetic acid	5 c.c.
Alcohol (70%)	90 c.c.

The fixed material was dehydrated through alcohol grades ranging upto absolute alcohol, cleared in xylol and then embedded in paraffin (melting point 56 - 58°c.) Serial transverse paraffin sections of the material were obtained by a rotary microtome. The sections were stained in Saffranin - fast green combination and mounted in 'Depex' mounting medium.

Humidity Experiments:-

The various levels of relative humidity were obtained by using sulphuric acid solutions of different specific gravities. These were obtained by mixing suitable quantities of water with sulphuric acid of known specific gravity (1.84). The following table gives the actual amounts of sulphuric acid and water that have been mixed (Stevens, 1916).



S.No.	Percentage of water	Percentage of H_2SO_4	Percentage of relative humitidy
1	100	Nil	100
2	94	6	98
3	88.5	11.5	95
4	80	20	90
5	77	23	85
6	73	27	80
7	67	33	70

The above mixtures of sulphuric acid - water solutions were taken in 10 x 22 cm glass cylindrical jars. In these jars conical flasks of suitable size were inverted as platforms, to keep the slides. The jars were covered with lids and sealed off with cellulose tape.

Spore germination experiments:-

All spore germination experiments were conducted on fresh clean glass slides. The desired liquid media were spread on the slides, not too thinly, and then the spores were dusted in such amounts as to avoid congestion. These slides were then transfered to the petriplate moist chambers

All the laboratory experiments were conducted at a room temperature of 26° - 30°c.

EXPERIMENTAL

Plate. 1

Left: Ground nut leaf infected by Cercospora arachidicola.
Top leaf is upper side and the bottom one lower side.

Right: Ground nut leaf infected with Cercospora personata.
Top leaf is upper side and the bottom one lower side.

TABLE I

Detalied description of symptoms on different varieties of ground nutinfected with *C. personata*.

a) Initial symptoms.

Sl. No.	Variety	Spot			Halo		
		Colour	Size	Shape	Colour	Size	Shape
1	417	Brick Red	Spots below 1 mm.	-	Halo absent		
2	TMV2	Light Tan	"	-	Faint yellow dis-col-ouration	-	-
3	SI	Brown	"	-	Faint greenish yellow	-	-
4	419	Light Tan	"	-	Halo absent	-	-
5	422	Dark Brown	"	-	Yellow	-	-
6	T-28	Brick Red	Specks	-	Light greenish yellow	-	-
7	P501/90	Dark Brown	Specks	-	Yellow	-	-

1. Symptomatology:-

Field observations indicated that the lesions produced on ground nut plants by the two species of Cercospora, vary, to some extent, according to the variety of ground nut. In general it was observed that lesions produced on creeping varieties were smaller than those on erect varieties.

Seven varieties of ground nuts comprising of five bunch varieties, Spanish Improved, TMV-2, 417, 419, 422 and two spreading varieties, K T - 28 and P501/90, were inoculated in the green house, separately, with Cercospora personata and C. arachidicola. The symptoms produced on these varieties were critically studied, once in the initial stages and next when the spots were mature. Particular attention was paid to note the size, shape and colour of the lesion and halo formation.

Symptomatology of tikka disease caused by cercospora personata:-

a) Initial symptoms: (Table Ia): The first observation was made eleven days after the plants were inoculated. The spots appeared as small specks, below 1 mm. in size and their colour varied from light brown to dark brown on the upper surface and light yellow on the lower surface. A slight depression was evident on the lower surface. The colour of the spots on the upper surface was brick red on 417, light brown on TMV-2, brown on Spanish Improved, light tan on 419, dark brown on 422, brick red on T-28 and dark brown on P501/90.

No discernable halo was present around the spots on 417 and

TABLE I

Detailed description of symptoms on different varieties of ground nut infected with C. personata.

b) Developed symptoms.

Sl. No.	Variety	Spot			Halo		
		Colour	Size	Shape	Colour	Size	Shape
1	417	Black	2.5-3mm.	Round	Halo absent		
2	TMV2	Black	3-3.5mm.	Irregular	Faint yellow	Less than $\frac{1}{2}$ mm.	Round
3	SI	Black	2 - 3mm.	Irregular round	Golden yellow	1 mm.	Round
4	419	Black	1.5-2.5mm.	Irregular	Halo almost absent		
5	422	Pitch black	2.5-3mm.	Round	Greenish yellow	$\frac{1}{2}$ mm.	Circular
6	T-28	Black	2.5-2.5mm.	Round	Faint greenish yellow	Less than $\frac{1}{2}$mm.	Round
7	P501/90	Black	1.5-2.5	Round	Faint yellow	Minutely thin	

TABLE II

Detailed description of symptoms on different varieties of ground nut infected with C. arachidicola.

a) Initial symptoms.

Sl. No.	Variety	Spot			Halo		
		Colour	Size	Shape	Colour	Size	Shape
1	417	Dark brown	1-1.5mm.	Round	Halo absent	-	-
2	TMV2	Dark brown	1-1.5mm.	Circular	Greenish yellow	-	-
3	SI	Dark brown	1-1.5mm.	Irregular	Yellow	-	-
4	419	Brick Red	1-1.5mm.	Irregularly Round	Faint greenish yellow	-	-
5	422	Brick Red	1-1.5mm.	-	Halo absent	-	-
6	T-28	Brown	1-1.5mm.	Irregular	Yellow	-	-
7	P501/90	Dark brown	1-1.5mm.	-	Greenish yellow	-	-

4l9. Light yellow areas which can be designated as halos were present on 422 and on P501/90. On TMV-2, Spanish Improved and T-28,faint greenish yellow halo merging into the leaf, appeared. No halo developed on the lower surface. Thus it may bee seen that in some varieties halo is formed even in the initial stages.

b) Developed symptoms (Table Ib): The second observation was made 15 days later. The spots were very well developed . The colour of the spot was carbon black in one variety, 422, and in the remaining varieties it was very deep black; on the lower surface the colour was still darker. Except in the varieties TMV-2 and 419 (in which the spots tend to be irregular), the spots were definitely circular. The spot size varied from 1.5 - 3.5 mm. in diameter.

Halo was almost entirely absent in 417 and 419. In other varieties, halo of varying width was present on the upper surface. On the lower surface of the leaf the halo was not visible,in T-28 and TMV-2, faintly visible in P501/90 and distinctly visible in 422.

Symptomatology of tikka disease caused by Cercospora arachidicola:-
a) Initial symptoms: (Table II a): The following observations were made in the intial stages of lesion development. The shape of the spots at this stage was irregular in Spanish Improved, T-28, 422 and P501/90; irregularly round in 419 and round in TMV-2 and 417. The spot size was bigger when compared to C. personata, varying from 1 to 1.5 mm. in diameter, in all the varieties. The colour was dark brown in Spanish Improved, TMV-2, 417 and P501/90; brick red in 419 and 422 and brown in T-28. On the lower surface the

TABLE II

Detailed description of symptoms on different varieties of ground nut infected with C. arachidicola.

b) Developed symptoms.

Sl. No.	Variety	Spot			Halo		
		Colour	Size	Shape	Colour	Size	Shape
1	417	Black	4-5mm.	Round	Halo absent	-	-
2	TMV2	Dark Tan	4-5mm.	Irregular Round	Faint Yellow	1mm.	Round
3	SI	Black	4 mm.	Round	Golden Yellow	1.5-2mm.	Round
4	419	Dark Brown	3-4mm.	Irregular Round	Halo absent	-	-
5	422	Black	4 mm.	Irregular Round	Halo absent	-	-
6	T-28	Dark Brown	3-4mm.	Round	Yellow	1-1.5mm.	Round
7	P501/90	Tan	3.5-4mm.	Irregular Round	Very faint yellow halo	½ mm.	Round

spots were lighter in colour in all varieties except 419 in which they were black. Halo was almost absent in 419, 417 and 422; yellow in Spanish Improved and T-28 and greenish yellow in P501/90 and TMV-2.

b) Developed symptoms: The spots were round on Spanish Improved, 417, and T-28 and irregularly round on TMV-2, 422, P501/90 and 419. The colour was drak brown (T-28 and 419), darktan (TMV-2), tan (P501/90) and black (Spanish Improved, 417 and 422). The spots measured 3 - 5 mm. in diameter. Spots were lighter coloured on the lower surface. Halo was not discernible on 417, 419 and 422. On all other varieties circular halo varying from 0.5 - 2 mm. in width was present. (Table. II. b.)

Based on the above studies the symptoms of tikka disease caused by Cercospora personata and Cercospora arachidicola can be described as follows:

i) C. personata: In the initial stages of infection the symptoms appear as brown to black specks measuring below 1mm. A yellowish bleached area, which can be designated as a halo, is present around the specks in some varieties. The shades of the halo depend on the variety. On the lower surface the spots appear as depressed areas with a slight yellowish discolouration.

As the spots mature the colour on the upper surface clearly attains a black shade and on the lower surface the colour is very deep black. The size of mature spots varies from 3 mm. to 1 cm. depending on the variety. Halos around mature spots either remain undeveloped or attain a golden yellow hue depending on the variety. The width of the halo varies from 0.5 to 2 mm. The discernibility

of the halo on the lower surface of the leaf also appears to be a varietal character.

ii) C. arachidicola: The initial symptoms produced by C. arachidicola are specks of a brick red to brown cllour, ranging from 1 - 1.5 mm. in size. Theyare less regular in shape and may possessa halo of faint yellow colour. On the lower surface they symptoms appear as depressed areas with a yellowish discolouration. The colour of the halo depends on the variety.

Mature spots of C. arachidicola vary in size from 1 mm. to 1 cm. and are irregularly round to round but less sharply defined than C. personata. They are definitely dark brown to black on the upper surface and light brown to dark tan on the lower surface. This constitutes an important difference between this spot and the one caused by C. personata. Halo,when formed is yellow to golden yellow in colour and 0.5 to 2.5 mm. wide. Halo may or may not be present on the lower surface.

2. The incidence of Cercospora personata and C. arachidicola under field conditions:-

To obtain information on the exact time of incidence of both the species and their persistence throughnout the life of the ground nut plant, field investigation has been taken up. A centrally situated plot in a ground nut field, sown with Spanish Improved variety, has been selected and fifty tikka affected leaves have been collected at random, from the four corners and the centre of the plot; on alternate days. The number of spots produced by C.arachidicola andC. personata were counted separately. In the earlier collections

TABLE III

The incidence of Cercospora personata and Cercospora arachidicola under field conditions.

Sl. No.	Date	Total No. of spots collected	No. of spots of C.a.	Percentage of C. a.	No. of spots of C.p.	Percentage of C. p.
1	25.7.63 to 22.8.63	All spots belong to Cercospora arachidicola				
2	24.8.63	296	294	99.29	2	0.71
3	26.8.63	427	424	99.29	3	0.71
4	28.8.63	1104	1101	99.70	3	0.30
5	30.8.63	906	895	98.78	11	1.22
6	1.9.63	1035	1024	98.93	11	1.07
7	3.9.63	936	912	97.40	24	2.60
8	5.9.63	864	828	95.08	36	4.20
9	7.9.63	724	693	95.71	31	4.29
10	9.9.63	756	722	95.54	34	4.46
11	11.9.63	956	871	91110	85	8.90
12	17.9.63	806	777	96.50	29	3.50
13	19.9.63	706	662	93.80	44	6.20
14	21.9.63	797	732	91.90	65	8.10
15	23.9.63	740	629	82.36	111	17.64
16	25.9.63	850	698	78.30	152	21.70

The crop was harvested soon after the final observation.

C.a: Cercospora arachidicola.

C.p: Cercospora personata.

this was done by a microscopical examination, but later it was found that separation of spots caused by the two fungi could be done by observing the external appearance. The percentage of spots due to C. personata and C. arachidicola, have been calculated.

The data are presented in Table III.

Results: It has been found that the disease actually appeared 40 days after the ground nuts were sown. C. arachidicola was the first to appear and it persisted until harvest. C. personata appeared one month after C. arachidicola. and gradually increased in percentage of infection, but remained low when compared to C. arachidicola. However C. personata persisted until harvest.

3. Age of the ground nut plant in relation to infection by C.personata and C. arachidicola:-

It is a general observation that tikka disease does not appear until the ground nut crop is 35 - 40 days old. Also, the lower leaves are more frequently attacked. This indicates that the older leaves may be more susceptible than the younger.

An experiment has been designed to see whether the ground nut plant is susceptible to leaf spots at all stages of its growth. Five stages of the plant have been selected for this purpose; these stages are expressed in the age of the plant from the sowing time. These stages are:

I - 10 days old plants (2 leaf stage)

II - 15 days old plants

III - 30 days old plants

TABLE IV

Age of the ground nut plant in relation to infection by Cercospora personata and Cercospora arachidicola.

Sl. No.	Age of the plant	Percentage of leaves infected		Time taken for defoliation (in days)	
		C.a.	C.p.	C.a.	C.p.
1	10	100	100	15	13
2	15	95.60	98.40	16	16
3	30	92.50	95.30	22	19
4	45	87.40	93.60	24	19
5	55	85.20	90.70	27	21

C.a: Cercospora arachidicola.

C.p: Cercospora personata.

IV - 45 days old plants

V - 55 days old plants.

At all the stages of growth the ground nut plants have been inoculated with separate inocula of thetwo species and incubated for 72 hours by covering with polythene bags. The plants have been closely observed for the symptoms which peappeared normally in a week's time. From the time the first symptoms appeared,the percentage of leaves infected and the time taken for the initiation of defoliation, have bean noted.

Results: The most striking observation from the above experiments is that the ground nut plant is almost equally susceptible, at all stages of growth, to both the leaf spottings fungi. Throughout the two month period Cercospora personata had been more intensive and destructive. It has also been observed that the earliest defoliation occured when the plants were inoculated at an age of 10 days and the longest time for defoliation was taken when the plants were inoculated at an age of 55 days. At any stage of growth defoliation due to C. personata had been earlier than due to C. arachidicola. (Table IV)

4. The period of high humidity required for successful infection to occur:-

Fungal pathogens, in general, require a period of high humidity in which their spores germinate and make successful entry into the susceptible host. The period of high humidity varies with individual species of plant pathogens. There is always an optimum

TABLE V

The period of high humidity required for successful infection.

Sl. No.	Period of incubation in hours	C.arachidicola		C.personata	
		No. of spots	Percentage to the maximum	No. of spots	Percentage to the maximum
1	24	0	0	0	0
2	48	36	69	78	67.80
3	72	52	100	115	100
4	96	43	82.60	93	80.80

period of high humidity during which the pathogen takes best advantage and produces symptoms with maximum severity.

An experiment was therefore conducted to find out the optimum period of high humidity required by C. personata and C. arachidicola for successful infection to occur.

Plants were inoculated with a mixed spore suspension of Cercospora personata and C. arachidicola. The plants were then covered with polythene bags and the bags were tied around the pots, to provide 100% humidity. The polythene bags were removed at intervals of 24, 48, 72 and 96 hours respectively.

Results:-

No symptoms were observed on plants kept under high humidity for only 24 hours.

The first symptoms were observed, on the plants provided with high humidity for 48, 72 and 96 hours, nine days after inoculation.

Twenty days after the first symptoms were observed, the plants were scored for the intensity of spotting of C. arachidicola and C. personata. The results are presented in Table V.

From the data obtained it is clear that the maximum infection is obtained, in the case of C. arachidicola.and C. personata, when the plants, after inoculation were provided with high humidity for 72 hours. No infection occurred when they were suspected to humidity for only 24 hours.

TABLE VI

The effect of humidity on size and septation of spores of *Cercospora personata* and *Cercospora arachidicola*.

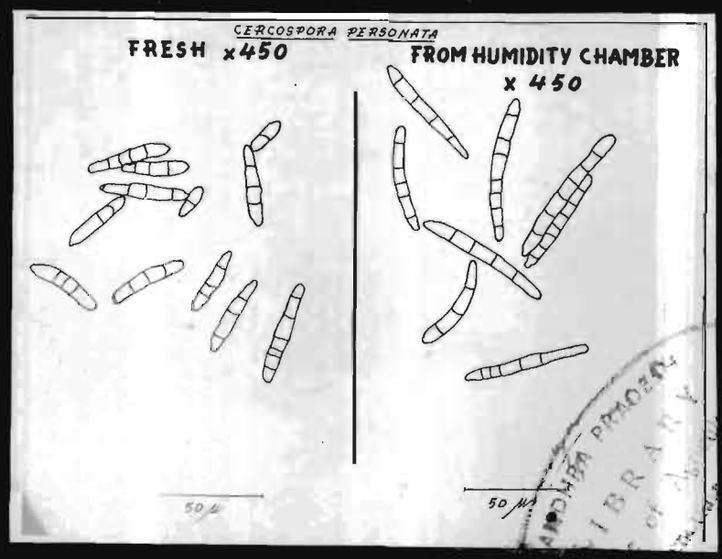
(a) *Cercospora personata* (Size expressed in u)

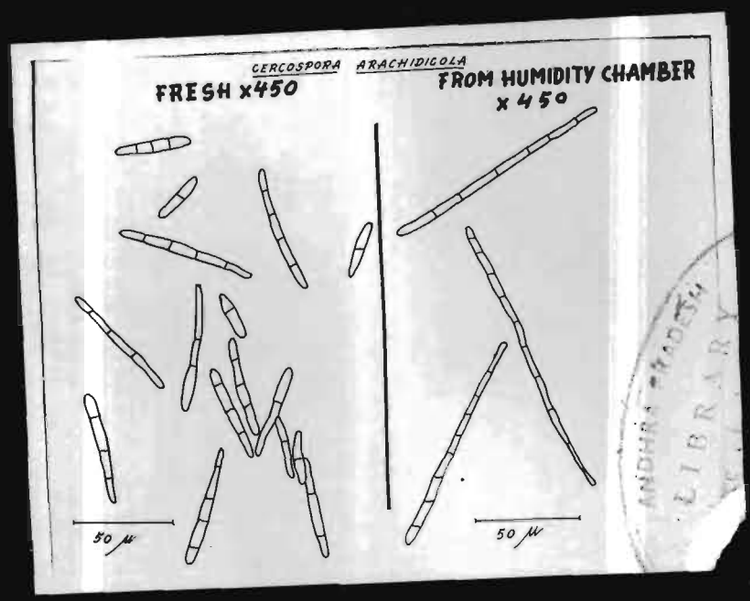
Humidity treatment	Length			Breadth			Septations		
	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.
Treated	58.37	24.32	88.16	6.35	4.56	10.64	5	1	11
Untreated	38.52	24.32	59.28	6.96	6.08	9.12	3	1	6

(b) *Cercospora arachidicola* (Size expressed in u)

Humidity treatment	Length			Breadth			Septations		
	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.
Treated	91.08	45.60	148.96	4.53	3.04	6.08	5	1	14
Untreated	59.58	18.24	100.32	3.77	3.04	6.08	3	1	10

PLATE 1 (a)





Camera lucida drawings of spores of Cercospora personata (top) and C. arachidicola (bottom) produced under dry and humid environment.

5. The effect of humidity on size and septation of spores of Cercospora personata and Cercospora arachidicola:-

Humidity is probably the most important environmental factor influencing the growth and reproduction of fungi. The asexual reproduction of fungi is more influenced by the atmospheric humidity than sexual reproduction.

It was observed by Jenkins (1938) that highly moist conditions were responsible for the production of lengthy conidia with more septations. Information on the extent of variation in length and septation of conidia, under varying humid conditions, appears to be missing. For these purpose conidia of Cercospora personata and Cercospora arachidicola were obtained both from field and from spots kept in petri plate moist chambers for 48 hours. Two hundred spores were measured from each source and their mean length and breadth obtained.

Results:-

The results are presented in Table ~~VI~~ V.

By glancing through the results it appears that the length and septation of spores are the most influenced. Both the species react strikingly to the variation in humidity. In C. personata the average length of the treated spores equals that of the maximum length of the untreated spores, w here as in C. arachidicola the variation is a bit less.

Apart from statistical results, it has been observed that the spores obtained under high humidity conditions differ strikingly

from those obtained under low humid conditions. But for their brownish colour conidia of C. personata would have been confused with C. arachidicola because the former obtained the length of the latter under high humid conditions.

The number of septa is also strikingly different from those of obtained under low humid conditions.

6. The effect of humidity pre-treatment on spore germination of Cercospora personata and Cercospora arachidicola:-

It has been observed experimentally that variations in humidity strikingly alters the size and septation of the spores of C. personata and C. arachidicola. It is quite possible that the spores produced under high humidity may behave differently from those produced under low humidity conditions, in addition to their increase in size and septation. The efficiency of germination is the probable behaviour which can be studied experimentally to observe the difference between prehumidity treated and untreated spores.

Thus an experiment has been designed to observe the difference in spore germination, if any, between prehumidity treated and untreated spores.

A thin film of water has been spread on clean glass slides and spores obtained from the sources already stated have been dusted evenly so as to avoid congestion of spores. The slides so prepared, have been kept in moist chambers improvised by using cotton padding and sterile water in sterilized petriplates.

TABLE VII

The effect of humidity pre-treatment on germination of Cercospora personata and Cercospora arachidicola spores.

Treatment	Cercospora personata				Cercospora arachidicola			
	No. of spores observed	Spores germinated	Percentage of germination	Maximum germ tube length	No. of spores observed	Spores germinated	Percentage of germination	Maximum germ tube length&
Treated spores	103	66	64	66.7u	106	60	56.6	53.3u
Untreated spores	138	90	65.2	93.3u	110	44	40	93.3u

The slides were then observed under the microscope after 32 hours to study spore germination. The number of spores that have germinated per 100 in the microscopic field, and the maximum germ tube length were recorded.

Results:-

From the data obtained, there appears to be no significant difference in the percentage germination of spores of C. personata obtained from prehumidity treated spots and those obtained from fresh spots. However a significant increase in the maximum germ tube length has been observed in untreated spores.

In the case of C. arachidicola an increase in the percentage of germination has been observed in the spores obtained from pre humidity-treated spots. But the reverse has been observed in germ tube length. (Table VII)

7. The effect of humidity on spore germination:-

The spores of many species of fungi do not germinate in the absence of liquid water. Others are capable of germination on dry surfaces in an atmosphere of high humidity, usually 95% or above. Liquid water is generally retained as very thin films on leaf surfaces, as most of the water is drained off because of the waxy cuticle. Under low humidity conditions such films are subjected to very quick evaporation resulting in a dry leaf surface which ultimately results in the desiccation of the spores. The same water film is retained if high humidity conditions prevail. Such is the influence of humidity on the germination of spores.

TABLE VIII

The effect of humidity on spore germination of Cercospora personata and Cercospora arachidicola.

(a) C.personata.

Sl. No.	Humidity level (percentage)	No. of spores observed	No. of spores germinated	Maximum germ tube length	Percentage of germination
1	70	113	-	-	-
2	80	100	11	27.6u	11
3	85	108	6	54.6u	5.5
4	90	99	13	40.0u	13.1
5	95	105	40	40.0u	38.1
6	98	103	47	54.6u	45.6
7	100	111	35	54.6u	31.5

(b) C.arachidicola.

Sl. No.	Humidity level (Percentage)	No. of spores observed	No. of spores germinated	Maximum germ tube length	Percentage of germination
1	70	105	2	27.6u	1.9
22	80	112	-	-	-
3	85	135	9	53.6u	6.7
4	90	102	16	46.0u	15.7
5	95	100	19	40.0u	19.0
6	98	99	15	53.6u	15.2
7	100	82	19	40.0u	23.1

Hence, to test the germination of the conidia of Cercospora personata and C. arachidicola, an experiment has been designed with different levels of humidity.

The various levels of humidity have been obtained by mixing concentrated sulphuric acid (sp. gr. 1.84) and water at different proportions (Stevens, 1916). The above mixtures were taken in 10 cm. x 22 cm. glass cylindrical jars upto $\frac{1}{4}$ volume. Conical flasks were inverted in the solutions on which the slides were kept. The mouth of the jars was covered by lids and sealed with cellulose tape.

Clean glass slides were swabbed with a wet cotton pad, to provide a thin film moisture; and the conidia of C. personata and C. arachidicola were dusted over the slides. The slides were then placed over the inverted flasks in the glass jars after which the jars were covered and sealed with cellulose tape.

The observations were recorded 24 hours after the slides were placed in the humidity chambers.

Results:-

From the observations, as represented in Table VIIIa and VIIIb. It appears that the conidia of C. personata germinate best at a humidity level of 98%. Where as the conidia of C. arachidicola germinate best at 100% humidity.

It has been observed that at humidity levels 70 to 90% the water film on the slides has completely disappeared, inspite of which, the spores have germinated.

TABLE IX

Percentage of germination of spores of *Cercospora personata* and *Cercospora arachidicola* in different media.

(a) *Cercospora personata*.

Sl. No.	Treatment	8 hrs	10 hrs	12 hrs	14 hrs	Percentage to control (14 hrs)
1	Control	57.8	75.8	81.8	86.0	100
2	1% Sugar solution	13.5	32.0	42.1	51.2	59.5
3	2% Sugar solution	2.5	4.5	7.4	9.9	11.5
4	2% Agar	11.4	12.2	13.4	13.5	15.6

(b) *Cercospora arachidicola*.

Sl. No.	Treatment	8 hrs	10 hrs	12 hrs	14 hrs	Percentage to control (14 hrs)
1	Control	0.98	8.3	16.3	53.9	100
2	1% Sugar Solution	1.4	3.5	9.3	22.1	41.0
3	2% Sugar Solution	16.3	21.4	27.9	33.8	62.7
4	2% Agar	4.9	16.3	26.0	48.4	89.7

Control: Sterile Distilled water

8. Percentage of germination of the conidia of Cercospora personata and Cercospora arachidicola, in different media:-

Spores of pathogenic fungi germinate best on their susceptible host. The successful germination of the spores, on the host, is influenced by many factors among which are the host secretions. It is quite impossible to obtain as much effieiency in germination as on the host surface unless untill the conditions which favour their germination on the host surface are completely understood.

To understand the above aspect of spore germination, and experiment has been conducted with two concentrations of sugar solution, sterile water and 2% agar. The germination of the spores has been counted as germination obtained per 100 spores. The development of the spores in different nutrient media has been observed upto 14 hours.

Results:-

From the data obtained it is evident that both the species germinate best in sterile water; Cercospora personata having 86% germination and C. arachidicola 53.9% germination, after 14 hours. The next favourable medium appears to be 1% sugar solution for C. personata and 2% agar for C. arachidicola. (Table IX and IX b)

9. Host-parasite relations:

For the purpose of the study of host-parasite relationships in tikka disease, three varieties - Spanish Improved, TMV-3 and 417 - have been selected. Spanish Improved is one of the most susceptible varieties and TMV-3 a less susceptible one. Variety 417 is different from the other two in that no halo develops on this variety (Expt.1 Symptomatology).

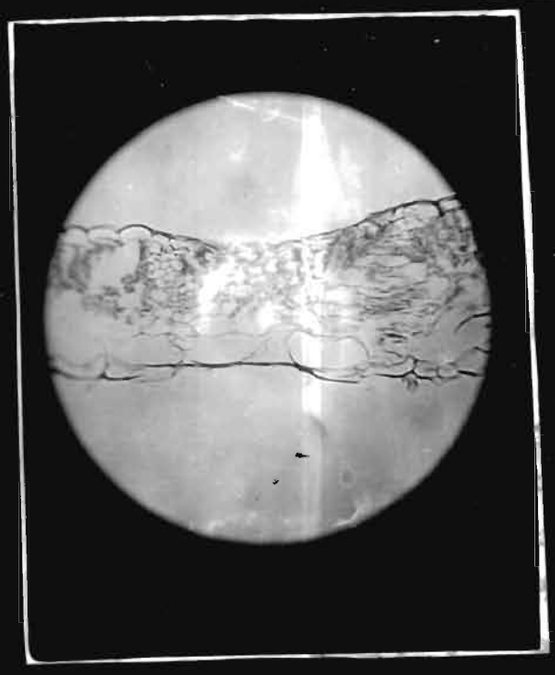
Inoculations of C. arachidicola and C. personata were made separately in the green house. Starting with the first appearance of symptoms, the diseased material was fixed in F.A.A. on alternate days until maximum lesion development occurred. Serial microtome sections were cut and stained in saffranin - fast green combination.

i) Cercospora arachidicola:-

a) Spanish Improved: In the initial stages, both the epidermal layers collapsed (Plate, 2a). No mycelium was observed at this stage. There was a general collapse of the cell walls of the palisade and spongy mesophyll. Beyond the necrotic zone and adjacent to it, cells were apparently normal, though the lower epidermis in that region appeared necrotic. Mycelium was inter-cellular and intra-cellular in the necrotic area (Plate, 2b).

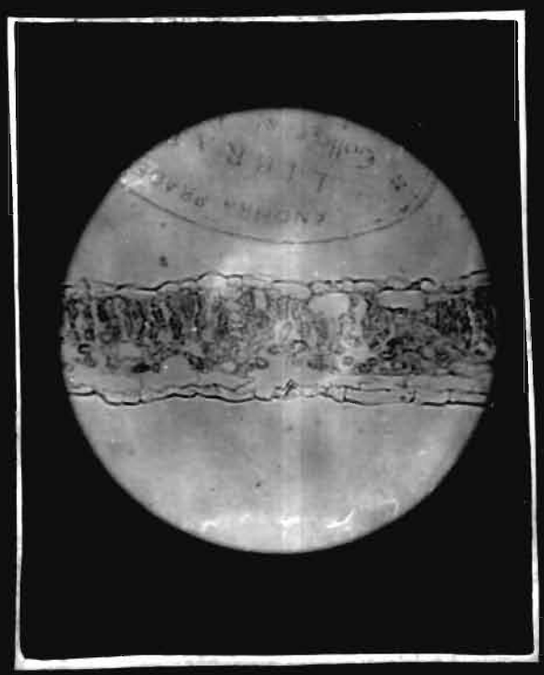
As the lesion progressed there was a complete collapse of the palisade and spongy cells in the necrotic area (Plate, 2c). The distorted epidermal layer was thickened in this region and deeply stained (Plate, 2d). There was a complete collapse and even disappearance of many of the mesophyll cells (Plate, 2d).

PLATE 2



0

a



b

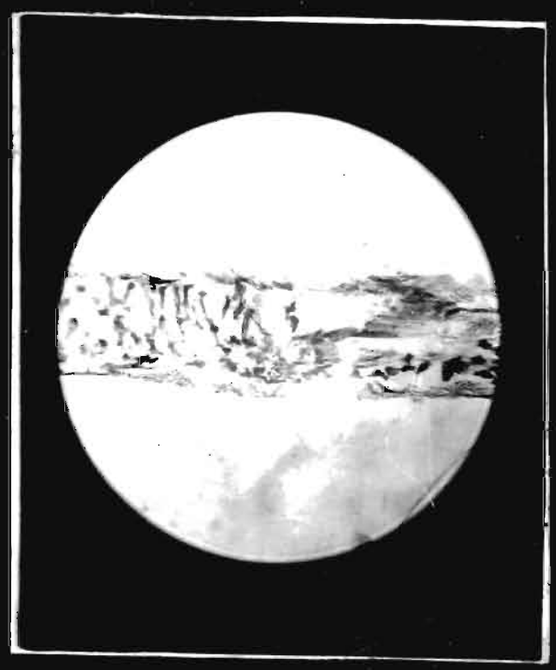
Plate 2: Spanish Improved infected by Cercospora arachidicola.

O: Healthy leaf.

a: Initial stages of infection.

b: Showing inter cellular and intra cellular mycelium.

PLATE 2 (contd.)



c

d

Plate 2: Spanish Improved infected by Cercospora arachidicola (Contd).

c: Collapsed palisade and spongy cells.

d: Complete collapse of the cells and stroma formation.

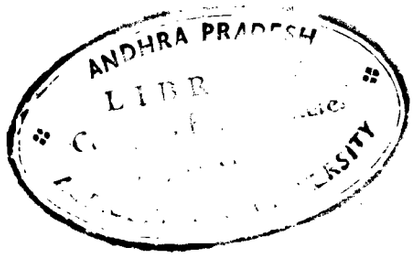
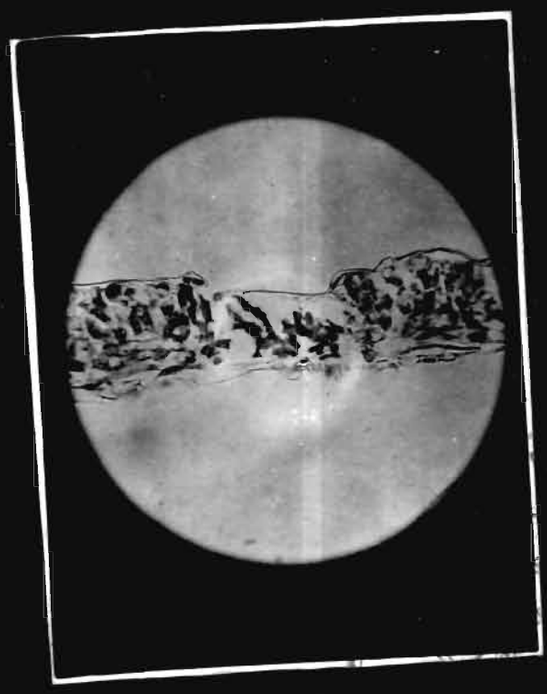
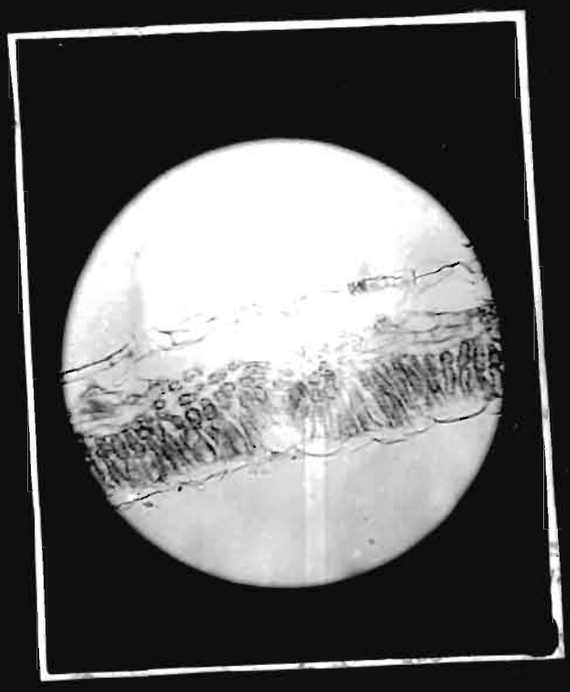


PLATE 3



c

a



b

Plate 3: TMV-3 infected by Cercospora arachidicola.

O: Healthy leaf. Note the closely packed nature of the palisade cells.

a: Initial stages of infection. Note the distorted epidermal layers.

b: Showing inter and intra cellular mycelium in the spongy mesophyll.

PLATE 3(contd.)

c

d

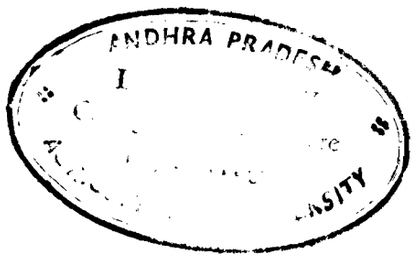
e

Plate 3: TMV-3 infected by Cercospora arachidicola (Contd).

c: Showing disorganised cells of the mesophyll resulting in vacant pockets.

d: Complete collapse of the cells of the necrotic area, and mycelial aggregation below the upper epidermis.

e: Stroma, emerging out through the ruptured epidermis.



Later on the mycelium was observed to be accumulating in abundance in the necrotic area.

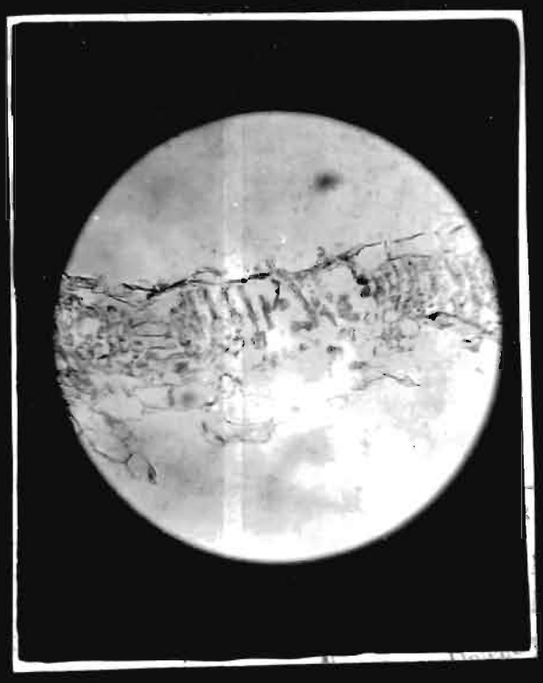
After the host cells have completely collapsed in the necrotic area, the mycelium began aggregating in masses in the vacant spaces below the upper epidermis. These masses also appear to contain the necrotic host tissues. The size of the hyphal matryx increased as the age of the lesion increased. The necrotic epidermal layer was gradually pushed and finally ruptured by the stromatic tissue.

b) TMV-3: Epidermal cells were distorted, making the dermal layers appear as mere threads (Plate, 3a). The cells of the palisade and spongy mesophyll started collapsing early. The area of the leaf at this place appeared thin due to the shrunken parenchymatic cells and the epidermal layers. Beyond the necrotic region and adjacent to it the palisade and spongy mesophyll cells stained darker than the healthy cells and lighter than necrotic cells.

Mycelium was observed to be inter cellular and intra cellular in spongy mesophyll, adjacent to the lower epidermis (Plate, 3b).

As the lesion growth progressed the upper epidermal cells were badly distorted and the palisade and spongy cells were shrunken. The cells of the mesophyll region were disorganised resulting in many vacant pockets (Plate, 3c). Severe necrosis occured in the mesophyll area. The upper and lower epidermis thickened considerably and hence has taken a deep stain, appearing almost black.

PLATE 4



c

a

b

Plate 4: Variety 417 infected by Cercospora arachidicola.

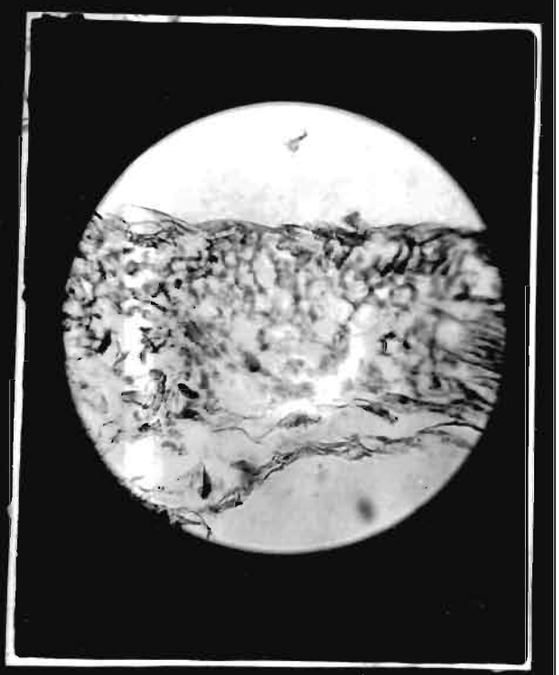
O: Healthy leaf.

a: Initial stages showing the disrupted upper epidermis and intact lower epidermis.

b: Showing a gradual collapse of the cells of the necrotic region.

PLATE 4 (Contd.)

c



d

e

Plate 4: Variety 417 infected by Cercospora arachidicola (Contd).

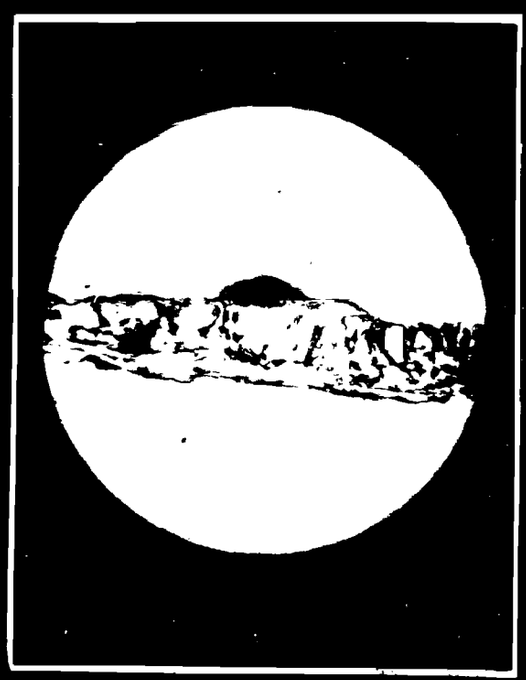
c: Gradual collapse of the cells of the necrotic region.

d: Stromatal formation on the upper and lower epidermis.

e: Mature stromata rupturing the epidermis, with inter and intracellular hyphae beneath.

PLATE 4(contd.)

f



g

Plate 4: Variety 417 infected by Cercospora arachidicola (Contd).

f: Intact vascular vessels surrounded by necrosed cells.

g: A mature stroma perched on the upper epidermis.

Beyond the necrotic zone, though the upper epidermis appeared necrotic,the mesophyll cells were apparently healthy but stained grey with slightly shrunken cell walls; some of their contents appear partially disintegrated. There was no indication of any cicatricial formation.

This was followed by a collapse of the cells in the necrotic area resulting in the formation of many vacant pockets. Both the epidermal layers were distorted. A peculiarity observed here is the extension of necrosis to the spongy mesophyll cells on either side, even though the palisade parenchyma and upper epidermis were apparently healthy.

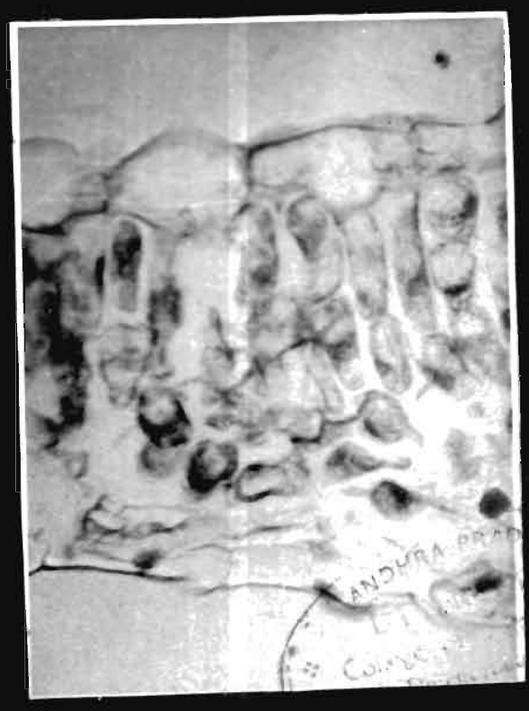
The complete collapse of cells of necrotic area was followed by the aggregation of hyphae just below the upper epidermis (Plate,3d). This structure gradually pushed the epidermis upwards until finally the epidermis was reptured (Plate, 3e).

c) 417: The upper epidermis was distorted and deeply stained. Almost all the cells of the palisade and spongy mesophyll collapsed. Some of them disappeared, creating many pockets. At this stage the lower epidermis was intact (Plate, 4a).

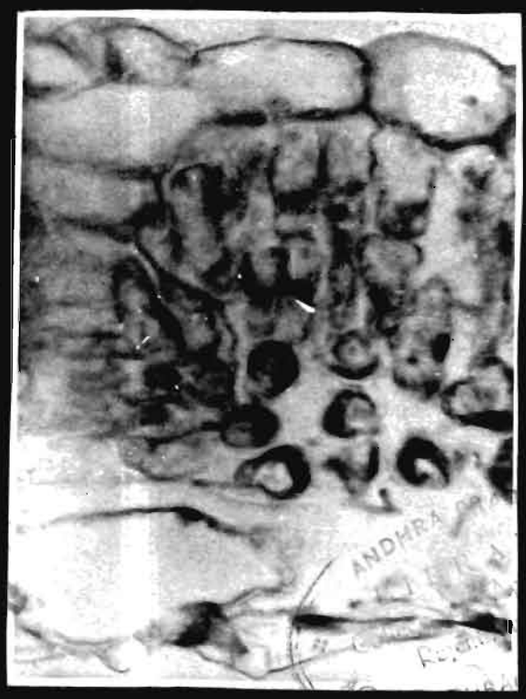
In the advanced stage of lesion development an increased area of necrosis was observed. There was a gradual collapse of cells in this region (Plate, 4b and 4c). Stromata were observed on the upper and lower epidermis (Plate, 4d).

To start with, a stroma was strangled mass of hyphae almost

PLATE 5



a



b

c

Plate 5: Spanish Improved infected by Cercospora personata.

a: Showing distorted epidermal layers and shrunken palisade cells.

b:)Inter cellular mycelium in the apparently
&)
c:)healthy cells.

PLATE 5(Contd.)

d

e

f

Plate 5: Spanish Improved infected by Cercospora personata (Contd).

d: Showing hyphal network in the necrotic area. Note the highly collapsed palisade and spongy cells.

e: Stroma raising the epidermis

f: Stroma rupturing the epidermis. Neighbourhood of stroma devoid of mycelium.

globular in shape which gradually forced its way upwards and ruptured the epidermis in the process (Plate, 4e). Mycelium was observed beneath the stroma, both inter and intra cellularly.

Mycelium was also observed to be present inter-cellular and intra-cellularly in the apparently healthy cells adjoining the necrotic area. The presence of mycelium in the healthy cells did not appear to influence either their size, shape or their contents. Vascular vessels retained their shape in spite of the severe necrosis of cells surrounding them (Plate, 4f).

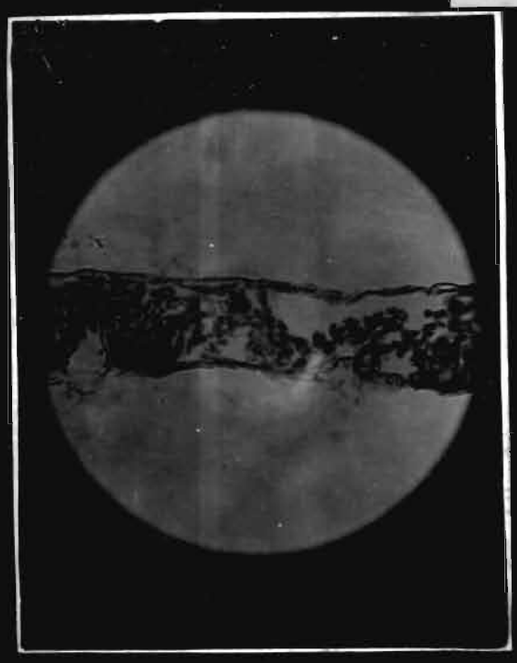
(i) Cercospora personata:-

a) Spanish Improved: There was a distortion of upper epidermis, and some of the palisade cells were shrunken in the initial stages (Plate, 5a). As the disease progressed, cells of the palisade and spongy layers have attained a grey colour; some of their cell walls slightly shrunken. A slight collapse of cells was also observed.

Mycelium was inter cellular (Plate, 5b). Hyphae were seen in a net work through out the necrotic zone (Plate, 5d). A severe collapse of the palisade and sponges cells occured in the necrotic area (Plate, 5d). The cells of both the epidermal layers were disintegrated but the layers were still compact. Mycelium was inter-cellular in the collapsed region. Mycelium was also observed in the area adjacent to the necrotic areas corresponding to the halo observed on the leaves. Cells in this region stained grey, but neither their contents nor their shape had been lost (Plate, 5b and 5c).

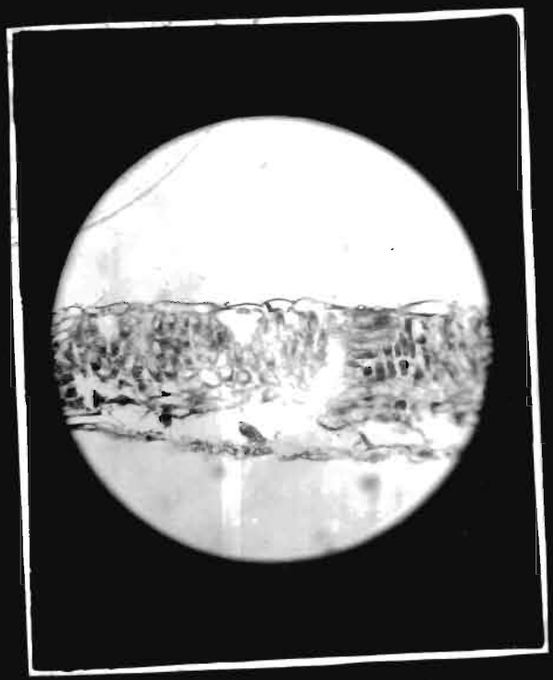
Myce

PLATE 6



a

b



c

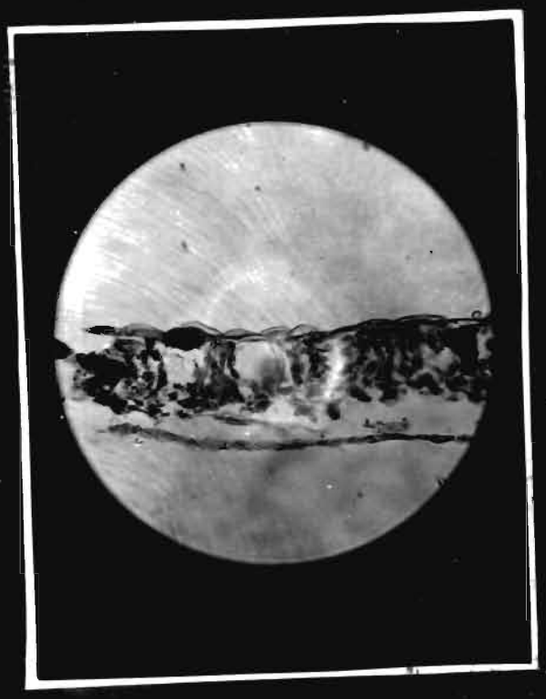
Plate 6: TMV-3 infected by Cercospora personata.

a: Showing distorted epidermal cells and shrunken palisade and spongy cells.

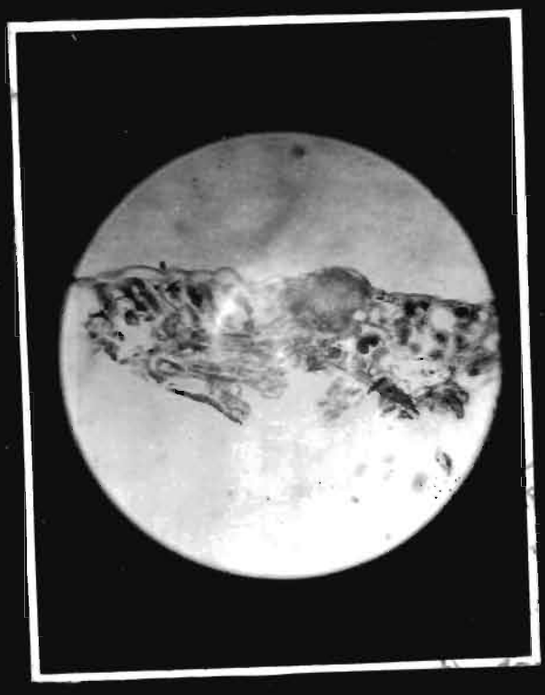
b: Inter cellular mycelium in the necrotic area

c: Darkly stained cells of the halo region.

PLATE 6 (Contd.)



d



e

Plate 6: TMV-3 infected by Cercospora personata (Contd).

d: Note the formation of stromatic tissue below the upper epidermis.

e: Mature stroma.

Mycelium aggregation leading to stromatal formation began just below the lower epidermis. The epidermis in that particular area was slightly raised. Abundant mycelium was observed in the necrotic region (Plate, 5e).

After further development, the epidermis covering the stroma was ruptured probably due to the pressure exerted by the stromatic tissue. No mycelium was observed in the neighbourhood of stromatic tissue (Plate, 5f).

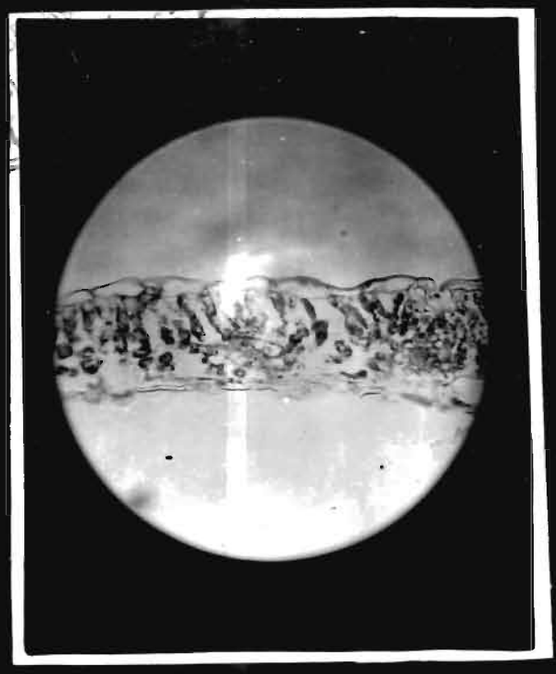
b) TMV-3: In the earlier stages of lesion development there was a distortion of the epidermal cells. The palisade and spongy cells were shrunken the disorganized but not fully collapsed. No mycelium was visible (Plate, 6a).

At an advanced stage of lesion development most of the cells of the palisade and spongy area were shrunken and collapsed (Plate, 6b). There was a transitional area between the healthy and necrotic area, probably representing the halo. Inter-cellular mycelium is observed in the necrotica area (Plate, 6b).

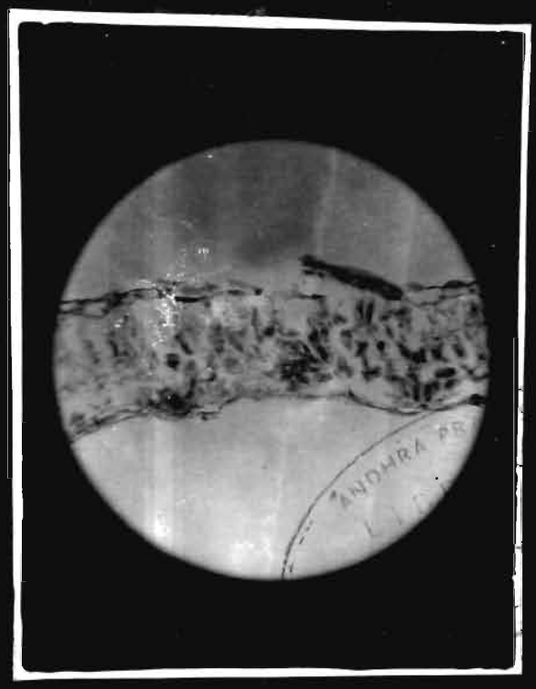
Stromatic formation took place after the mycelium aggregated below the lower epidermis. However stromatic tissues were also observed below the upper epidermis (Plate, 6d). With the advance in the age of the lesion the epidermis covering the stromata, was ruptured, exposing the stromatic tissue.

c) 417: In the early stages the epidermal cells of both the layers were almost unaffected. Some palisade cells in this region were

PLATE 7



a



b

c

Plate 7: Variety 417 infected by *Cercospora personata*.

a: Fairly healthy epidermal cells. Note the deeply stained and slightly shrunken palisade cells with inter cellular mycelium.

b: Showing distorted epidermis and collapsed palisade and spongy cells.

c: Note the perfectly healthy cells beyond the necrotic. region.

PLATE 7 (Contd.)

d

e

f

Plate 7: Variety 417 infected by Cercospora personata (Contd).

d: Extensive mycelium in the region of the lower epidermis.

e: Free mycelium in the proximity of the stroma..

f: Stroma formation on the upper and lower epidermis.

disorganized (all of them were deeply stained, their walls in particular) and their walls were slightly shrunken. Spongy cells were almost unaffected (Plate, 7a).

Mycelium was seen ramifying throughout the palisade and spongy parenchymatic cells inter cellularly (Plate, 7a). As the disease progressed epidermal cells of both the layers were disintegrated, the epidermis appearing as a thread like structure. A majority of the palisade and spongy cells were collapsed (Plate, 7b). Beyond the necrotic area the tissues appeared perfectly healthy (Plate, 7c).

In the necrotic area mycelium was observed to be very extensive, particularly below the lower epidermis. Although many hyphae were observed to be inter cellular in the palisade zone a few intra cellular hyphae were also observed.(plate, 7d)

Further, there ~~is~~ was a dissolution of the cells of the necrotic area,due to which large vacant pockets were found. In these zones mycelial aggregation appeared just below the lower epidermis. Free mycelium was also observed in the necrotic area in the proximity of the stromata (Plate, 7e). Stromatic formation was also observed below the upper epidermis (Plate, 7f).

DISCUSSION

Ever since it was recognised that tikka disease was caused by two species of Cercospora, C. personata and C. arachidicola, there were several accounts of differences in symptomatology, both internal and external, of the disease due to the two species. Particular emphasis had been placed on the lesion shapes, the period of appearance of the halo and the location of the mycelium in relation to the cells (Woodroof, 1933 and Jenkins, 1938).

In the present study the symptomatology of the disease was studied on many varieties of varied parentage, under identical conditions. The results obtained from such a study revealed that some of the differences made out by the previous workers appeared to be not very constant. Earlier workers indicated that while the lesions are circular in the case of C. personata, they are irregular in the case of C. arachidicola. A critical examination of table I and II shows that on several varieties, the spots due to C. arachidicola were as circular as those of C. personata (Plate I). Out of the seven varieties tested the lesions were ciruclar on four varieties infected by C. personata and three varieties infected by C. arachidicola. On two varieties, 417 and T-28, both the fungi produced circular lesions. On Spanish Improved the spots produced by C. personata were more circular than those due to C. arachidicola. However, spots produced by C. personata were more circularly defined than those produced by C. arachidicola.

Much emphasis was placed in the past on the period of appearance of the halo in differentiating spots produced by the two fungi (Butler, 1918 ; Woodroof, 1933 and Jenkins, 1938). Woodroof (1933)

emphasised the fact that a halo is present from the beginning around the spots produced by C. arachidicola where as halo was observed only around mature spots in the case of C. personata. The results obtained in the present studies are in variance with those observations. A halo was discernable in C. personata also, from the initial stages. It may however be pointed out that the development of the spot in the case of C. personata was slower compared to C. arachidicola. Thus ten days after inoculation the spots due to C. personata measured below 1mm. while those due to C. arachidicola measured upto 1.5mm. The early appearance of the halo is perhaps a result of the faster development of the spot itself. Nor was there any marked difference in the colour of the halo which varies from faint greenish yellow to golden yellow in both the cases.

Another interesting fact that has emerged out of this experiment is that no halo at all may be produced in some varieties. Thus dno discernable halo developed around the spots on the varieties 417 and 419 infected by both the fungi. There does not appear to be any report, as far as the author is aware, about the complete absence of halo in Cercospora infected ground nut leaves. Although the reaction of these varieties was not observed in the field, it can be concluded that atleast under the environmental conditions obtaining in the present green house studies, halo may not develop in the case of some varieties. This indicates that the development of halo depends on the host also and therefore not solely governed by the pathogen.

The precise host-parasite reaction leading to the production of halo in tikka disease of ground nut is not known. The role of toxins in the host parasite relationships and lesion development had been a elucidated in many diseases, like rice blast, early blight of tomato and wild fire of tobacco (Tamari and Kazi, 1952 and Ludwig, 1960). It would be interesting to investigate whether the two species of Cercospora causing tikka disease of ground nut produced any toxin(s) which play a role in the development of the halo.

A more reliable criterion which serves in ready differentiation of the spots produced by the two species of Cercospora is the colour of the spot, on the lower surface of the leaf. Field observations indicated that it would be difficult to distinguish the spots by viewing from the upper surface. Both the spots were dark brown to black in colour with a yellow halo. But the colour of the spots due to the two species differed strikingly on the lower surface; in the case of C. personata the spots were of deep black colour and in the case of C. arachidicola, they were light brown to brown. In the present study a few hundreds of spots were separated by the author using the above driterion and later varified by examining the spores. Without exception the identification was found to be correct.

Although there were no marked differences in lesion size, in general it was observed that lesions on the spreading varieties tend to be smaller than those of the bunch varieties. Also the lesions due to C. personata were smaller than those caused by C. arachidicola.

Butler (1918), Rhind (1924) and Roger (1935) reported that C. personata occurs early in the season. Woodroof (1933), however, designated the diseases caused by C. arachidicola and C. personata as early spot and late spot respectively based on the period of incidence of these fungi. Subsequent reports (Jenkings, 1938; Garren and Wilson, 1951; Chevaugeon, 1952; Vasudeva, 1961; Corbett, 1962 and Rothwell, 1962) amply justify Woodroof's differentiation.

In the present study also it was observed that under field conditions C. arachidicola occurs earlier than C. personata and the former remained the dominant one during the entire period of the experimental crop. It was however observed in a late sown crop that although C. arachidicola appeared early, C. personata which appeared later was the dominant one. These results indicate that the relative predominance of these fungi depends on the date of sowing; when the crop is sown early C. arachidicola is the dominating species, while in the late sown crop C. personata dominates. Jenkins (1938) also reported that in the United States C. arachidicola was was epiphytotic during August - September and C. personata from September onwards.

The early appearance of C. arachidicola raises the question whether the ground nut plant is more susceptible to this fungus in the earlier stages. The results obtained (Table IV) does not however support this view as the ground nut plants were equally susceptible to both the fungi at all stages of growth. The early incidence of C. arachidicola, then, is perhaps due to early liberation of the inoculum under field conditions. These results are also in variance

with the field observations made by several workers (Butler, 1918; Woodroof, 1933 and Garren & Wilson, 1951) that the lower leaves are first to be attacked. This could be explained by the fact that while, in the green house the environmental conditions tend to be more uniform, in the field the microclimate obtaining nearer to the ground level is more congenial for the infection.

Among the environmental conditions, relative humidity is the most important single factor in the initiations of infection and the subsequent spread of the pathogen. The results obtained in experiment (Table V) revealed that neither of the two species could infect the ground nut plant when high humidity was provided for a period of only 24 hours. Maximum infection was obtained when a 72 hour period of high humidity was provided. Under the field conditions also there was an increase of incidence of the disease after a week long spell of wet weather. This limited field observation indicates that the humidity plays an important part in the epidemiology of the disease. It was also observed that following high humidity the spots were larger and darker coloured and the halo was much brighter.

High humidity was observed to influence the sporulation of the fungus also. In fact the common method of obtaining the spores of these fungi were by keeping the affected leaves in a moist chamber for about three days. High humidity not only affected the quantity of the spores produced but also the size and septation of spores. Jenkins (1938) also made similar observations. A quantitative study of this aspect revealed that spores of both species react strikingly

to the variation in humidity (Table VI). The length of the spore and the number of septa increased (Plate 1a) the germination percentage of the spores, however was not altered. An increase in the length and number of septa was reported to be a general response to high humidity (Hawker, 1957). Gregory (1939) however, reported conidia of Ramularia vallisumbosae found under very wet condition were shorter and broader and had fewer septa than those from drier situations.

As spore size and septation are important taxanomic criteria, great caution is necessary while interpreting small differences in these characters. Indeed in the present study it was found that spores with almost identical length and septation could be obtained from C. personata and C. arachidicola by manipulating the relative humidity in the incubation chamber. In view of the strong influence of environment on the morphology of the spores of these two species of Cercospora it is doubtful whether the recent suggestion of Khan and Kamal (1961), that C. personata should be shifted to the genus Passalora because of its spore morphology, is valid.

Spore germination is probably the most important of all the factors related to epidemiology. The factors influencing spore germination thus play an important role in the spread of the disease. Among these factors relative humdity is of prime importance. Many fungi do not germinate in the absence of free water (Cochrane, 1958). For instance uredospores of many rusts may not germinate even at 100% humidity in the absence of liquid water. Results obtained in the

present studies revealed that a humidity of 98% favoured maximum spore germination (45.6%) in C. personata and a humidity of 100% was required for maximum spore germination (23.1%) in the case of C. arachidicola (Table VIII). These results indicate that spores of C. personata not only require a slighly lower humidty but also have a higher germination percentage. This is the probable reason why, where the two fungi occur together C. personata spreads much more faster than C. arachidicola.

Besides relative humidity the nutrients in the infection drop are known to play an important role in the spore germination. Results obtained in the present studies, however, indicated that the spores of both C. personata and C. arachidicola germinate best in sterile water (Table IX). Here again the percentage of germination of spores of C. personata was more than that of C. arachidicola.

Host-parasite relationships: In all the three host varieties studied the initial histopathological symptom was collapse of the epidermal cells except in the variety 417 infected by C. arachidicola where the epidermal cells collapsed at a later stage. This was followed by collapse of palisade and spongy cells. The vascular bundles however appeared to be unaltered. One significant observation made was that the mycelium was never extensive. Indeed it is hardly possible to explain the rapid collapse of the cells in the absence of extensive mycelium without postulating that some diffusable substance which travels

in advance of mycelium is produced by both the species. It is tempting to assign this role to some toxin(s) secreted by these fungi. Jenkins (1938) reported killing of the cells in advance of the mycelium in leaves infected with C. arachidicola.

According to Butler (1914) and Woodroof (1933) the mycelium in the case of C. arachidicola was internal and external, inter cellular and intra-cellular without haustoria. In the present studies the mycelium was never found to be external either in the case of C. personata or in the case of C. arachidicola. The mycelium however was both inter and intra-cellular in the case of C. arachidicola. The mycelium of C. personata was predominently inter-cellular although in a few slides it appeared to be intra-cellular also. The haustoria which were stated to be present in the case of C. personata (Butler, 1914 and Woodroof, 1933) could not be observed.

Stromatal formation was predominently on the upper surface in the case of C. arachidicola and on the lower side in the case of C. personata. Perhaps the dark colour of the spots of C. personata on the lower surface may be due to the production of numerous stromata on the lower surface. Stromatal formation in most cases was preceded by a complete collapse of the host tissues.

In general mycelium in TMV-3 variety was more scanty than in the other two varieties. The spread of the mycelium and lysis of the cells was observed to be slower in the spreading variety than in the bunch varieties. Histological observations of the healthy

sections of the three varieties had shown that the palisade layer in the spreading variety (TMV-3) was very closely packed with minimum inter-cellular spaces. In the other two varieties this layer was loosely packed with plenty of inter-cellular spaces. This difference in the palisade tissues of TMV-3 and the other varieties probably accounts for the slow lesion development in the spreading varieties when compared to the bunch varieties. Hemingway (1957) attributed the slower lesion growth on the resistant varieties to the extra thickness of palisade tissue.

The presence of halo in Spanish Improved and TMV-3 varieties and its absence invariety 417 was correlated with intermediary transitional area which stained lighter than the necrotic area but darker than the healthy tissues in the former and by the absence of such transitional area in the latter. However inter and intra-cellular mycelium was observed in healthy tissues beyond the necrotic area in variety 417 infected by C. arachidicola. But the cells were not damaged indicating that in varieties in which no halo was produced the substance responsible for halo production (toxin?) was not produced.

SUMMARY

A detailed study of the symptomatology of tikka disease of ground nut caused by Cercospora personata and C. arachidicola revealed that:

a) The spots caused by C. personata were almost black on the upper surface and deep black on the under surface. The spots caused by C. arachidicola were dark brown to almost black on the upper surface and lighter coloured on the lower surface. This difference is the most important criterion to distinguish the spots caused by the two fungi.

b) Well developed spots due to C. arachidicola were irregularly round to round while those due to C. personata were, in general, more circularly defined.

c) The development of halo around the spots appeared to be more a host varietal character than that of the pathogen and thus this is not a reliable criterion to distinguish the symptoms due to the two species. In two varieties, 417 and 422, no halo developed around the spots caused by both the species of the pathogen.

2. Cercospora arachidicola appeared 30 days earlier than C. personata in the field and the former was the dominating species in the early sown crop.

3. The ground nut plant was almost equally susceptible at all stages of growth to both the species of Cercospora. The defoliation was greater due to C. personata than C. arachidicola.

4. A period of 72 hours of high humidity was required for maximum infection to occur in the case of both the species. No infection occurred when the inoculated plants were subjected to humidity for only 24 hours.

5. The conidial size and septation, in both the fungi, increased strikingly under high moisture conditions. The germination capacity of the spores was not however altered.

6. The conidia of C. personata germinated best at a humidity level of 98% while those of C. arachidicola germinated best at 100% humidity. The germination percentage of C. personata conidia was much higher than that of C. arachidicola.

7. The conidia of both the species germinated best in distilled water indicating that they may not require any nutrients in the infection drop for successful infection.

8. A study of the host-parasite relationships in three varieties of ground nut infected by C. personata and C. arachidicola revealed that:
a) The mycelium of Cercospora personata was inter-cellular although a few hyphae were suspected to be intra-cellular also. The mycelium of C. arachidicola was inter-cellular and intra-cellular.

b) In general the mycelium was not extensive in the case of both the fungi except during the stroma formation.

c) Stromata were more frequently formed on the lower surface of the leaf in the case of C. personata while they were generally confined to the upper surface in the case of C. arachidicola.

d) In most cases the spongy and palisade cells were completely disintegrated in the necrotic region.

e) The palisade layer in the spreading variety, TMV-3, was closely packed with minimum inter-cellular spaces than in the other two bunch varieties. It is suggested that this anatomical difference may account for the slow lesion development in the spreading varieties compared to the bunch varieties.

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