STUDIES ON SOME DISEASES OF MAIZE IN EGYPT

BY

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INTRODUCTION

INTRODUCTION

Maize (*Zea mays* L.) is the premier crop and the main source of food in Africa. It is added to wheat and used as a stable food for the majority of Egyptians. It is the third most important cereal crop in the world after wheat and rice. It occupies nearly one-third of the total crop land in Egypt.

Maize, like other cultivated crops, is susceptible to a wide number of diseases which reduce both yield and quality. In Egypt, the sorghum downy mildew disease caused by *Peronosclerospora sorghi* was first recorded in 1931 by Melchers, but it was of minor importance. During the last decade, however, the importance of that disease tended to increase and nowadays, it becomes a serious problem threaten maize cultivation and production allover the country.

Up till now, the knowledge on sorghum-downy mildew disease of maize in Egypt is scanty and uncertain . This work aims to find answer on the following :-

1- The status of the disease in some governorates.

2- Is there any resistant variety or hybrid among the cultivated ones ?

3- Effect of various levels of the NPK fertilizers on susceptibility of maize to the disease.

REVIEW OF LITERATURE

I-Distribution of sorghum downy mildew disease of maize:

In the past few years, sorghum downy mildew caused by *Peronosclerospora sorghi* (Weston and Uppal) Shaw (Syn. *Sclerospora sorghi* (Kulk.) Weston and Uppal) has appeared in Sudan (Tarr, 1963); the United States (Reyes *et al*., 1964); Israel (Kenneth, 1966); Mexico (De Leon, 1970) ; Argentina (Nider *et al*., 1969 and Frezzi, 1970);Uruguay (Chiara and Artola, 1974); Brazil (Fernandes and Grobman, 1975), Venezuela (Fernandez *et al*., 1975); South Africa, (Westhuizen, 1978); Australia, (Reddy, 1979 and Navaratnon, 1986) and Nebraska, (Partridge and Doupink, 1979).

This disease was observed in India by Butler (1907) who recognized the similarity of the oospores of *Sclerospora sorghi* to those of *S. graminicola* (Sacc.) Schroet on millet and assigned it to the same species . In 1913, Kulkarni described the oospores and conidia and he used disease symptoms and characteristics of the asexual stage to differentiate *S. graminicola* var. *andropogonis sorghi*. Melhus *et al*. (1928) found two natural occurrence of *S. graminicola*; one in 1925 on dent maize seedlings and the second in 1927 on sweet maize.

Futrell and Bain (1967) observed *S. sorghi* on Sudan grass, sorghum hybrids and in commercial sorghum fields in Mississipi in 1966, having spread rapidly in Texas in 1964.

Anonymous reported in 1973 that maize was attacked by at least nine species of Sclerophthora and Sclerospora . Disease symptoms caused by all these species are somewhat similar and manifest chlorotic streaking, motling, stunting, malformation of ears and tassels and excessive tillering. The symptoms of sorghum downy mildew on maize plants are characterized by narrower and more erect leaves than those of healthy plants, and diseased plants may have phyllodied tassels. Frederiksen et al. (1973b) added that symptoms of sorghum downy mildew disease may are either systemic or localized form . The systemic form of the disease is caused by infection of seedlings with either oospores or conidia of the fungus soon after seedling emergence from the soil. The localized form of the disease is caused from foliar infection by conidia.

Williams and Herron (1974) found that S.sorghi in Kentucky on sudangrass, sudan-sorghum hybrids,corn not on shattercane during 1972. This fungus was also observed on maize by Warren et al. (1974).

Malaguti (1976) reported that a limited area of diseased sorghum and corn was first seen in the state of Yaracuy in 1973, subsequently observed in three additional states in 1974, and in 1975, it was found to be present in nine states. Covering at least one-third of the national cultivated corn area. The average of diseased plants in the total affected area was about 1.6%, but, in many particuler fields they have reached 60 % . Malaguti et al. (1978) added that 21% of inoculated maize seedlings in the fields by S. sorghi were stunted and died prematurely, 36% had deformed, phyllodied to tassels, while the rest had chlorotic striped, erect leaves, and only 8.5% of the seedlings developed into healthy plants.

Thomas and Lengkeek (1979) stated that sorghum downy mildew incidence reached significant levels in several localization areas in Kansas in 1978.They showed that both shuttercane (Sorghum bicolor)and Johnsongrass (S. halapense) were found to be infected.

Navaratnon (1986) found that maize downy mildew, caused by Peronosclerospora mayids, was detected in N. Queensland for the first time in June 1985. The disease occurred first in Australia in 1980 in the Northern Territory and Parts of Western Australia. Action is being taken to prevent spread to the major maize and sweet corn production areas in the South.

In Egypt, Melchers(1931)observed the spread of sorghum downy mildew from sorghum to maize, and he sepeculated that inoculum entered via sorghum packing materials from India. Salama (1976) decided that sorghum downy mildew was not listed as a disease of sorghum in Egypt before 1975. El-Sharawi (1985) in Egypt, reported that this disease was limited in about ten thousand feddans of the Experimental Farm of Sakha Agric. Res. St., Kafr El-Sheikh Governorate. This disease was not observed in the other abovementioned locations until 1980 season. However, it was first observed as a single infected plants in some experimental plots in 1977, it was become wide-spread in the other neighbour fields in the next years. Moreover, the incidence of infected plants varied from 5-60% within the maize fields checked in 1982 season, it was more distribution on sorghum sowing in this area.

2-Environmental conditions effects on the downy mildew disease development:

In the Philippiness, Exconde *et al.* (1968)reported that the severity of downy mildew of maize was highest in the crop sown in July, November and December , when temperature were 27.5, 27.0 and 26.3°C and relative humidity were 88, 88 and 88.4%,respectively.

Chang and Wu (1969) indicated that the optimum, minimum and maximum degrees of temperature for conidial production of S. sacchari on corn were 22.25, 13.00 and 31.00°C, respectively. The conidial germination percentages at different temperature degrees were; 62%, 92.7% and 100% at 13, 16 and 19-28°C, respectively. In addition they also reported in 1970 that, under natural conditions the dispersal of the fungal spores on maize began at 1-2 a.m. and ended at 3-4.30 a.m.

In Uganda, Doggett (1970) stated that sorghum downy mildew which caused by S. sorghi was seldom severe in early season (August-November) and increased with later plantings.

Shah and Tuladhar (1971) obtained the highest infection of downy mildew disease in maize sown in 16 June when average of temperature was 38.3°C and relative humidity was 83.2%. The lowest severity was recorded in plantations occurred between 1-15 May, and the disease did not develop in the crop sown after August nor prior to May.

In Israel, Kenneth and Shahor (1973) observed that systemic infection of sorghum downy mildew was higher at 17-18°C than that at 23°C. They interpretated that the higher rate of infection at the lower temperature could be attributed to the larger amount of inoculum presented in these conditions. Under the laboratory conditions, Wongsinchaun (1975) found no sporulation occurred on infected leaves with S. sorghi under incubation conditions of 81-84% R.H., while it occurred at 90% R.H. and 20°C for a period of 8 hours. In addition, the fungus did not produce conidia at or below 16°C nor at 30°C; sporulation was rather light at 18°C, and highest at 24-26°C.

Exconde (1976) suggested that conidial production of corn downy mildew was highly affected by temperature and relative humidity. This usually occurred during night at 21-26°C and 85-95% R.H. Correlation matrices showed that local infection was positively correlated with sunshine duration. Systemic infection was positively correlated with night and day R.H. and spore production. It was adversely correlated with night and day temperature, or sunshine duration.

Bonde et al. (1978) reported that the optimum temperatures for conidial germination and germ tubes growth of S. sorghi were 15°C and 22°C, respectively.

3-Economic impact and grain yield losses:

In Texas 1964, Reyes et al. reported that sorghum downy mildew disease becomes a great hazard on sorghum and maize cultivation, and is presently one of the major factors caused reduction in yields of broom corn, forage, grain sorghums, sweet and field maize. Broom corn suffered serious yield reduction in 1967 and 1968 due to severe infection, broom corn acreage has decreased (30.000 to 5.000 acres) in 1960-1971 period; several commercial maize fields have been wiped out and other heavily damaged. As a result of that, farmers had to discontinue the use of sorghum-sudangrass hybrids as a green manure, pasture, silage or hay crops because their highly susceptibility and consequent heavy residual inoculum extended to infect any succeeding susceptible crop. Fields of sorghum when cultivated following sorghum-sudangrass hybrids, or fields with long histories of grain sorghum production, have a higher percentage of diseased plants than other fields of sorghum or maize which cultivated following a nonsusceptible host.

Frederiksen (1973) reported that the incidence of systemically infected plants in 1967 ranged from 1% when grain sorghum cultivated after a nonsusceptible crop to as high as 30% in another location in the same field when it cultivated after a crop of diseased sorghum. By season of 1972 some of commercially available grain sorghum hybrids (177-191 cvs.) were classified as susceptible.

Frederiksen et al. (1969) reported that losses of total income for sorghum and maize were estimated by about 2.5 million Dollars- as a result of sorghum downy mildew infection. Estimation reductions in grain sorghum cultivation due to the sorghum downy mildew disease were ranged by about 0-70% in grain yield. The actual estimation of losses become obviously difficult because disease severity were greatly independent on some variable factors such as plant populations, environmental conditions, hybrid susceptibility , crop maturity at time of estimation and incidence of sorghum downy mildew. The disease effects on yield are relatively easy to measure in case of satisfactory field scale inoculation technique is available.

Cosper (1969) noted that, infected plants produced a great yield reduction in dry weight (56-80%) . Plant systemically infected in the seedling stage, usually died and those of seedlings which survived and became infected at adult stage of maturity lossed 56-82% from their yield in comparison with healthy plants. It is interesting to note here that, vast majority of systemically infected sorghum plants produced no seed. Moreover, regrowth from clipped forage plots have higher incidence of sorghum downy mildew. The disease damage effects on tested cultivars were obviously increased as the season progress .

4-<u>The mode of infection and inoculation techniques</u>:

Jones (1968) reported that seedling infection of grain sorghum with *S. sorghi* was obtained in the laboratory and greenhouse by using young sorghum leaves bearing conidia and conidiophores. With ample moisture; the conidia, conidiophores and hyphae within excised leaves produced zoospores which adhered to young seedlings as the later emerged from their seed coats. and entered the coleoptile, coleorhiza and the central portion of the shoot. Columns of zoospores formed intercellularely within the host tissue. A thin-walled hypha was formed by each column. The fungus spread from the coleoptile to the basal leaves, but seldom spread to the enterior of the seedling. He added that systemic infection appears to be initiated by zoospores entered the shoot from beneath the coleorhiza at break made by the primary root. The same author found in 1970 that infection with S. sorghi was obtained in sorghum seedlings by leaves collected from infected corn and sorghum plants in direct contact with healthy seedlings and covered overnight. Infection occurred readily through stomatal openings, and sporulation occurred on infected seedlings 6 days after exposure to inoculum. On the other hand, in 1971, he showed that germ tubes from conidia grew by random on the leaf surface until, they reached a stoma then an appresorium formed over the stomatal opening. The penetrating structure enlarged inside to form a substomatal vesicle which gave rise to one or more infection hyphae. In the same manner he added that conidia were formed during the night , and it was germinated shortly after discharge and had penetrated by 7.00 a.m., the host cells contained houstoria three hours later. This indicates that the fungus can enters its host and establish infection in 3-4 hours.

Henneth and Shahor (1973) stated that seedlings 1-14 days of age were susceptible to conidial inoculum of S. sorghi, becoming systemically infected. Older seedlings did not show chlorotic symptoms on those leaves which had elongated, such as on the first and second leaves of 14-days-old plants in which the third leaf had already begun to appear.

Safeeulla (1976) found that when two-days-old sorghum seedlings sown in pots were brought in contact with sporulating maize leaves for 24-48 hours in the field, then transfered to a glass-house and watered daily, the symptoms of sorghum downy mildew appeared 3-4 days after transplanting. The same author added that when the seedlings 3-4 days-old were inoculated with the conidia from sorghum plants, chlorosis appeared at the first or second leaf stage (5-6 days after transplanting). The first leaf of the seedlings was half chlorotic and the successive formed leaves were completely chlorotic. When maize sown in plots infested with S. sorghi oospores, systemic infection appeared 2 weeks after sowing and the first leaf is invariably free from infection. However, by using conidial inoculum in the laboratory, it is possible to induce systemic infection on the first leaf itself. He concluded that this difference may be due to the fact that the first leaf overgrows the pathogen which takes time to penetrate the root and invades the stem tissues under natural conditions. However, he also obtained a close correlation between leaf age and symptoms appearance, if no infection observed within 2 weeks, the second and the third leaves escape from infection, while the younger leaves may develop symptoms subsequently. Like-wise, if the 4th, 9th and 11th leaves do not show infection after 4, 6 and 8 weeks, respectively, symptoms expression does not take place and the leaves below this region escape from infection.

Siradhana et al. (1976) obtained infection with S. sorghi by placing 2-3 drops of conidial suspension prepared from infected leaves at about 3:00 a.m.in the whorle of each seedling (2-3 leaf stage) for 3 consecutive days between 4:00 and 6:00 a.m.

Shah (1976) suggested that the best and easiest method of inoculation was to collect conidia from the field at 200-400 hours and spray the suspension in the whorl with a knapsack sprayer. Moreover, Siradhana et al. (1978) reported that in the 6-days old inoculated maize plants, systemic infection of sorghum downy mildew was 69-93.3%. The percentage of systemic infection decreased in each subsequent sowing date, plants inoculated when they were 16-days-old or older exhibited localized infection.

Frederiksen, (1980) summarized the source of infection of sorghum downy mildew as follows:-
1) Oospores on seed, or debris, carried by wind, and soil from infested area; 2) Conidia from infected plants; and 3) Mycelium in seed or in living hosts.

Shetty and Sofeeulla (1981) suggested that plants inoculated just after emergence and up to 4-5 leaf stage were highly susceptible to P. sorghi plants inoculated after 6-7 leaf stage, systemic symptoms were not observed and only local lesion appeared, whereas, soil and seed-borne inoculum can initiate both systemic and local lesion type of symptoms at any growth stage of the host plant.

Shivakumar and Bhat (1983) stated that oospores produced in naturally infected maize and sorghum by P. sorghi were able to infect either host.

4- Varietal resistance:

The need for new varieties, inbred lines and hybrids with resistance to downy mildew has been pointed out by a number of workers.

Safeeula and Thirumalachar (1955) and Frederiksen *et al.* (1965) reported that grain sorghum and maize varieties show difference in the incidence of sorghum downy mildew disease caused by *S. sorghi*.

Futrell and Webster (1966) concluded that the most of the resistant entries were collected in Southern Africa, which is probably the geographic point of origin for resistant sorghums to sorghum downy mildew disease.

Futrell (1967) observed that the symptoms of sorghum downy mildew disease on the leaves of 2.693 lines or varieties of grain sorghum, but, systemic symptoms were rarely found. In the same report he added that the late maturing varieties and sudangrass sorghum hybrids were highly susceptible, but lines from East Nigeria and Southern Africa were resistant.

Frederiksen *et al.* (1971) tested 50 Mid Western corn inbreds, 5 Texas inbreds and one grain sorghum hybrid to *S. sorghi*. They found that, Tx 441, Tx 601, H 52, and Oh 43 can be considered sources of resistance. A large number of Mid Western corn inbreds were highly susceptible to sorghum downy mildew disease.

Frederiksen *et al.* (1973a) suggested that over half of the tested corn entries had a sorghum downy mildew disease incidence of 75% or greater, 16 entries had 100% systemically infected plants. Resistant inbreds were Syn.D 1-1, K 175 and A 297. They found that in most crosses of resistant by susceptible, the reaction of resulting hybrids is intermediate in reaction of their parents.

In Venzuela, Malaguti (1976) reported that all the tested commercial cultivars are susceptible to sorghum downy mildew. Whereas, in India, Siradhana *et al.*(1976) recorded that of 1764 materials tested, 138 maize germplasms had no infection with sorghum downy mildew. In the remaining materials, infection varied up to 100%.

Safeeulla (1976) suggested that most of maize hybrids and Composites introduced for commercial production were susceptible to *S. sorghi*. Dange (1976) added that maize hybrid 'Ganga 5' was highly susceptible to *S. sorghi*, while the local varieties, mainly "Malan" was fairly resistant in comparison to 'Ganga 5'.

Titatarn (1976) found that all maize entries were infected with *S. sorghi*, the infection ranged from 11.8-100%. In the same manner, Schmitt and Freytag(1977) stated that maize lines 3316, R.177, K.10 and Tex.601 and the cross Tx 601 x MP 337 have good resistance to

S. sorghi. Craig *et al*. (1977) found that 22 of the 33 corn inbred lines which used as parents for hybrid seed production were susceptible to sorghum downy mildew. In addition to that mentioned before, Concli and Sobrinho (1979) recorded that 9 lines and commercial hybrids were susceptible to sorghum downy mildew disease, but the line Disconhecido 15 had the highest genetic resistance. Nakamura *et al*. (1981) recorded that none of maize cultivars screened in the field was immune to *S. sorghi*.

Craig, (1982) reported that ten corn inbred lines were compared for symptoms on leaves inoculated with conidia of *Peronosclerospora sorghi* in the greenhouse and for susceptibility system, leaf symptoms was devised. The correlation between leaf symptom types in the greenhouse and levels of downy mildew susceptibility in the field was calculated to determine the feasibility of using leaf reactions to predict levels of downy mildew susceptibility. Degree of severity of leaf symptoms was positively and significantly correlated with degree of downy mildew susceptibility.

Shabani and Frederiksen (1983) reported that Tx 601 maize inbred line was resistant to *P. sorghi*, whereas, Tx 441 was more susceptible.

6- Histopathological studies:

Nusrat et al. (1969) reported that in downy mildew disease, infected leaf tissue showed a decrease in number and size of chloroplasts , contained abnormal numbers of nuclear bodies, and there was disintegration of mesophyll cell walls which left a mass of multonucleate cytoplasm. In host tissue , the fungus appeared irregular in growth in the interveinal parenchyma. Plasmodium-like bodies of different sizes and shapes were observed in the mesophyll tissue . Aggregations of fungal material appeared in the substomatal cavities prior to asexual sporulation . No antheridia or oogonia were observed , but oospores were numerous in interveinal tissue in later stages of disease development.

Dogma (1975) showed that nuclear number was proportionate to conidial size . There is no report of nuclear number of Sclerospora sorghi . Studies were conducted to determine the morphology , cytology and germination of conidia of Sclerospora sorghi . Visarathanonth (1973) showed that cytological knowledge of the corn sorghum downy mildew is very limited . The nuclear number was reported to be 10-29, 10-26, 22-48 and 15-38 in Sclerospora philippinensis, S.sacchari , S.miscanthi and S. spontanea,respectively.Pitakspraiwan and Giatgong (1976) showed that conidia , conidiophors,germ tubes and mycelium were found to be multinucleate. The nuclei were varied in size and shape. The number of nuclei in mature detached conidia was 6-12. The number of nuclei in the bulb-like conidiophore initial was 1-4. They divided mitotically and at the same time increased in number, while the conidiphore enlarged. Nuclei divided mitotically and migrated into conidia through streigmata. At an earlier stage, young conidia were formed at the tips of the streigmata.One daughter nucleus migrated into the newly formed conidia,until each conidium contained an average of 6-12 nuclei before they were matured (i.e. until stepa were formed). The number of nuclei in the detached matured conidia were eight. These nuclei divited in the conidia as well as in the conidiophore Chromosomes within the nuclear envelope could be observed under an oil objective. The nucleus was rather spherical in shape and contained about 12 chromosomes which were linked together by a fine thread. The chromosomes were irregular in shape and number varied from 12-24 during active mitotic division.

Chemical components in relation to disease severity:

Total, reducing and non-reducing sugars:

Holbert et al. (1935) , found that the increase susceptibility of the stalks to the fungus is associated with conditions that may well result in a reduction of the carbohydrate reserves of the plant. Apparently, this situation does not hold , however, for susceptibility of their ears. Sucorose, reducing sugar and total sugar, and high pith density were associated with resistance to stalk rot. It is theorized that a decrease in sugar level of the stalk causes senescense of pith tissue, indicated by decrease in pith density. Therefore, plants with senescent pith tissue are susceptible to stalk rot.

Czaplinska et al. (1979), found that when plants were examined 6 and 13 weeks after inoculation no relation was found between sugar content and intensity of stalk rot.

7-Effect of fertilizer on downy mildew disease of maize:

Matocha et al. (1973) reported that the fertility levels appear to influence sorghum downy mildew incidence. Higher levels of nitrogen favor disease incidence in sorghum. Low levels of zinc reduce the incidence of sorghum downy mildew in maize. The zinc probability affects plant growth and development in some manner by which reduce the probability of systemic infection by *Sclerospora sorghi*.

Shah (1976) indicated that disease severity was lowest (21.2%) when 160 kg/ha of nitrogen was applied and highest (52.53%) at 0-60 kg/ha. No significant different was obtained when nitrogen levels were increased from 180-240 kg/ha. Phosphate application (0-60 kg/ha) did not appreciably change the incidence of disease (45.7-53.7%) nor did the application of lime (0-2000 kg/ha) to the soil.

Yamada and Aday (1977) reported that the infection of susceptible maize seedlings in nursery boxes by Sclerospora philippinensis was considerably greater when N, NP, NK or NPK were applied than in seedlings given no fertilizers, P, K or PK. Infection of resistant seedlings was in all cases less than infection of susceptible seedlings, and was less affected by fertilizers; however, infection was least in plants receiving no fertilizers.

Balasubramanion (1978) showed that increase of phosphorus fertilization from 0-67.3 kg/ha significantly increased sorghum downy mildew incidence in susceptible variety DMS-652. In the resistant hybrid CSH-1, increased susceptibility was observed only when phosphorus application was increased from 0-33.6 kg/ha. Additional phosphorus application did not influence the disease significantly. Nitrogen did not significantly affect the incidence of the disease in DMS-652 or CSH-1, zinc and manganese application did not influence sorghum downy mildew incidence significantly.

Bonman and Pitipornchai (1984) stated that incidence of downy mildew caused by Peronosclerospora sorghi increased with the third sowing dates because the plants received inoculum at progressively earlier growth stages. When plants received high concentration of inoculum at emergence, as in the third sowing, applications of N and NP increased disease incidence. However, these fertilizers tended to reduce incidence in the first and second sowings. Thus, the effects of P, N and NP varied with the growth stage at which the plants received inoculum. Contradictory results obtained by other researchers could be reconciled if plant age were treated as a variable in future studies on the effects of fertilizer on the disease.

MATERIALS AND METHODS

1-Survey of sorghum downy mildew disease on maize in some governorates:

A survey for the incidence of sorghum downy mildew disease was conducted in five governorates namely Kafr El-Sheikh, Behera, Gharbia, Sharkia, and Ismaillia governorates during the growing seasons of 1985, 1986, 1987 and 1988 years.

The survey was carried out in Sakha, Qalleen, Desok, and El-Riyad counties of Kafr El-Sheikh governorate; Qotoor, Zifta, and El-Santa counties of Gharbia governorate; Damanhoor, and Abo-El-Matameer counties of Behera governorate; Diarb Nigm, El-Ebrahemia and Abo-Hammad counties of Sharkia governorate; Qassassen and El-Tall El-Kebeer counties of Ismaillia governorate.

Ten feddans were chosen at random and inspected to represent each county. A random samples of 5 hundred plants wereinspected from each field at the age of 60 days.
Samples were classified into healthy and diseased plants. Percentage of infected plants were recorded.

Temperature and Relative Humidity (RH) were recorded monthly through 1985 to 1988 growing seasons for Kafr El-Sheikh governorate by Sakha Agriculture Research Station, while the rest governorates, the temperature and relative humidity were recorded by Egyptian Meteorological Institute at Cairo.

II - Artificial inoculation techniques:

A- Inoculation with oospores:

Shredded infected leaves bairing resting oospores were collected from systemically infected plants of sorghum sudangrass. The samples were blended in a waring blender for two minutes at a reasonable speed. Inoculation was made by putting 1 gm.milled dry leaves along side the seeds, as described by Malaguti (1976).

B-Inoculation with conidia:

Methods described by Jones (1971) was used. Seedlings of maize and sorghum sudangrass at 2-3 leaf stage grown in pots under greenhouse conditions were transferred to the field and placed beside infected plants of sorghum sudangrass for 48 hours, then returned to the greenhouse again. Uninoculated plants were served as a control treatment. Four pots represent each treatment. The percentage of the infected plants was calculated at 40 days after sowing.

3- Evaluation of varietal resistance for some varieties and hybrids under greenhouse conditions:

Seeds of Giza 2, Pioneer varieties and D.C. 202, S.C.107 and 3 W.C.309 hybrids of maize were planted in sterilized pots (25 cm) filled with semi-sterilized Nile-silt soil in complete randomized block design, with four replicates. Fertilizers were added at rate of 3 gm. Urea, 5 gm. calcium superphosphate and 2 gm. potassium sulphate per pot and watered regularly with tap water. The percentage of systemic infected plants was recorded 40 days after sowing. Statistical analysis was conducted after transforming the percentage of infection to degrees using the angular transformation (arcsine).

4- Histopathological studies:

Transverse sections were made from infected plants of Giza 2 and sorghum Giza varieties. Samples were taken from leaves, stems and roots of the plants at 60 days after cultivation. Samples were killed and fixed in Formaline-Acetic Acid alcohol solution (F.A.A.). Dehydration was performed in increasing concentrations of ethanol serials, then imbedded in a paraffin wax melted at 56-58°C. Sectioning, staining and mounting procedures were conducted according to Johansen (1940). Sections of 18 U thick were cut by a rotary microtome and fixed on microscopic slides with Hauptis adhesive (1 gm gelatin + 100 ml water + 2 gm phenol + 15 ml glycerol) according to Sass (1961).Slides were left to complete dryness for 24 hours in dry oven at 40°C. Sections were stained with safranine light green combination, cleared in xylene, mounted in Canada balsam and examined microscopically and results were recorded by means of photocolour pictures.

5- Biochemical analysis:

Seeds of Giza 2 and S.C.107 maize varieties were sown in pots filled with loamy sand soil which was either disinfested or infested with oospores of *P. sorghi* as mentioned and put under greenhouse conditions. Fertilizers were added at rate of 3 gm urea, 5 gm calcium superphosphate and 2 gm. potassium sulphate per and watered regularly. Leaf-samples from healthy and infected seedlings were taken at 3, 4 and 5 weeks after sowing to determine their contents of pigments and sugars.

1-Determination of leaf pigments:

The leaf pigments content were determined in fresh leaf samples according to Fadeel's method(1962). The optical densities were measured spectrophotometrically using "spectronic-21" at wave length 662, 644 and 440.5 nm., for chlorophyll a,b and carotenoids, respectively. The pigments concentrations were calculated using formula of Wettstein (1957) as follow:-

Chl. a = (9.784 x E 662) - (0.99 x E 644) = mg/liter

Chl. b = (21.426 x E 644) - (4.65 x E 662) = mg/liter

Carotenoids = (4.695 x E 440.5)-(0.268 "chl.a+b")= mg/liter.

The contents of pigments were then expressed as mg/g fresh weight of the leaves.

2-Determination of total, reducing and non-reducing sugars:

Carbohydrate fractions were determined according to method of Miller (1959).

A-Determination of reducing sugars:

Half gram powder of dry plant material was extracted with 50 ml. of 70% ethanol alcohol in carbohydrate tube and incubated in water bath at 70°C for 3-4 hours, then the mixture was filtered. The filtrate was made up to 100 ml. with distilled water. Five ml.of the filtrate were taken and 2 ml of the colour reagent 3,5 dinitro cilcilic acid were added in a test tube, shaked well and heated for 10 minutes in a boiling water bath and then cooled under running tap water. The colour intensities were measured colorimetrically at 550 nm, using "spectronic-21" spectrophotometer.

B- Determination of total sugars:

From the filtrate of the above-mentioned reducing sugars, 10 ml. were taken in carbohydrate tube, 5 ml. of 6 N HCl were added and incubated for 2 hours in a water bath. After incubation, 5 ml. of 6 N NaOH were added for neutralization and the volume was made up to 25 ml. Five ml. from the neutralized solution and 2 ml. of the colour reagent (3,5 dinitro seleclic acid)were added to the sample, then density of colour was measured as above mentioned.

C- Determination of non-reducing sugars:

The difference between the concentrations of total and reducing sugars was calculated and considered as the concentration of non-reducing sugars.

Colour reagent preparation (3,5 dinitro cilcilic acid):

One gm. of 3,5 dinitro cilcilic acid was dissolved in 20 ml. of 2 N NaOH, then 50 ml. distilled water and 30 gm. of Rochelle salt were added and mixture was shaken well until dissolving the salt , then the volume was made up to 100 ml.with distilled water.

6- Effect of NPK fertilizers on resistance of maize to sorghum downy mildew disease:

Field experiments were conducted in natural infested soil at the maize disease nursery in the experimental Farm of Sakha Agricultural Research Station, Kafr El-Sheikh Governorate during the maize growing seasons of 1985 and 1986.

Seeds : Seeds of maize and sorghum varieties were obtained through the cortesy of the Maize and Sorghum Breeding Section of the Agricultural Research Center, Giza, Egypt. All seeds were surface sterilized in 0.2 % corresive sublimate and throughly washed in tap water and dried prior to sowing. These experiments were carried out to investigate effect of different levels of NPK on the infection of some maize varieties with sorghum downy mildew disease. In this experiments two maize varieties were used; Double cross 202 (D.C.202) and Giza 2 Composite variety . Experimental design was split-split plot with four replications. The nitrogen levels 0,60 and 90 kg/fedd. were assigned to the main-plots, whereas the phosphorus levels 0, 15, and 30 kg/fedd. were assigned to the sub-plots and potassium levels 0, and 15 kg/fedd. were assigned to the sub-sub-plots . The plot size was 16.8 m^2 and each plot contained for rows (6 meter length and 70 cms. apart). The plants were thinned to one plant per hill at 25 cms. between hills Seeds of sorghum sudangrass "Sordan Giza 2" were drilled in a single row alternating with four rows of each maize plot, as a spreader of inoculum.

Fertilizer of calcium superphosphate was added before the sowing. Nitrogen and potassium fertilizers were divided to two equal parts; the first part was added just before the first irrigation, while the second part added before the second irrigation . The systemic infectión of sorghum downy mildew was determined as a percentage of the infected plants at 60 days after the sowing .

Fertilizers: The fertilizers used in the present investigation included:-

Ammonium nitrate	33 % N
Calcium superphosphate	15.5% P_2O_5
Potassium sulphate	50 % H_2O

RESULTS

A-Disease symptoms on maize:

Sorghum downy mildew caused by Peronosclerospora sorghi (Weston and Uppal) Shaw, occurs in either a systematic or localized form on maize plants. The systemic infected plants were chlorotic and stunted with narrower and more erect leaves than those of healthy plants(Figs. 1 and 2). The first diseased leaf usually has a sharp margin between diseased and nondiseased tissue, forming a half-diseased leaf. White downy mildew growth consists of the fungal conidia and conidiophores appears clearly during periods of relatively high humidity and low temperature. Leaf shredding rarely occurs in maize. Oospores were found embedded in leaf tissues between viens. Some systemically infected plants appeared to have phyllodied tassels(Fig.2),other diseased plants were failed to produce heads (Fig. 3), produced sterile heads (Figs. 1 and 3) or formed partially affected heads. The local form of the disease appeared as long,narrow and chlorotic local lesions on the lower side of the infected maize leaves. Later, leaf shredding occurred on these leaves.

This disease symptoms were similar to symptoms of sorghum downy mildew disease caused by P. sorghi described by some investigators, i.e., Frederiksen et al.(1973), Anon.(1973),Safeeulla(1976) and Malaguti et al.(1978).

Fig. (1): Erect and chlorotic maize leaves of a stunted plant systemically infected with Peronosclerospora sorghi.

Fig. (2): Symptoms of sorghum downy mildew disease on maize showing phylloided tassels.

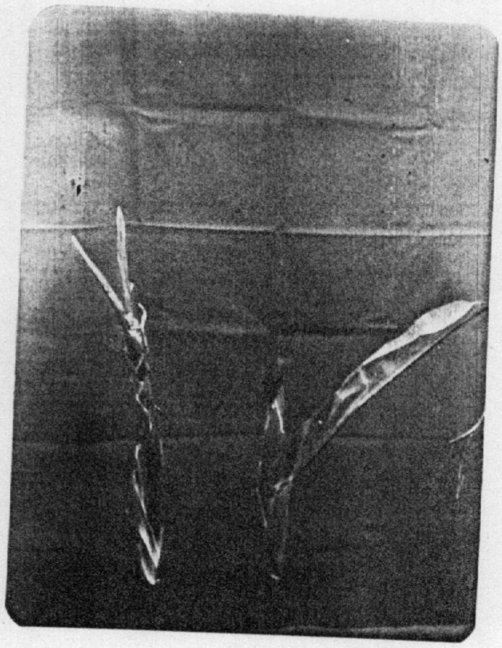


Fig. (3): Symptoms of downy mildew disease on infected maize ears showing the sterile head (left) compared with healthy one (right).

1-Survey and distribution of sorghum downy mildew disease in maize caused by *Peronosclerospora sorghi* in different governorates:

Survey of downy mildew disease incidence was carried out in five governorates namely, i.e. Kafr El-Sheikh, Behera, Gharbia, Sharkia and Ismaillia throughout 1985 to 1988 years. The percentage of the disease was estimated in different counties of the abovementioned governorates and the data were tabulated in table (1). The percentage of the diseased plants ranged from zero to 53.55%. The obtained data revealed that the highest percentages of the disease were observed in Kafr El-Sheikh during the four seasons as compared to the other governorates. The percentages of the disease were 2.2%, 15.0%, 53.55% and 15.2% during 1985, 1986, 1987 and 1988 years, respectively in Kafr El-Sheikh. However, Behera and Gharbia governorates showed closed infection percentages ranged from 0.05% to 6.70%, means of sorghum downy mildew disease incidence during the four growing seasons were 0.05%, 0.70%, 1.80% and 6.70% in Gharbia and 0.25%,0.45%, 2.0% and 4.15% in Behera. On the other hand, the least percentages of infected maize plants were recorded in both Sharkia and Ismaillia governorates and ranged from zero-percent to 0.57%. The general means of infection, throughout the four growing seasons did not exceed than 0.20% in Sharkia and 0.12% in Ismaillia.

Table (1): Percentages of sorghum downy mildewed plants of maize in periods of 1985 to 1988 years in Kafr El-Sheikh, Behera, Gharbia, Sharkia and Ismaillia governorates.

Gover-norates	Counties	1985	1986	1987	1988	Mean of infec-tion
Kafr El-Sheikh	Kafr El-Sheikh (Sakha)	6.65	32.62	83.15	18.57	35.25
	Desok	1.37	12.55	23.95	17.03	13.73
	Qalleen	0.78	11.83	-	14.00	8.87
	El-Riyad	0.00	3.00	-	11.20	4.73
Mean of infection		2.20	15.00	53.55	15.20	15.65
Behera	Abo-El-Matameer	0.50	0.83	2.70	4.76	2.20
	Damanhoor	0.00	0.18	1.30	3.73	1.30
Mean of infection		0.25	0.45	2.00	4.15	1.75
Gharbia	Qotoor	0.15	1.92	2.83	12.00	4.23
	El-Santa	0.00	0.18	1.82	5.50	1.88
	Zifta	0.00	0.00	0.75	2.60	0.84
Mean of infection		0.05	0.70	1.80	6.70	2.32
Sharkia	Diarb Nigm	0.008	0.21	0.42	1.03	0.42
	Ebrahimia	0.001	0.00	0.07	0.66	0.18
	Abo-Hammad	0.000	0.00	0.03	0.02	0.01
Mean of infection		0.003	0.07	0.17	0.57	0.20
Ismaillia	El-Tell El-Kibeer	0.000	0.00	0.00	0.23	0.06
	Al-Qassassen	0.030	0.10	0.10	0.47	0.18
Mean of infection		0.015	0.05	0.05	0.35	0.12
General mean of infection		0.50	3.25	11.51	5.39	5.22

Counties which had the highest incidence of the disease in each governorate were Kafr El-Sheikh (Sakha) in Kafr El-Sheikh, Abo-El-Matameer in Behera, Qotoor in Gharbia, Diarb-Nigm in Sharkia and El-Qassessen in Ismaillia. The general means of infection through the four years of the survey were 35.25%, 2.20%, 4.23%, 0.42% and 0.18% in Sakha, Abo-El-Matameer, Qotoor, Diarb-Nigm and El-Qassessen counties, respectively. On the contrary, counties of El-Riyad, Damanhoor, Zifta, Abo-Hammad and El-Tell-El-Kibeer had the lowest percentages of infection. The highest percentages of infection were recorded in the year of 1987 at Kafr El-Sheikh governorate and in the year of 1988 at the other governorates as compared to the other years at these governorates.

Data in Table (2) show the minimum and maximum values of temperature and relative humidity which were recorded in such counties had the highest percentages of sorghum downy mildew disease incidence. It could be noticed that mostly the lowest temperature and lowest ranges between the minimum and maximum degrees were recorded at Kafr El-Sheikh county (Sakha) followed by Qotoor and then Abo-El-Matameer. The highest relative humidity values were found at Qotoor and the lowest ones were at Kafr El-Sheikh county (Sakha). Values of the ranges between minimum and maximum relative humidity degrees followed the same trend.

Table (2): Temperature, relative humidity degrees in some counties which had the highest percentages of sorghum downy mildew disease incidence.

Years	Locations	Temperature °C		Relative humidity		Infected plants %
		Minimum	Maximum	Minimum	Maximum	
1985	Sakha	13.85	27.84	47.80	61.66	6.65
	Qotor	16.00	28.95	43.50	88.50	0.15
	Abo-El-Matamer	17.80	29.75	47.00	75.50	0.50
1986	Sakha	16.95	22.49	44.65	58.42	32.62
	Qotor	17.10	30.75	45.00	92.00	1.92
	Abo-El-Matamer	18.30	31.65	47.50	80.50	0.83
1987	Sakha	15.55	21.55	55.60	70.18	83.15
	Qotor	16.10	29.75	45.10	92.00	2.83
	Abo-El-Matamer	17.90	31.35	48.00	80.00	2.70
1988	Sakha	15.05	21.23	47.80	62.54	18.57
	Qotor	16.50	28.51	47.10	90.50	12.00
	Abo-El-Matamer	15.80	30.71	50.00	82.30	4.67

Relationship between temperature and relative humidity on systemic infection of sorghum downy mildew of maize cultivars, 1985-1988 seasons:

Dealing with data in Table (3), it is clearly observed that, in spite of the insignificant correlation coefficient value between temperature and systemic sorghum downy mildew infection in 1985, this value had a negatively highly significant estimates in each of 1986, 1987 and 1988 seasons. Meanwhile, correlation coefficients between infection intensity and relative humidity were significant and had a negative sign in both 1985 and 1986 seasons, but were insignificant in 1987 and 1988 seasons. These results suggest that maize cultivars infection intensity with *P. sorghi* in the five governorates was more dependent upon the changes in temperatures than that in relative humidity that had a slight effect. Herewith, it is clearly demonstrated that infection intensity were greatly reduced in temperature exceeds 27°C, even in high relative humidity percentages (Table 2). These results are in agreement with Li (1983), Chang and Wu (1969a) and Exconde (1976).

Data in Table (4) and illustrated in Figures (4 and 5) show the regression coefficients of infection intensity on each of temperature and relative humidity percentages over the five governorates. No significant regression values in the four seasons were observed between the intensity of

Table (3): Correlation coefficient between temperature, relative humidity and systemic infection of sorghum downy mildew of some maize cultivars throughout 1985-1988 seasons.

Factors / Years	1985	1986	1987	1988
Temperature(°C)	-0.851	-0.994**	-0.989**	-0.978**
Relative humidity (R.H.)	-0.922*	-0.909*	-0.832	-0.757

* Significant at 5% level.

** Significant at 1% level.

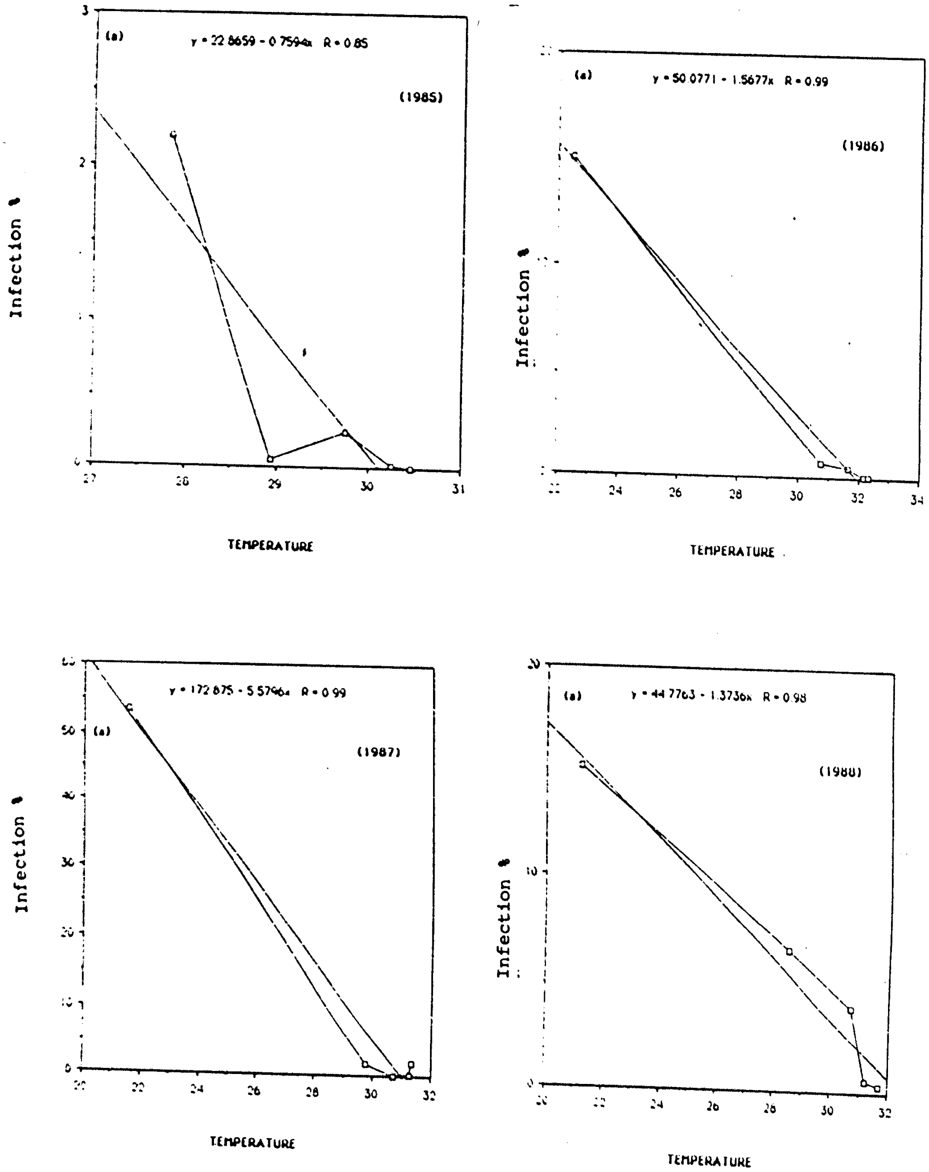


Fig. (4) Percent of sorghun downy mildew disease incidence on maize plants under different temperature degrees.

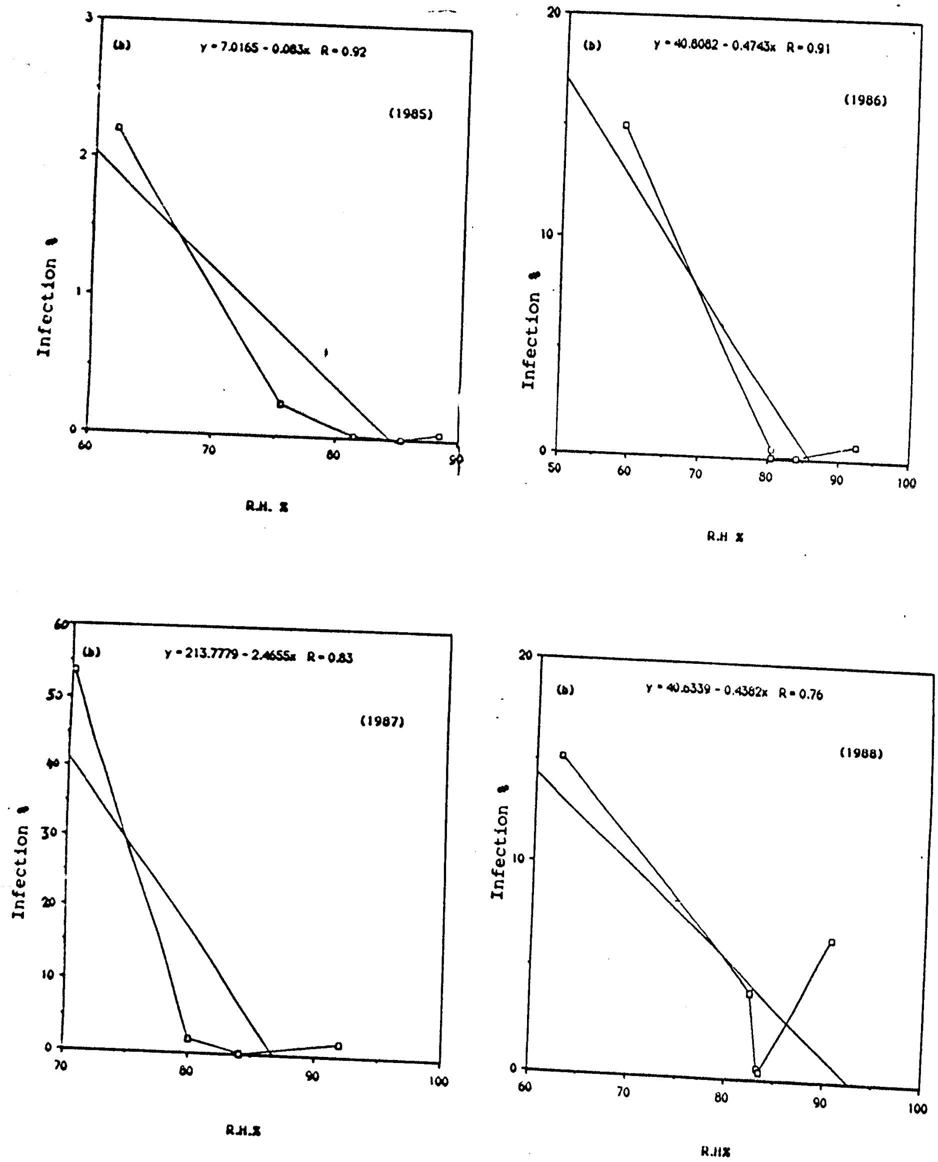


Fig .(5) Percent of sorghum downy mildew disease incidence on maize plants under different values of relative humidity .

Table (4): Regression coefficient between temperature, relative humidity and systemic infection of sorghum, downy mildew of some maize cultivars throughout 1985-1988 seasons.

Years / Factors	1985	1986	1987	1988
Temperature (°C)	2.09	-1.568	0.094	-1.358
Relative humidity (R.H.)	-0.081	0.0098	-2.863**	-0.079

* Significant at 1% level.

infection and any of temperature recorded over four seasons. But, the regression coefficient was highly significant in only 1987 season for the relationship between relative humidity percentages and sorghum downy mildew infection intensity. Data suggests that many factors might effect and/or involved in the infection process under the environmental conditions that effect the enhancement of disease distribution. These results are in accordance with the finding found by El-Sharawi 1985.

II-Greenhouse experiments:

1- Inoculation techniques:

The obligate parasite nature of the downy mildew pathogen of maize and sorghum poses problems in artificial inoculation that are not encountered in studies of many plant parasitic fungi. Since *S. sorghi* is capable of systemically infecting maize and sorghum from either sexually produced oospores or the asexual conidia , two inoculation techniques devised which mimic nature were used to infect seedlings of maize (Giza 2) and sorghum Sudangrass (Giza 2):

a) Infestation the soil by putting milled dry oospores-leaf material with seeds in sterilized soil.

b) Exposure seedlings at 2-3 leaf stage to conidia transfered naturally from infected plants in the field. The reaction of the tested plants was recorded 40 days after the sowing, by counting systemically infected plants, and calculating percent infection based on the total number of plants. Local lesions are not considered.

Data in Table (5) show that the percent infection of maize, Giza 2 variety, ranged from 4.48% to 14.01%, when the inoculation was occurred by conidial spores or by oospores, respectively. Addition the fungal oospores to the seeds in soil at sowing increased highly significantly the systemic infected plants comparing to the other method. However, the percent of infected plants of Sudangrass Giza 2 was more higher than that of maize Giza 2 which reached 14.38% and 17.01% for inoculation by the conidial and oospores, respectively.

2- Evaluation of some maize cultivars for sorghum downy mildew infection under greenhouse conditions:

Five maize cultivars namely Giza 2, D.C. 202, Pioneer 514, 3 W.C. 309 and S.C.107, and Sudangrass Giza 2 were screened and a wide range of downy mildew reactions was observed. Data of the screening are further indicated in Table (6).

Percent incidence of sorghum downy mildew for Giza 2, D.C. 202, Pioneer 514 and 3 W.C.309 cultivars were similar and

Table (5): Effect of two artificial inoculation methods on the ability of maize (Giza 2 variety) and Sudangrass "Giza 2 variety" to infection with sorghum downy mildew under greenhouse conditions.

Varieties	Infection method	No. of the total plants	No. of the infected plants	Infected plants %	Arcsine value
Maize (Giza 2)	Conidia	233	11	4.48	11.98
	Oospores	219	32	14.01	21.95
Sorghum (Sudangrass Giza 2)	Conidia	237	34	14.38	22.29
	Oospores	226	39	17.01	24.36

L.S.D. at 5% level 5.09
at 1% level 6.89

Table (6): Percent incidence of sorghum downy mildew disease in some maize cultivars under greenhouse conditions.

Varieties	Total plants	Mean of infection		
		Infected plants	Infection %	Arcsine* value
Giza 2	85	3	3.11	10.11
D.C.202	92	2	2.22	8.43
Pioneer 514	71	2	2.74	9.23
3 W.C.309	130	4	3.27	10.63
S.C.107	117	10	8.33	16.44
Sudangrass (Giza 2)	160	22	13.32	21.32

L.S.D. at 5% level 6.66.

* Arcsine transformed data.

ranged from 2.22% - 3.27%. No significant difference was found among them. On the other hand, Sudangrass "Giza 2" and S.C.107 maize cultivar exhibited the highest percentages of the systemic infected plants which reached to 13.32% and 8.33%, respectively.

Under the conditions of this experiment, it could be concluded that D.C. 202 and Pioneer 514 were moderate resistant cultivars, for sorghum downy mildew disease, followed by Giza 2 and 3 W.C.309 cultivars. However , Sudangrass "Giza 2" the main host for S. sorghi was the most susceptible one followed by S.C.107 maize cultivar.

3- Biochemical studies:

1- Pigments content:

Determination of the pigments content in the healthy and infected plants of Giza 2 which is a moderate resistant and S.C.107 which is a susceptible maize varieties comparing the other maize cultivars tested, to sorghum downy mildew at 3, 4 and 5 weeks after sowing.

Data in Table(7)show the interaction effect of infection with S. sorghi on pigments content in leaves of Giza 2 and S.C.107 maize cultivars at different intervals of sowing. It could be noticed that, in all cases, chlorophyll a was significantly more higher than chlorophyll-b, while carotenoids content was the least one. The highest values of chlorophyll-a was in the healthy leaves of Giza 2

Table (7): Interaction effect of sorghum downy mildew infection on pigments content (mg/g fresh weight) in leaves of Giza 2 and S.C.107 maize varieties at different intervals of infection.

Samples intervals (weeks)(S)	Treatments (T)	Giza 2 (V_1)			S.C.107 (V_2)		
		Chl.a	Chl.b	Car.	Chl.a	Chl.b	Car.
3	Healthy	4.31	2.59	1.00	3.12	1.88	1.09
	Infected	4.95	2.33	0.82	4.55	1.05	0.72
4	Healthy	5.48	2.95	1.06	4.18	2.18	1.11
	Infected	2.92	1.38	0.76	2.04	1.59	0.59
5	Healthy	4.11	2.03	0.91	3.77	1.75	0.87
	Infected	3.30	1.76	0.73	2.61	1.38	0.65
Average	Healthy	4.63	2.40	1.00	3.69	1.94	1.02
	Infected	3.72	1.82	0.77	3.07	1.34	0.65

L.S.D. at 0.05 are 0.50, 0.29 and 0.19 for chlorophyll a,b and carotenoids, respectively.

at the 4th week followed by the infected leaves of Giza 2 and S.C.107 cultivars at the 3rd week, since their corresponding values were 5.48, 4.95 and 4.55 mg/g fresh weight, respectively. On the other hand, generally, the infected leaves of both cultivars contained significantly less amounts of chlorophyll-b and carotenoids than the healthy leaves did. The highest increment of chlorophyll-b content in the healthy leaves over the infected leaves reached 53.22 % for Giza 2 at the 4th week and 44.15% for S.C.107 at the 3rd week. The minimum difference between the healthy and infected leaves in chlorophyll-b content was observed at the 5th week after sowing, since the values of the difference did not exceed 21.14% and 13.30 % in S.C.107 and Giza 2 maize cultivars, respectively.

Concerning the carotenoids content, at the 4th week, infected leaves of S.C.107,and Giza 2,showed the upper most decrease which reached 46.85% and 28.30 % less than the healthy leaves, respectively.

Data in Table (8) indicate the effect of sorghum downy mildew infection, irrespective of plant age, on means of pigments content in leaves of Giza 2,the moderate resistant maize variety,and S.C.107,the susceptible one in comparison with the screened cultivars. Generally, Giza 2 had mostly more pigments content than S.C. 107 either in the healthy or in the infected leaves. It is

Table (8): Effect of sorghum downy mildew infection on pigments content (mg/g fresh weight) in leaves of two maize varieties Giza 2 and S.C. 107.

Treatments	Giza 2			S.C. 107			Mean		
	Chl.a	Chl.b	Car.	Chl.a	Chl.b	Car.	Chl.a	Chl.b	Car.
Healthy	4.85	2.52	1.00	4.17	1.94	1.02	4.51	2.23	1.01
Infected	3.51	1.82	0.78	2.95	1.34	0.65	3.23	1.58	0.71
Mean	4.18	2.17	0.89	3.38	1.64	0.84	3.87	1.90	0.86

L.S.D. at 0.05 are 0.29, 0.17 and 0.11 for chlorophyll (Chl.)a,b and carotenoids (Car.), respectively.

interesting to note that sorghum downy mildew infection significantly decreased pigments content of either chlorophyll a, b or carotenoids in leaves of both cultivars. The percent of this increment reached 27.63% , 27.78% and 22.00% in Giza 2, and 29.26%, 30.43% and 56.92% in S.C.107 for chlorophyll a, b and carotenoids, respectively. Meanwhile, it worth to mention that the relative increments of pigments content were more higher in S.C.107 than in Giza 2 maize variety.

The present data in Table (9) show the effect of infection with S. sorghi, irrespective of maize variety, on pigments content in leaves at different intervals after sowing. The data obviously declared that infection led to a significant increase in chlorophyll a content at the 3rd week in infected leaves comparing with healthy leaves. On the contrary, chlorophyll a content was significantly decreased at the rate of 48.65% and 25.13% in the infected leaves in comparison with the healthy leaves at the 4th and 5th week, respectively. As respect of chlorophyll b and carotenoids, infection decreased them significantly at all examined intervals and this decrement was 41.80% and 37.61% at the 4th week, for chlorophyll b and carotenoids, respectively.

In the healthy leaves, chlorophyll a recorded the highest value at the 4th week and the lowest value at the 3rd week after sowing. Meanwhile, in the infected leaves, Table (9): Effect of sorghum downy mildew infection on pigments content (mg/g fresh weight) in leaves at three intervals 3,4,and 5 weeks after sowing.

Treatments	3 wks.			4 wks.			5 wks.			Mean		
	Chl.a	Chl.b	Car.	Chl.a	Chl.b	Car.	Chl.a	Chl.b	Car.	Chl.a	Chl.b	Car.
Healthy	3.72	2.24	1.05	4.83	2.56	1.09	3.94	1.89	0.91	4.16	2.23	1.02
Infected	4.75	1.69	0.77	2.48	1.49	0.68	2.95	1.57	0.69	3.39	1.58	0.71
Mean	4.23	1.96	0.91	3.66	2.02	0.88	3.45	1.73	0.80	3.78	2.08	0.86

L.S.D.at 0.05 are 0.36, 0.20 and 0.14 for chlorophyll (Chl.) a,b and carotenoids (Car.), respectively.

chlorophyll a significantly decreased at the successive intervals. Chlorophyll b in the healthy leaves exhibited higher increment at the 4th week and declined at the 5th week. However, the infected leaves failed to record any significant changes at the different intervals. Carotenoids content in the healthy leaves increased significantly at the 5th week only. On the other hand, carotenoids did not significantly change in infected leaves at the different intervals.

2- Sugars content:

The effect of sorghum downy mildew infection on the sugars content (expressed as mg/g dry weight of leaves) was evaluated as non-reducing, reducing and total sugars in the leaves of plants of Giza 2 as a moderate resistant and S.C. 107 as a susceptible maize varieties. The data are presented in Tables (10), (11) and (12) and illustrated in Figures (6 and 7). These results showed that the healthy and the infected leaves of both Giza 2 and S.C.107 contained significantly higher amounts of non-reducing sugar than that of reducing sugar (Table 10). The highest levels of the non-reducing sugar was observed in the healthy leaves of Giza 2 followed by S.C.107 maize variety at the third week after sowing, while the lowest amounts were found , at 4th week, in both healthy leaves of S.C.107 and infected leaves of Giza 2. Concerning the reducing

Table (10): Effect of sorghum downy mildew infection on the sugar contents (total, reducing and non-reducing) in the leaves of Giza 2 and S.C.107 maize varieties after 3, 4 and 5 weeks of infection.

Varieties (V)	Treatments (T)	Intervals after sowing (weeks) (I)	ug glucose/g dry weight		
			Non-reducing	Reducing	Total
Giza 2	Healthy	3	16.209	4.351	20.560
		4	10.960	4.216	15.176
		5	9.994	4.081	14.075
	Infected	3	11.680	3.804	15.484
		4	7.571	4.252	11.823
		5	7.653	3.653	11.305
S.C.107	Healthy	3	13.299	4.189	17.488
		4	7.053	4.567	11.620
		5	11.436	4.162	15.598
	Infected	3	10.866	4.189	15.055
		4	9.871	3.516	13.387
		5	10.649	1.750	12.399

L.S.D. at 0.05 are 1.942, 0.660 and 1.113 for non-reducing, reducing and total sugars content, resoectively.

Table (11): **Effect of sorghum downy mildew infection on the sugars content (mg/g dry weight) in the leaves of Giza 2 and S.C.107 maize varieties.**

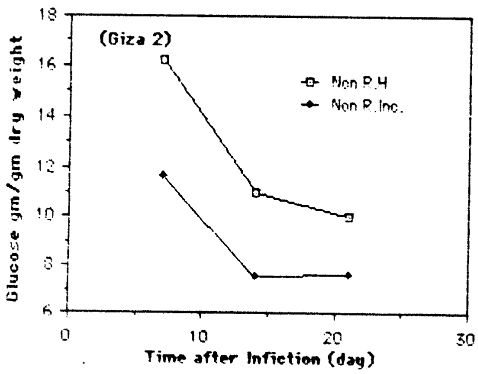
Treatments	Giza 2			S.C. 107		
	Non-reducing	Reducing	Total	Non-reducing	Reducing	Total
Healthy	12.388	4.216	16.604	10.596	4.306	14.902
Infected	8.968	3.903	12.871	10.462	3.152	13.614
Mean	10.678	4.060	14.738	10.529	3.729	14.258

L.S.D. at 0.05 are 1.235, 0.467 and 1.935 for non-reducing, reducing and total sugars content, respectively.

Table (12): Effect of sorghum downy mildew infection on sugars content (mg/g dry weight) in leaves of maize plants at different intervals.

Treatments	Intervals (weeks)	Sugars content		
		Non-reducing	Reducing	Total
Healthy	3	14.754	4.270	19.024
	4	9.007	4.392	13.399
	5	10.715	4.122	14.837
Infected	3	11.273	3.997	15.270
	4	8.721	3.884	12.605
	5	9.151	2.702	11.853
Mean	3	13.013	4.133	17.147
	4	8.864	4.138	13.002
	5	9.933	3.412	13.345

L.S.D. at 0.05 are 1.235, 0.839 and 1.670 for non-reducing, reducing and total sugars content, respectively.



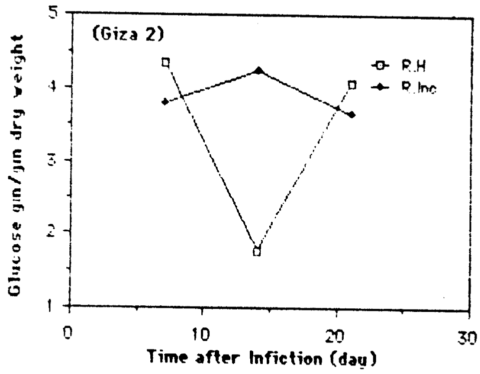
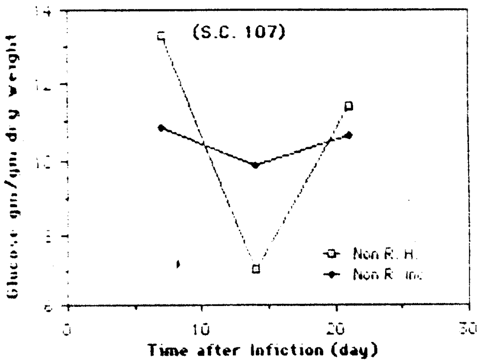


Fig.(6): Effect of sorghum downy mildew infection on the non-reducing and reducing sugars content in leaves of Giza 2 maize variety at different intervals.



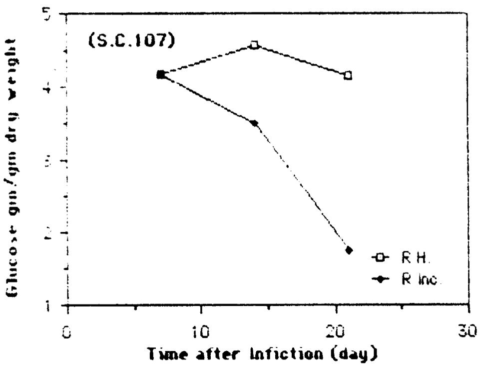


Fig.(7): Effect of sorghum downy mildew infection on the non-reducing and reducing sugars content in leaves of S.C.107 maize variety at different intervals.

sugar, the healthy leaves of both cultivars exhibited higher amounts of reducing sugar than those determined in the corresponding infected leaves. Total sugars followed mostly the same pattern of non-reducing sugars (Table 10).

Data in Table (11) indicate the sugar intensity in both healthy and infected leaves of Giza 2 the moderate resistant maize variety and S.C.107 the susceptible variety, irrespective to the plant age. It could be noticed that infection with sorghum downy mildew caused a decrease in either non-reducing, reducing or total sugars comparing with those in the corresponding healthy leaves. The highest percent of reduction of non-reducing sugars due to infection was 38.14% in Giza 2, while it was 36.61% of reducing sugars in S.C.107 maize variety. It is noteworthy to mention, that the percent of the total sugars reduction attributed to infection was 29.003% in Giza 2 the moderate resistant cultivar, while it was 9.46% in S.C.107 the susceptible variety.

The tabulated data of Table (12) show the sugars content in either the healthy or sorghum downy mildew infected leaves as influenced by the plant age, irrespective to the variety of maize. The highest amounts of the non-reducing sugars in both of healthy and infected leaves were observed at the 3rd week followed by those recorded at the 5th week and the lowest amounts occurred at the 4th week. On the contrary, there were no significant differences among the levels of the reducing sugars in either the healthy or the infected leaves at any age tested. Total sugars exhibited the highest intensity at the 3rd week, while the lowest amount was observed at the 4th week in the healthy leaves and at the 5th week in the infected ones.

It is noteworthy to point out that, sorghum downy mildew infection decreased the non-reducing, reducing and total sugars in maize leaves at any age tested. The highest percent reductions in infected leaves as related to that of healthy leaves of the non-reducing sugars were 30.88%, 17.09% and 3.28% at the 3rd, 5th and 4th weeks, respectively. On the other hand, values of reduction in the reduced sugars, due to infection, increased parallel with plant age. Concerning the total sugars, the highest percent reduction was found at the 5th week (24.58%) followed by the 3rd week, however, at the 4th week was the least one (6.30%).

Histopathological studies:

Results of the present study of pathological histology of maize infected with *S. sorghi* is indicated in Figures 8, 9a, 9b and 10. Conidia germinated and germ tube elongated continually until a stoma was encountered or until energy for growth was exhausted. When an open stoma was reached, an appressorium formed over the stomatal opening and penetration occurred (Fig. 8). It was observed that germ tubes grow at random on the leaf surface. When they crossed junctions between epidermal cells, irregular-shaped swellings developed near or at these junctions. However, penetration was not observed at the site of these swellings.

S. sorghi varied in shape and diameter between cortex and vascular cells (Fig. 9a & 9b). In advanced stages of the disease, the fungus appeared to have broken into pieces and was difficult to differentiate from the host tissue (Fig. 10). S. sorghi caused disintegration of the cortex and the vascular cell walls and an increase in the nuclear material in the diseased tissue was observed in either in a root (Fig. 9a) or in a stem tissue (Fig. 9b).

Effect of NPK fertilizers on resistance of maize to sorghum downy mildew disease:

Effect of various levels of nitrogen, phosphorus and potassium on resistance of Giza 2 and the Double Cross 202 maize cultivars to sorghum downy mildew infections was studied. Two field experiments were conducted in 1985 and 1986 growing seasons. The experimental design

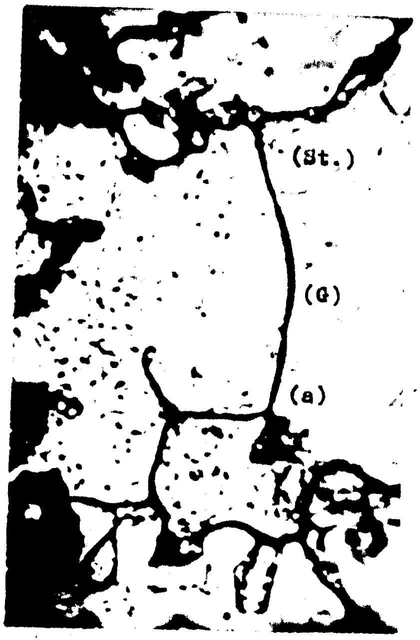
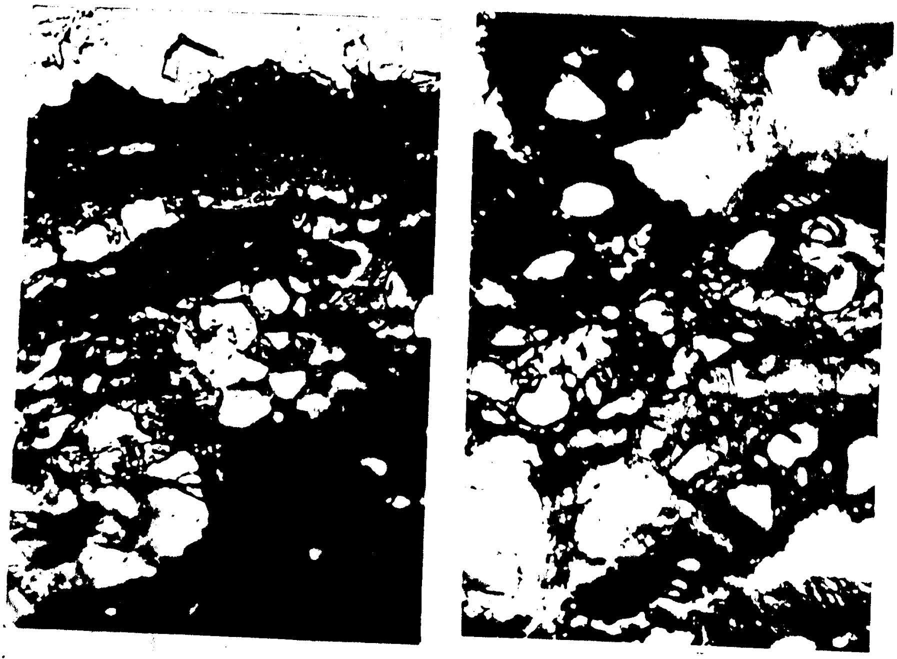


Fig.(8): S. sorghi penetration in maize leaves. Germ tubes (G) on the surface of a leaf showing swellings and an appressorium (a) over a stoma (st.)



(a) (b)

Fig.(9): Cross section in a maize (a) root and (b) stem systemically infected with S. sorghi showing breakdown of the vascular cell walls and various shape and diameter of the fungal mycelium.

Fig.(10): Cross section in a maize root systemically infected with S. sorghi which appeared to have broken into pieces.

was split-split plot and the nitrogen levels were assigned to the main-plots. Whereas the phosphorus levels were assigned to the sub-plots and potassium levels were assigned to the sub-sub-plots.

Data presented in Table (13) show effects of the triple interaction among the tested levels of N, P and K fertilizers. The different combinations of the fertilizers did not significantly influence the disease incidence of S. sorghi either in Giza 2 or in the Double Cross 202 at both the growing seasons.

The statistical analysis of the obtained data revealed the effect of the different levels of each fertilizer solo or in combinations with each one of the rest. The concerned data are indicated in Tables 14, 15, 16 and 17 as well as illustrated in Figures 11 and 12.

Data presented in Table (14) and illustrated in Figures (11 and 12) show that neither the nitrogen nor the potassium fertilizers influenced the percentages of sorghum downy mildewed plants from both Giza 2 and D.C.202 maize cultivars at the two growing seasons. However, the various levels of phosphorus did not affect the disease incidence, except at the rate of zero which significantly increased only the number of the infected plant of Giza 2 at the first season.

Table (13): Effect of interaction between nitrogen, phosphorus and potassium fertilization levels on percentage of downy mildew disease in Giza 2 and D.C.202 maize varieties throughout 1985 and 1986 seasons.

Varieties	Potassium levels (kg/fed)	Phosphorus levels (kg/fed.)	1985			1986		
			Nitrogen levels (kg/fed.)					
			Zero	60	90	Zero	60	90
Giza 2	Zero	Zero	2.31	1.05	4.93	1.19	8.23	5.72
		15	1.07	1.09	1.25	2.99	4.99	2.41
		30	1.41	1.47	1.80	7.66	0.75	5.95
	15	Zero	1.34	2.79	4.31	1.81	5.69	4.40
		15	2.30	3.42	0.88	4.09	3.51	4.33
		30	0.40	3.47	1.14	3.12	6.11	6.63
D.C. 202	Zero	Zero	0.72	0.55	1.90	1.88	0.38	1.39
		15	1.38	1.16	0.43	0.58	0.66	1.29
		30	1.39	1.62	0.86	2.09	1.78	0.42
	15	Zero	0.70	0.50	1.03	0.90	1.12	1.93
		15	0.10	1.09	0.10	0.10	0.81	1.52
		30	1.55	0.38	0.44	0.76	0.42	0.70

		1985	1986
Means of	Giza 2	2.02	4.42
	D.C.202	C.88	1.04
L.S.D. at 5%	Giza 2	-	4.21
	D.C.202	1.35	1.19

Table (14): Effect of nitrogen, phosphorus and potassium fertilization levels on percentage of downy mildew disease in Giza 2 and D.C.202 maize varieties throughout 1985 and 1986 seasons.

Fertilizers	kg/fed.	1985		1986	
		Giza 2	D.C.202	Giza 2	D.C.202
Nitrogen	Zero	1.47	1.06	3.48	1.05
	60	2.21	0.88	4.88	0.86
	90	2.83	0.79	4.91	1.22
Means		2.02	0.91	4.42	1.04
L.S.D.at 5%		0.87	0.62	1.50	0.60
Phosphorus	Zero	5.57	1.79	9.02	2.52
	15	3.34	1.42	7.44	1.65
	30	3.23	2.26	10.07	2.05
Means		4.05	1.82	8.84	2.07
L.S.D.at 5%		0.81	0.50	1.92	0.65
Potassium	0	1.80	1.17	4.43	1.16
	15	2.23	0.65	4.41	0.91
Means		2.03	0.91	4.42	1.04
L.S.D.at 5%		0.43	0.48	1.40	0.50

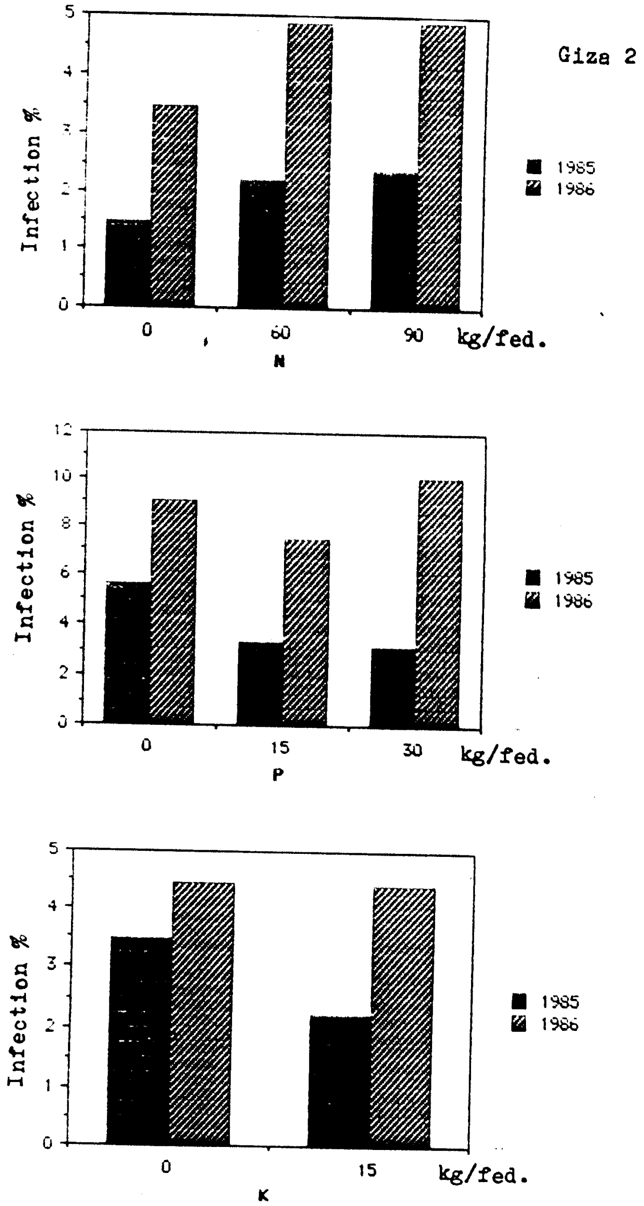


Fig.(11): Effect of nitrogen (N), phosphorus (P) and potassium (K) fertilization levels on percentage of sorghum downy mildew in Giza 2 maize variety throughout 1985 and 1986 seasons.

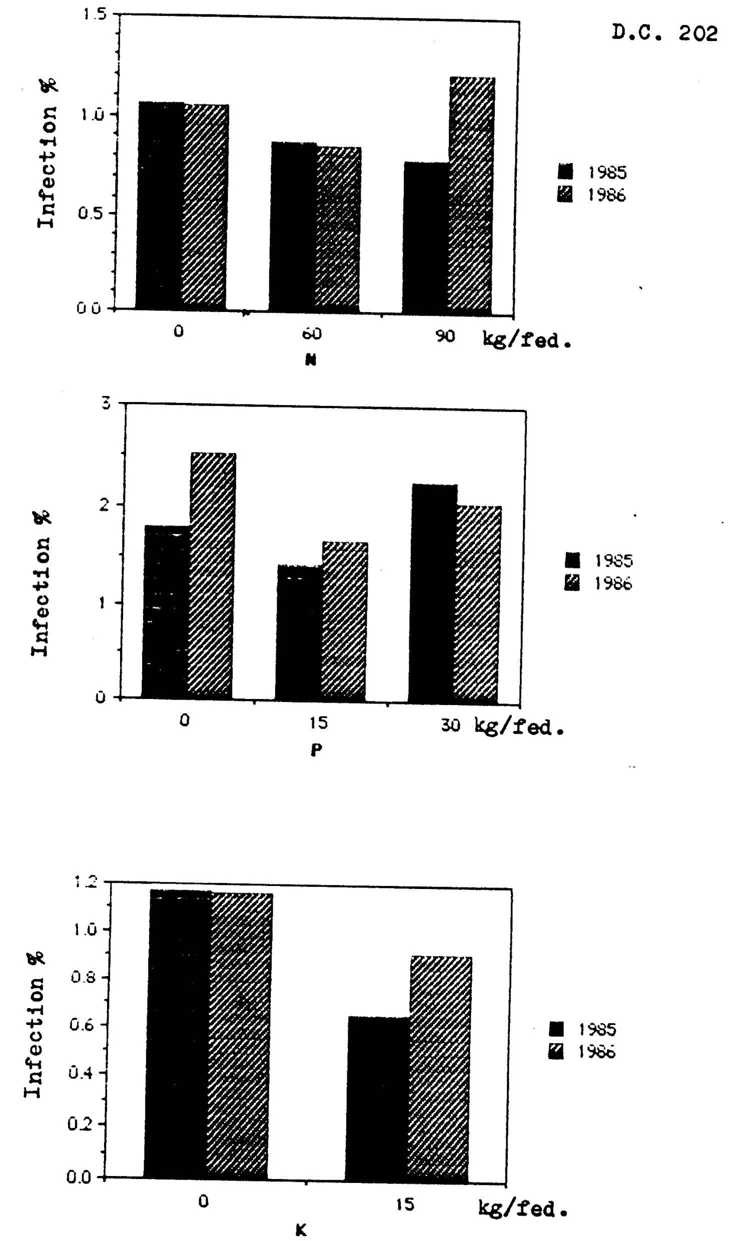


Fig.(12):Effect of nitrogen (N), phosphorus (P) and potassium (K) fertilization levels on percentage of sorghum downy in D.C.202 maize variety throughout 1985 and 1986 seasons.

Data in Tables(15, 16 and 17)indicate the effect of the combinations of each possible pair of the NPK fertilizers on the percentages of S. sorghi infection. Application of both nitrogen and phosphorus at the tested levels had no significant effect on the disease incidence, either in Giza 2 or in D.C.202 maize cultivars, except at the level of 90 nitrogen plus zero phosphorus which increase the number of infected plants from Giza 2 at the first season (Table 15).

On the other hand, application of 60 and 15 kg of nitrogen and potassium significantly increased the infected plants of Giza 2 at the first season, as well as application of 90 kg of nitrogen without potassium increased the disease in D.C.202 at the first season also (Table 16).

Application of phosphorus plus potassium at the tested levels did not affect the percentage of infected plants either of Giza 2 or D.C. 202 maize varieties neither in 1985 nor in 1986 growing season.

Table (15): Effect of interaction between nitrogen and phosphorus fertilization levels on percentage of downy mildew disease in Giza 2 and D.C.202 maize varieties throughout 1985 and 1986 seasons.

Varieties	Phosphorus levels (kg/fed.)	1985			1986		
		Nitrogen levels (kg/fed.)					
		Zero	60	90	Zero	60	90
Giza 2	Zero	1.83	1.92	4.62*	1.50	6.96	5.06
	15	1.69	2.26	1.07	3.54	4.25	3.37
	30	0.90	2.47	1.47	5.39	3.43	6.29
D.C.202	Zero	0.71	0.53	1.46	1.39	0.75	1.66
	15	0.74	1.12	0.27	0.34	0.73	1.40
	30	1.74	1.00	0.65	1.42	1.10	0.56
Means of	Giza 2	2.03			4.42		
	D.C.202	0.91			1.04		
L.S.D. at 5%	Giza 2	1.40			3.32		
	D.C.202	0.86			1.64		

Table (16): Effect of interactions between nitrogen and potassium fertilization levels on percentage of downy mildew disease in Giza 2 and D.C.202 maize varieties throughout 1985 and 1986 season.

Varieties	Potassium levels (kg/fed.)	1985			1986		
		Nitrogen levels (kg/fed.)					
		Zero	60	90	Zero	60	90
Giza 2	Zero	1.60	1.20	2.66	3.95	4.66	4.69
	15	1.26	3.23xx	2.11	3.01	5.10	5.12
D.C.202	Zero	1.34x	1.11	1.06x	1.52	0.94	1.03
	15	0.78	0.66	0.52	0.59	0.78	1.38
Means of	Giza 2	0.75			2.43		
	D.C.202	0.12			0.65		
L.S.D.at 5%	Giza 2	2.01			4.42		
	D.C.202	0.91			1.04		

Table (17): Effect of interactions between phosphorus and potassium fertilization levels on percentage of sorghum downy mildew disease in Giza 2 and D.C.202 maize varieties throughout 1985 and 1986 seasons.

Varieties	Potassium levels (kg/fed.)	1985			1986		
		Phosphorus levels (kg/fed.)					
		Zero	15	30	Zero	15	30
Giza 2	Zero	2.76	1.14	1.56	5.05	3.46	4.78
	15	2.81	2.20	1.67	3.97	3.98	5.29
D.C.202	Zero	1.05	0.99	1.47x	1.21	0.84	1.43
	15	0.74	0.43	0.79	1.31	0.81	0.62
Means of	Giza 2	2.02			4.42		
	D.C.202	0.91			1.04		
L.S.D.at 5%	Giza 2	0.75			2.43		
	D.C.202	0.39			1.00		

DISCUSSION

Results indicate that there were wide variations of sorghum downy mildew incidence among the different governorates and even among the various counties within the same governorate. The highest disease occurence was found in Kafr El-Sheikh governorate namely Sakha location where the percentage of mildewed maize plants reached 83.15% in the growing season of 1987. However, the percentages of infection in the other counties in Kafr El-Sheikh were more less than Sakha . This is may be due to the seed-borne transmission of the causal pathogen which was introduced to Egypt by the imported seeds of maize or sorghum used in experimental programs. These are in agreement with the finding obtained by El-Sharawi 1985.

Considerable variations in percentage of mildewed plants were observed among the other governorates and also within the counties of each governorate. The environmental conditions differ in the different governorates. Temperatures and relative humidity values were more lower in Kafr El-Sheikh than in the other governorates. This lower temperatures may be favor the occurence of sorghum downy mildew in Kafr El-Sheikh. These results coincidence with Chang and Wu (1969a) who demonstrated that the minimum, optimum and maximum temperatures for conidia production of S.sacchari on maize were 13°C, 22-25°C and 31°C, respectively.Conidial germination was 62.1%, 92.7% and 100% at 13°C, 16°C and 19-28°C, respectively. Also, Kenneth and Shahor (1973) recorded that systemic infection of sorghum downy mildew was at 17-18°C higher than at 23°C. They concluded that the higher rate of infection at the lower temperature could be attributed to the large production of inocula under these conditions.

In spite of the abovementioned, variation in percentage of infected plants among counties within each governorate cannot be attributed to the variation in climatic conditions prevailing on these counties. In fact, there is no considerable variation in climatic conditions on the different counties within each governorate. In addition, the variation of percentage of infection among the growing seasons did not go parallel with such differences in the climatic conditions prevalent during those growing seasons. It is more likable that the variation in such disease incidence may be due to considerable variations in infestation of soil and/or seed-borne transmission of the primary inocula.

It is noteworthy to mention that, under condition of limited primary inocula, neither climatic conditions nor different varietal resistance can express on increase or decrease incidence of the disease. Therefore, it could be concluded that the apparent influence of either the location or the growing season on the percentage of infection is due to the irregular distribution of primary inocula of the sorghum downy mildew disease throughout the different plantations.

Uniform distribution of virulent and viable inoculum is essential where natural infection cannot be depended upon-studies of host-parasite interactions require more sophisticated control over experimental conditions than field tests allow. However, the obligate parasite nature of the downy mildew pathogen of maize and sorghum poses problems in artificial inoculations that are not encountered in studies of many plant parasitic fungi.Although two methods have been used (inoculation with either oospores or with conidia) it has been found that the inoculation with oospores method to be successfull only in promoting 14.01% and 17.01% systemic infection for maize and sorghum plants, respectively (Table 5).

Several factors affect the systemic infection of sorghum downy mildew by conidia in maize field. Bonde (1979) has summarized the critical factors involved. Weather conditions and virulence of the pathogen strongly influence the processes of sporulation, germination, infection and disease development. The most critical environmental factors for optimum conidial formation are dew deposition, R.H. value above 89% (Shah, 1973 and Wongsinchaum, 1975) and a temperature of 20-24°C. No sporulation occurred below 80% or temperature below 16°C or above 30°C. Moderate to high wind velocities, which inhibits dew formation, prevents infection process. In addition, Safeeulla and Thirumalachar 1955 found that conidia of S. sorghi formed during early hours of the morning. They germinate and penetrate the host leaves through open stomata by 9.00 a.m. (Jones, 1970). This indicates that the time of application of conidia to foliage may well explain the difficulty that has been encountered by former researchers in obtaining infection with this pathogen (Jones, 1970).

Conidial inoculation of plants in the greenhouse requires equipments to control temperature, relative humidity and light intensity. Lack of these equipments may explain the lower values of systemic infection in this work.

The absence of effective, economically feasible chemical control method necessiated the development of resistant cultivars. The effectiveness of the technique used was not accurate under the unconditioned greenhouse. Under a conditioned greenhouse or field conditions , the values of percent infection may be become more higher for the tested cultivars. However, their relative value of infection for each cultivar may be will not change . As before-mentioned, several attempts to inoculate with conidia in the greenhouse have been unsuccessful (Safeulla and Thirumalachar, 1955, Uppal and Desai, 1931 and Weston and Uppal, 1932). In spite of this difficults, the major advantages of the technique used, are -1) the ability to do resistance screening on a large scale, unlike a field-based system, 2) moreuniform inoculum distribution and 3) allow of an extended period of inoculation.

There are many conflicting reports indicate that obligate parasite infection can either decrease (Allen,1954, Livine,1964,Yarwood,1967,Tu et al.,1968, Magyarosy,1977 and Omar et al., 1985) or increase (Livine, 1964 and Yarwood, 1959) the rate of photosynthesis.

In an attempt to resolve this discrepancy, biochemical analysis was carried out to investigate the effects of S. sorghi infection on the pigments content,chlorophyll a, b and carotenoids in either healthy or infected leaves of Giza 2 the moderate resistant maize cultivar and S.C. 107 the susceptible one.

The present results provide evidence that sorghum downy mildew infection mostly reduced the pigments content. This observation confirming the results of Kristev and Dimov, 1977 and Omar et al., 1985. However, infection increased chlorophyll-a at the 3rd week after inoculation and this increment was relatively higher in the moderate resistant cultivar (Giza 2) than in the susceptible cultivar (S.C.107). This increment in chlorophyll a may elucidate the observation of Livine (1964) and Yarwood (1959) that obligate parasite infection increase the rate of photosynthesis.

It is noteworthy to mention that percent of reduction in the pigments content in the infected leaves at the different sampling intervals, was more higher in the susceptible cultivar (S.C.107) than in the moderate resistant cultivar (Giza 2). Similar results were observed by Kristev and Dimov (1977) who reported that intensities of the plastid pigments chlorophyll a,b and carotenoids in immune, resistant and susceptible wheat cultivars infected with Puccinia recondita f. sp. tritici were connected with the reduced healthy leaf area, which corresponds to the spreading of the fungus in the leaf tissues "susceptibility".

Determination of sugars content in plant leaves may declare a fungal effect on translocation pattern in diseased plants. Altered translocation may contribute as much to the economic damage of disease as do the more obvious mechanisms of reduction in photosynthetic capacity or loss of carbon through respiration, and in ways that are not immediately obvious (Livne and Daly, 1966). Moreover, they suggested that tolerance to disease might be due to an ability to persist in normal patterns of translocation despite disease. Therefore, the present work was carried out to show the effect of sorghum downy mildew disease infection on sugars content in leaves of the moderate resistant maize variety (Giza 2) comparing with those in the susceptible maize variety (S.C.107) at three successive plant ages, namely 3,4 and 5 weeks.

Infection by sorghum downy mildew significantly decreased the amounts of non-reducing and total sugars in leaves of both varieties comparing with those in the corresponding healthy leaves (Table 11). This finding confirmed by Inman (1962) who reported that heavy infection by obligate parasites appreciably reduced the level of the free host sugars detectable in entire leaves.

Although, the healthy leaves of the moderate resistant variety (Giza 2) had significant higher amounts of both non-reducing and total sugars than healthy leaves of the susceptible variety (S.C. 107). The intensity of non-reducing sugars and total sugars were more higher in the infected leaves of the susceptible variety than in the infected leaves of the resistant variety . The rates of reduction of non-reducing sugar and total sugars due to infection were 38.14% and 29.00%; and 1.28% and 9.46% in Giza 2 and S.C.107 varieties , respectively .

These results indicate, more likely, that sorghum downy mildew infection decrease the transport of assimilate to other parts of plants at more rate in the susceptible variety (S.C.107) than in the moderate resistant variety (Giza 2). This explanation was demonstrated by Holligan et al. (1974), Parberry (1978) and Clancy (1979) who reported that when hosts are resistant or are only highly infected, the consequences of infection on translocation are less marked.

Changes in carbohydrate levels are apparently complex. The highest rate of decrease the non-reducing and total sugars in the infected leaves was observed at the 3rd week followed by 5th weeks and the lowest reduction occurred at the 4th week after inoculation (Table 12). Similar results were recorded by Schipper and Mirocha(1969) who detected an initial depletion in carbohydrate levels followed much later by synthesis in rusted bean.

In the present study, it was observed that germ tubes grow at random on the maize leaf surface. When they crossed junctions between epidermal cells, irregular-shaped swelling developed at or near these junctions. However, penetration was not observed at the site of these swellings. Jones (1971) reported similar observation or sorghum bicolor leaves infected with S. sorghi and suggested that this swelling may represent attempts for direct penetration.

Previous investigators (Naqui and Futrell,1969) found that S. sorghi infection caused breakdown of cell walls of leaf maize with an increase in the number of nuclear bodies. The present data confirm their findings in this respect.

Fungal bodies were prominent in the host tissue in the early stage of infection, however, as the disintegration of host cells advanced, the fungus was not readily discernible from the host tissue. Yamanaka and Kawai (1974), and Naqvi and Futrell (1969) reported a similar breakdown of the downy mildew fungal mycelium of S. macrospora in rice leaves and S. sorghi in maize leaves. The previous researchers reported disintegration of cell walls only in the mesophyll tissue of leaves, however, in the present work, the breakdown of cell walls and the increase in number and size of nuclear-like bodies were encountered in the cortex and the vascular tissues of maize stem and root systemically infected with S. sorghi. According to this, the reduction of translocation in plants infected by the obligate parasites (Livne and Daly, 1966)may contribute as much to the disintegration of the vascular cell walls. The reduction in translocation which attributed to the disintegration of the vascular tissue caused by a parasite, may likely elucidate the higher accumulation of non-reducing and total sugars in leaves of the susceptible cultivar (S.C. 107) and not in the resistant cultivar (Giza 2), which was observed thereafter in the present work.

The previous data available on the effect of fertilization on the sorghum downy mildew disease in maize are limited and confusing. Yamada and Aday (1977) reported that infection of susceptible maize seedlings was considerably greater when, N, NP, NK or NPK were applied than in seedlings given no fertilizers, P, K or PK. Matocha et al. (1973) found that higher levels of available soil nitrogen favor disease incidence in sorghum. Data of the present study confirmed those only when the higher level of nitrogen (90 kg/fad.) without phosphorus (Table 15), or without potassium (Table 16) was added or when 60 kg of N plus 15 kg of K were used (Table 16). On the contrary, the higher levels of nitrogen either solo or in a possible combinations could not influence the disease incidence. This finding may be similar to that found by Shah (1976) who indicated that disease severity of S. sorghi was lowest (21.2%) when 160 kg/ha of nitrogen was applied and highest (52 and 53%)at zero and 60 kg/ha. In addition, no significant different was obtained when nitrogen levels were increased from 180 to 240 kg/ha.

Balasubramanian (1978) indicated that in the resistant hybrid CSH-1, increased susceptibility was observed only when phosphorus application was increased from zero to 33.6 kg/ha. Additional phosphorus application did not influence the disease significantly. This finding contradict one case in the present study (Table 14) show that the lowest level of phosphorus (zero) increased the number of infected plants of Giza 2 in the first season. However,this level of phosphorus (zero) did not influence the disease incidence either in D.C.202 nor in Giza 2 at the second season. Shah (1976) found similar results that phosphate application (zero - 60 kg/ha) did not appreciably change the incidence of sorghum downy mildew disease.

It seems likely, that fertilization solo had little effect on S. sorghi, and may several factors acting together to increase or decrease the influence of fertilizers on the disease incidence. Bonman and Pitipornchai (1984) suggested that the effect of P, N and NP varied with the growth stage at which the plants received inoculum.Contradicory results obtained by researchers could be reconciled if plant age was treated as a variable in future studies. resistance or susceptibility of the host may be change the effect of the fertilizers and led to contradictory results,as well as under the limited and irregular intensity of inocula,the effect of nutritions does not appear.

SUMMARY

This study was carried out on the Sorghum downy mildew disease caused by *Perenosclerospora sorghi* in maize plants. Field, greenhouse experiments and chemical analysis were conducted and resulted the following data:

1. Survey on downy mildew disease incidence on maize plants was carried out in five governorates namely Kafr El-Sheikh, Behera, Gharbia, Sharkia and Ismaillia throughout 1985 to 1988.

2. The highest percentages of the diseased plants were observed in Kafr El-Sheikh and ranged from 2.20% to 53.55% during the four growing seasons. However, the lowest percentages were in Ismaillia and Sharkia governorates, and ranged from 0.003% to 0.570%. The percentage of infection were similar to more extend in Behera and Gharbia governorates and their values ranged from 0.05% to 6.70% during the four seasons.

3. The degrees of temperature and relative humidity were registered during the four growing seasons in the five governorates under the study.
   The results of the relationship among disease intensity, temperature and relative humidity degrees suggested that the incidence of the disease in the five governorates was more dependent upon the changes in temperature than the changes of relative humidity.

4.The data of the artificial inoculation techniques revealed that the infestation of the soil by putting milled dry oospores-leaf materials resulted in a higher percentage of infected maize seedlings compared with exposure of the healthy seedlings to conidia transfered naturally from infected plants.

5.Evaluation of resistance of five varieties and hybrid of maize to the Sorghum downy mildew disease under greenhouse conditions revealed that D.C. 202 and Giza 2 were the most resistant varieties, however, S.C.107 was the most susceptible one. 3 W.C.309 and Pioneer 514 were moderate in their resistance.

6.Biochemical studies were carried out to determine the pigments content and sugars in the healthy and infected leaves of a moderate resistant variety (Giza 2) and a susceptible variety (S.C.107) at 3,4 and 5 weeks after sowing. The obtained results indicated that:

a-Generally the infected leaves of both cultivars contained significantly less amounts of Chl.b and carotenoids than the healthy leaves did.

b-Mostly, the moderate resistant cultivar (Giza 2) had more pigments content than the susceptible variety (S.C.107) either in the healthy or in the infected leaves.

c-Infection significantly increased chlorophyll a at the 3rd week and decreased it thereafter.

d-Infection with S. sorghi caused a decrease in either non-reducing, reducing or total sugars and this reduction was more pronounced in the leaves of Giza 2 (the moderate resistant variety) than in the leaves of S.C.107 "the susceptible variety).

e-Infection decreased the non-reducing, reducing and total sugars in maize-leaves at any age tested. This reduction was more obvious with plant age.

6.a. Histopathological studies showed the penetration process by conidiospores.

b. S. sorghi infection caused disintegration of the cortex and the vascular cell walls of maize root and stem. In advanced stage of the disease , the fungus appeared to have broken in pieces.

7. Effect of the NPK fertilizers on the disease incidence was studied under field condition and the obtained results indicated that:

a.The different combination of NPK fertilizer did not significantly influence the disease incidence in either Giza 2 or D.C.202 at two growing seasons.

b.Data showed that neither the tested levels of nitrogen

(0, 60 and 90 kg/fad.) nor that of potassium (0 and 15 kg/fad.) influenced the percentage of infected plants of both varieties at the both seasons.

c. The lowest level of phosphorus (zero) significantly increased the number of infected plants of Giza 2 at the first season only.

d. Application of either 60 plus 15 or 90 plus zero kg/fad. of nitrogen plus potassium significantly increased the infected plants of both Giza 2 and D.C. 202 at the first season, respectively.

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ARABIC SUMMARY

الملخـــص العـــربي

اجريت هذه الدراسه على مرض البياض الزغبى الذى يسببـــه الفطـــــــــر peronosclerospora sorghi لنباتات الذره الشاميه • وقد اجريت تجارب فـــى كل من الصـــوبه والحقل كما تمت تحليلات كيماويه واعطت النتائج الآتيـه :ـ

١ـ اجريت عملية حصر لدراسة مدى انتشار المرض على نباتات الذره فى خمسة محافظات وهى كفرالشيخ والبحيره والغربيـه والشرقيه والاسماعليه وذلك خلال المواســـم الزراعيه من ١٩٨٥ الى ١٩٨٨ •

٢ـ كانت اعلى نسبه مئويه لأصابة النباتات فى محافظة كفرالشيخ وقد تراوحت هـــذه النسبه من ٢ر٢ الى ٥٥ر٥٣٪ وذلك خلال الأربعة مواسم الزراعيه • وقد كـــانت أقل المحافظات انتشارا للمرض هى محافظة الاسماعليه والشرقيه وتراوحـت نسبـــة اصابة النباتات فيها بالمرض من ٠٣ر٠٪ الى ٥٧ر٠٪ • وقد كانت نسبة انتشار المرض فى محافظة البحيره والغربيه متقاربه الى حـد كبير وتراوحـت من ٠٥ر٠٪ الـــى ٧ر٦٪ خلال الاعـــوام الاربعه •

٣ـ سجلت درجات الحراره والرطوبه النسبيه فى المحافظات المذكـوره خلال الاربعـــة مواسم وعملت علاقات بين نسبة الاصابه ودرجة الحراره والرطوبه النسبيه خلال تلـك المواسم واظهرت النتائج ان هناك علاقه قويه بين انتشار المرض والتغير فـــى درجات الحراره وكانت هذه العلاقه اكثر ارتباطا من العلاقه التى بين انتشـــار المرض والتغير فى درجات الرطوبه النسبيـه •

٤ـ دلت نتائج تجارب العدوى الصناعيه بطرق مختلفه ان انجحها فى احداث المرض هـى تلويث التربه المستعمله لزراعة الذره باورق نباتات السورجم المصابه والموجود عليها الجراثيم البيضيه للفطـر وذلك بالمقارنه بوضع النباتات المراد تلقيحها فى حقـــل سورجم مصاب لمدة ٤٨ ساعه ثم نقلها للصـوبه •

٥ـ اجريت دراسه لتقييم مـدى مقاومة خمسة اصناف وهجن للاصابه بالمرض تحت ظروف الصـوبه ودلت النتائج على انه اكثر الاصناف مقاومه كان هما الصنفـان هجـــن زوجى ٢٠٢ وجيزه ٢ ، بينما كان الصنف هجين فردى ١٠٧ هو اكثر الاصنـــاف قابليه للأصـابه بهذا المرض وقد كان الصنفان هجين ثلاثى ٣٠٩ وبيونيـر ٥١٤ متوسطيـــن فى مـدى مقاومتهما للمـــرض •

٦ - أجريت تحليلات كيمو حيويه لتقدير كل من الصبغات والسكريات (الكلية ، والمختزلة وغير المختزلة) فى أوراق النباتات السليمه والمصابه من الصنف المقاوم نسبيا (جيزة ٢) والصنف القابل للاصابه (هجين فردى ١٠٧) وذلك بعد ٣ ، ٤ ، ٥ أسابيع من تاريخ الزراعه ، ودلت النتائج على مايلى :-

أ - احتوت الاوراق المصابه من كلا الصنفين على كميه أقل من كلور فيل ب والكاروتينات بالمقارنه بمحتوى الاوراق السليمه .

ب - احتوت أوراق الصنف (جيزة ٢) المقاوم نسبيا على معدلات أكبر من الصبغات النباتية بالمقارنه بالصنف (هجين فردى ١٠٧) القابل للاصابه ، وذلك سواء كانت النباتات سليمه أو معديه .

جـ - وجد أن العدوى تزيد من كلوروفيل أ فى الاسبوع الثالث ثم تؤدى الى تقليله بعد ذلك .

د - أدت العدوى بالفطر **S.sorghi** الى تقليل كلا من السكريات الغير مختزلة والمختزلة والكلية . وهذا النقص كان أوضح فى الصنف (جيزة ٢) المقاوم نسبيا غير الصنف (هجين فردى ١٠٧) القابل للاصابه

هـ - أدت العدوى بالفطر السابق الى تقليل كل من السكريات الغير مختزلة والمختزلة والكلية عند أى عمر أخذت فيه العينات (٣ ، ٤ ، ٥ اسبوع من تاريخ الزراعة وازداد هذا النقص مع زياده عمر النبات .

٧ - أ - أجريت دراسات تشريحيه على أوراق وساق وجذور النباتات المصابة بالفطر **S.sorghi** وأوضحت الصور فيها عمليه اختراق الفطر بواسطه الجراثيم الكونيدية .

ب - العدوى بالفطر **S.sorghi** أدى الى تحطيم الجدر الخلويه لنسيجى القشرة والاسطوانه الوعائيه فى كل من جذر وساق الذرة . وبتقدم المرض ظهر أن أنسجة الفطر تقطعت الى قطع صغيرة .

٨ - أجريت دراسه فى الحقل لمعرفه تأثير الأسمده الأزوتيه والفوسفاتية والبوتاسية على الاصابة بالمرض وأتضح أن :-

ا - لم تؤثر أضافه النتروجين والفوسفور والبوتاسيوم عند أى مستوى تحت الدراسة على الاصابه بالمرض سواء فى نباتات الصنف جيزه ٢ أو هجين زوجى ٢٠٢ وذلك فى موسمى الزراعه .

ب - اضافه النتروجين بمستوياته الثلاثه (صفر ، ٦٠ ، ٩٠ كجم / فدان) أو البوتاسيوم بمستوياته (صفر ، ١٥ كجم / فدان) .

جـ - لم تؤثر أضافة النتروجين بمعدل (صفر أو ٦٠ أو ٩٠ كجم / فدان ، أو اضافه البوتاسيوم بمعدل صفر أو ١٥ كجم /فدان على قابلية النباتات للاصابه بالمرض سواء فى الصنف جيزه ٢ أو هجين زوجى ٢٠٢ .

د - أدت عدم اضافة الفوسفور (المستوى صفر) الى زياده اصابه نباتات الصنف جيزة ٢ فى الموسم الاول فقط ٠

هـ - زادت النسبه المئويه للنباتات المريضه من الصنف جيزه ٢ عند اضافه ٦٠ كجم نتروجين + ١٥ كجم بوتاسيوم / فدان ،كما زادت النباتات المريضه من الصنف هجين زوجى ٢٠٢ عند اضافه ٩٠ كجم نتروجين صفر كجم / بوتاسيوم وذلك فى الموسم الاول فقط٠

تمت بحمد الله ٠

دراسات على بعض أمراض الذرة الشامية

في مصـــــر

رسالة مقدمة من

أحمد محمد أحمد حشيش

بكالوريوس العلوم الزراعية (أمراض النبات) ١٩٧٨

جامعة الأزهر

للحصول على درجة الماجستير
في العلوم الزراعية

(أمراض النبات)

قسم النبات الزراعي
كلية الزراعة - كفر الشيخ

جامعة طنطا

١٩٨٩