STUDIES ON ALTERNARIA BLIGHT OF SUNFLOWER INDUCED BY ALTERNARIA HELIANTHI (HANSF.) TUB. & NISH. IN NIGERIA

By

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DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for a higher degree.

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CERTIFICATION

This thesis titled "Studies on Alternaria blight of sunflower induced by Alternaria helianthi (Hansf.) Tub. & Nish. in Nigeria" by B.S. Tang'an meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University, Zaria and is approved for it's contribution to knowledge and literary presentation.

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DEDICATION

This piece of work is specially dedicated to my wife Mrs. Monica B. Tang'an and my sons Masters Zughumna'an, Diret and Tapji.

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ABSTRACT

Some aspects of the control of Altenaria blight of sunflower incited by Alternaria helianthi (Hans.) Tub. & Nis. were studied in Samaru during the 1991 and 1992 wet seasons. Laboratory studies confirmed that the pathogen is seed-borne and that ail the five sunflower varieties evaluated were susceptible to the disease. In both glasshouse and field trials, it was demonstrated that seed treatment with metalaxyl + carboxin, carbendazim + maneb, mancozeb and carbendazim + iprodione each at. 1, 2 and 5g a.i/kg seed significantly increased seedling emergence and also reduced incidence of seedling blight, numbers of leaves shed and leaf spot severity compared with the untreated check. Metalaxyl + carboxin at 1 and 2g a.i/kg seed gave the overall best results.

The three fungicides (benomyl, Carbendazim + maneb and mancozeb) evaluated for the control of Alternaria leaf spots significantly reduced the leaf spot severity compared with the unsprayed check. Carbendazim + maneb at 2.4kg a.i/ha gave the best leaf spot control probably because of its systemic and protectant qualities.

Whereas the differences among the five sunflower varieties (Record, Funtua, Chernaanka, Isanka and Smena) screened for resistance to Alternaria blight in respect of needling emergence, numbers of leaves shed prematurely and blight severity were not significant during the 1991 wet season, those of 1992 were significant. Smena bad the highest blight- severity while Funtua and Chernaanka had the lowest.

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An integration of chemical and other disease control strategies has been recommended for control of Alternaria blight,

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1.1 The Sunflower

Sunflower (Helianthus annuus L.) is an economically valuable crop throughout the world and cultivated on a large scale in the Commonwealth of Independent States (C.I.S.), Romania, USA and Central America. It is relatively new to most other parts of the world. There is, however, an increase in the demand for the crop because of its high quality oil which is a rich source of polyunsaturated fatty acids for human consumption and industrial purposes.

1.1.1 Systematics, Origin, History and Distribution

Sunflower is a dicotyledenous plant with stout and often unbranched erect stems. It belongs to the division spermatophyta, Class Angiospermae, Subclass Dicotyledonae, Order Asterales and the family Compositae, the largest of all plant families comprising of about 20,000 species (Benson, 1959; Cobley, 1976). It is a member of the tribe Heliantheae (Benson, 1959), and the genus Helianthus, consisting of 60-100 annual and perennial species (Sackston, 1981; Purseglove, 1974).

The crop is said to have originated from temperate North America (Sackston, 1981). The European explorers who came to the Americas in the 15th and 16th Centuries sent samples of all the plants home. The plant is believed to have been revered by ancient sunworshippers in Peru. The crop was introduced into Spain from Central America by early explorers and Merchants (Chapman and Carter, 1976). According to Sackston (1981)

sunflowers which were used by American Indians as source of food oil and dye were grown largely as curiosities and ornamentals. Early in the 19th century the plant reached the farmlands of Russians and found favour as source of food and edible oil. Its success in Russia and Europe led to the introduction and trial of the sunflower as a crop in North and South Africa, India, China, Australia and North and South America (Sackston, 1981). El Baradi (1973) also reported that by the 19th century, cultivation of the crop had extended rapidly, first in the CIS and South Eastern Europe and later in Argentina where it became established. Today the crop is adapted to both tropical and temperate regions where rainfall is below 3500mm (Weiss, 1966). Thus it is now grown in very many parts of the world (Masefield et al., 1975. Acland, 1977; Ogunremi, 1979).

1.1.2 Usage, Production and Importance

Sunflowers were practically unknown as a commercial crop in North America and many parts of the world prior to 1940. However, the worldwide interest in the crop was aroused during the 1960s and by 1980, it was the second most important source of edible vegetable oil in the world (Sackston, 1981). Sackston (1981) further pointed out that the skyrocketting prices of petroleum in the 1970s led to experimentation with sunflower oil as fuel for diesel engines. Jaap (1979) reported that sunflower seed is produced in significant commercial quantities in at least twenty different countries dispersed among the developed, developing and

centrally planned economies.

The leading producers of the crop are the CIS, Argentina, Romania, Bulgaria, Poland, Hungary, Uruguay, Chile and Yugoslavia (Martin et al., 1976). In Nigeria, Ogunremi (1979) reported a preliminarytrial conducted at various parts of Oyo, Ogun and Ondo States where yields of up to 4.0t/ha were obtained. Preliminary varietal t. ls in parts of Kadawa, Sada and Kazaure in the Savannah region of Nigeria proved that the crop had some production potentials in those areas (Anon, 1986).

The world production as at 1980 was 13,174,000 metric tonnes from 12,374,000 hectares while the production in Africa stood at 473,000 metric tons from 506,000 hectares (Anon, 1980). Though there has been no officially recorded hectarage figures in Nigeria, the crop was once cultivated rather widely in the semi-arid Sudan Zone and it is known to be tolerant to drought (Yayock et. al; 1986). However, high as the potential of sunflower is as a crop for the drought-prone areas of Nigeria, it has so far received li' ' e research attention (Yayock, et al., 1986).

Sunflower is produced mainly for its oil which varies from 25-50% (Acland, 1977; Martin et al., 1976). According to El Baradi (1973) the oil is a soft type with excellent keeping qualities, a relatively low solidifying point; it is high in polyunsaturates and when refined attains a pleasant flavour. It is highly regarded as a salad and cooking oil and is widely used as an ingredient in the manufacture of margarine and compound cooking fats (Masefield, et al., 1975). The oil is also used for

technical pu ses, varnishes, paints, plastics, cosmetics and soap (El Baradi, 1973). Research using several makes of diesel engine has shown that sunflowe: seed oil and particularly when mixed with ethyl ester has the potential to extend fuel (Bruwer et al., 1981). Martin et al. (1976) reported that hybrid varieties with large stripped seeds can be eaten as a confection either roasted or in candies. The leaves and stems can also be used as fodder either fresh or as silage while the oil cake is mostly fed to livestock and some for fertilizer manufacture (Martin et al., 1976). The seedmeal is a good source of vitamin complex suitable for infant feeding. Furthermore, the husk is used for preparation of ethyl alcc' ', furfural and yeast while the hulls are sometimes used as source of heat (El Baradi, 1973)

1.1.3 Insect Pests and Diseases

1.1.3.1 Insects Pests

Several insect pests have been reported associated with sunflower. Such insect pests attack sunflower at seedling, foliage production as well as ear and head formation stages. The major insect pests include false wireworm (Gonocephalum macleayi) bud worms Heliothis armigera Syn. Helicoverpa), aphids (Aphis gossypi) and Jassids (Antroasca terraeviginae). Sunflower moths(Homoeosoma electullum) as well as Neotrephristis finalis which damage the developing seeds also attack the crop (El Baradi, 1973; Chapman and Carter, 1976; Arthur and Campbell, 1979; Genung and Green, 1984).

1.1.3.2 Diseases

Diseases have constituted a serious set back to the production of sunflower. The crop is seriously affected by various fungal diseases notably Alternaria leaf and Stem spots (Alternaria helianthi (Hausf.) Tub. and Nis. which is highly destructive in areas with high temperature and humidity. Pirone (1978) reported the following as the fungal pathogens causing diseases in sunflower: Alternaria helianthi, Cercospora helianthi, Phyllostica helianthi, Ascochyta compositarum, Septoria helianthi all causing leafspots while Puccinia helianthi, P. massalis, Urenyces junci, U. silphi and Coleosporium helianthi are rust pathogens. Other pathogens according to Richardson (1979), Fivawo (1987), Neergaard (1977) and Sackston (1987) are Plasmopara halstedii (downy mildew), Verticillium albo-atrum (verticillium wilt) Sclerotinia sclerotiorum (Sclerotinia wilt and Stem rot), Botrytis cinerea (grey mold) and Macrophomina phaseolina (Charcoal rot).

Nyvall (1979) reported that the most severe seed-borne diseases of sunflower are downy mildew (Plasmopara halstedii) and Alternaria leaf and stem spots (Alternaria helianthi). Similar fungal infections have been reported by Bekesi et al. (1970), El Baradi (1973) and Green et al. (1984) who in addition documented attack by Rhizoctonia solani (Rhizoctonia stem canker) and Rhizopus arrhizus (Rhizopus head rot) as well as Pythium spp and Fusarium solani causing seedling blight. Woldekidan (1986) reported that among the various diseases identified in Ethiopia

from 1981-1986 the economically important ones were downy mildew, stem and head rot, rust and Alternaria leaf spot.

Some assorted bacteria and viruses attack the crop. According to Pirone (1978), Green et al. (1984), Jones and Walt (1988) and Nyvall (1979), the bacterial pathogens include Pseudomonas syringae pv helianthi (bacterial spot), P. solanacearum (bacterial wilt), Agrobacterium tumefaciens (crown gall) and Erwinia carotovora var atroseptica (Erwinia stalk rot).

Lamboll (1987) reported the incidence of rugose mosaic and yellow ringspot (viral infections) in Tanzania. Theuri et al. (1979) similarly reported that these viruses were associated with two different disease symptoms in sunflower in Kenya; one a yellow blotch and the other a leaf crinkle.

From the foregoing it is evident that sunflower has long been subjected to attack by pests and diseases. It can, therefore, be predicted that if sunflower hectarages in Nigeria continue to increase, disease problems will increase in number and severity unless the crop is skillfully managed. Hitherto the introduction of sunflower to Nigeria has not been accompanied by a systematic focus onthe diseases of the crop. Research on the occurrence of A. helianthi and yield loss studies have shown that it is a potentially serious disease (Lipps and Herr, 1986; Carson, 1985). The plant parts usually attacked by the pathogen include roots, stems, leaves, capitulum and seeds.

In many countries, consistent use of seed treatment chemicals has been the practice in order to reduce the density of

primary inoculum. A high level of primary inoculum results in early infection of the seedlings and subsequently the growing crop thereby causing serious losses.

If the potential of sunflower as an alternative oil crop in Nigeria is to be realised the damage and subsequent loss caused by Alternaria should be given proper and immediate attention. Steps should be taken to avoid a potential epidemic status it is likely to attain under large scale production. So far, there is a paucity of published information on the biology and control of the fungus in Nigeria. It is against this background that a detailed work on this disease was deemed necessary. Experiments were therefore designed to:-

1. Determine the pathogenicity of the fungus;
2. Determine the effects of seed treatment chemicals on the incidence and severity of the disease;
3. Evaluate foliar fungicide sprays for the control of the disease; and
4. Screen some sunflower varieties for resistance to the disease.

2. LITERATURE REVIEW

2.1 THE PATHOGEN AND THE DISEASE

2.1.1 Aetiology

The involvement of Alternaria helianthi in pathogenicity of sunflower has not been fully studied. El Baradi (1973) however reported that A. helianthi is much more destructive under high temperature and humidity. After inoculating sunflower with A. helianthi both in the field and in the greenhouse, Acimovic (1979) discovered that spotting of the leaves increased destroying plant parts in 8-10 days. He reasoned that the rapid withering of plant parts may be due to a secretion of toxins by the fungus into the tissue of the host plant. Barash and Mor (1981) reported the ability of Alternaria spp to produce phytotoxic substances. They isolated zinniol produced by A. dauci from blighted carrot leaves. It was found to be the major metabolite. It is therefore most likely that such phytotoxic substances are produced by A. helianthi thereby enhancing disease establishment and development.

2.1.2 Systematics and Cultural Characteristics

Alternaria helianthi is a fungus belonging to the group of Dematiaceous Hyphomycetes (Joly, 1967). It belongs to the order Monilales, the family Dematiaceae and the Porosporae series characterised by the production of dark spores (Clements and Shear, 1954; Barron, 1968). The pathogen was first described as Helminthosporium helianthi Hansf. in 1943 as the cause of blackish

brown zonate spots on leaves of sunflower in Uganda (Herr and Lipps, 1982). According to Acimovic (1979) Tubaki and Nisihara discovered the pathogen and renamed it Alternaria helianthi because of the occurrence of longitudinal septa in the conidia and the porogenous conidial development. He further maintained that A. leucanthemi, Alternaria spp, Helminthosporium helianthi and A. helianthi are one fungus. Today the current name of the pathogen is Alternaria helianthi (Hansf.) Tub. and Nis (Acimovic, 1979).

A. helianthi conidia are cylindrical, non-beaked and borne singly with average size of 100 x 25 µm (Herr and Lipps, 1981). Under higher magnification conidia are cylindrical to enlongated-elliptic, straight or slightly curved, yellowish brown in colour, septate with 4-11 transverse or occasionally longitudinal septa, constricted at the septa and rounded at both ends. They further maintained that the pathogen on seeds is confined to the seed coat or plant fragments present in seed lots. Colony characterization is usually reddish brown and less fuzzy (Herr and Lipps, 1982). The best growth media for A. helianthi according to Herr and Lipps (1982) was shown to be V-8 juice agar which produced average colony diameter of 18.7mm in darkness and 30.3mm in continuous fluorescent light at 25°C. Growth was enhanced under continuous fluorescent light than under darkness. The pathogen also grows well in fresh Potato Dextrose Agar (PDA) (Jeffrey et al., 1985). Allen et al. (1983) also reported that the pathogen grows and sporulates better on PDA amended with a sunflower seed extract than other media tested.

2.1.3 Symptoms of the Disease

Seedling blight and leaf spot induced by Alternaria helianthi is characterised by symptoms which vary with the age of the plant and cultivar. Tosi and Zazzerini (1990) observed that the symptom of infection starts with an irregular or angular necrotic spot surrounded by a chlorotic halo which develops initially on the lower leaves and gradually spread to the upper leaves. Coalescence and enlargement of leaf spots results in withering, drying and loss of leaves (Herr and Lipps, 1982). Herr and Lipps (1981) observed that leafspots have dark brown margins with grey centres ranging from several millimetres to 1.5cm in diameter while stem lesions start as black flecks or streaks enlarging later to cover large area of the stem. Allen et al. (1983) further demonstrated that the highest level of disease occurred in the lowest leaves which move up the plant under favourable condition thereby increasing the apparent rate of senescence relative to natural senescence on disease-free plants. Thus the fungus causes brownish-black spot on sunflower which results in premature withering of leaves causing serious yield losses (Acimovic, 1979). Infected stems bear blackened lesions with some stalk breakage. Shane et al. (1981) also observed that infected plants showed dark brown, oval to diamond shaped, slightly sunken lesions on the stems at or slightly below the soil. It was also shown that some of the stems completely girdled by lesions were killed while affected leaves were greatly reduced in size and completely blighted. Infected plants also suffer defoliation with frequent

exhibition of lodging.

2.1.4 Transmission

The leafspot of sunflower induced by Alternaria helianthi was reported in Ohio. Herr and Lipps (1982) demonstrated that the pathogen is seed-borne and attributed the introduction of the disease into the area to planting of infected seeds. Hence the seed-borne means of dispersal constituted a serious threat to the production of sunflower in North America (Sackston, 1981). The occurrence of the pathgogen on sunflower was reported in several places (Herr and Lipps 1982; Moris et al; 1983, Shane et al 1981). The pathogen is capable of initiating disease over a wide range of temperatures. Jeefrey et al. (1985) showed that inoculation of sunflower seeds with conidial suspensions of A. helianthi resulted in the development of lesions on the stems and leaves. It has also been noted that over-wintering of the pathogen on sunflower residues may be of great significance in maintaining the disease once the pathogen has been introduced into an area (Herr and Lipps, 1982).

2.1.5 Host Range

Alternaria helianthi is known to have a wide host range though it is more restricted to sunflower. During the comparative testing for the degree of pathogenicity of A. helianthi in Helianthus annuus L., H. tuberosus L., Ricinus communis L, Leucanthemum vulgare L and Zinnia elegans J., a high degree of

pathogenicity was found on H. annuus, very high on H. tuberosus low on R.communis and very low on L. vulgare and Z. elegans (Acimovic, 1979).

Lipps and Herr (1986) studied the reaction of Helianthus annuus and H. tuberosus to Alternaria helianthi. They demonstrated that H. t osus accessions had significantly lower disease incidences than H. annuus hybrids. They suggested that H. tuberosus may be a promising source of resistance to A. helianthi. This further confirms that the pathogen survives much more on these two plant species. Moris et al. (1983) also studied the reaction of Helianthus spp to A. helianthi. The result showed that all the annual taxon, Tithonia rodundifolia, were susceptible. The perennial Helianthus species were susceptible except for H. hirsutus, H. rigidus and H. tuberosus. Plants with the highest disease incidence include H. annuus, H. anomalus B, H. bolanderi G., H. debilis sub sp debilis Nutt; H. exilis Gray, H. neglectus H or H. niveus Gray, H. paradoxus, H. atrorubense L., H eggertii Small, H. gracilentus, H. longifolus, H. pumilus Nutt and H. silphioides Nutt, the majority of which are annuals.

2.1.6 Geographical Distribution and Importance

Fungi are the most prevalent phytopathogens in every region. According to Acimovic (1979) Alternaria helianthi is the most widely distributed and the most harmful agent causing spotting of aerial parts of sunflowers. Sackston (1981) reported that the disease is widely distributed in Asia, Australia, Argentina and

various countries in Eastern Europe - being particularly destructive in Yugoslavia. The disease has also been reported in many parts of the USA and China (Herr and Lipps 1981, Shane et al. 1981; Liu and Li, 1988). This suggests the wide distribution of the pathogen (as it is favoured by high temperature and humidity (Agrawat et al 1979).

Alternaria helianthi is the most recent leaf-, stem-, and head- spotting pathogen which appears to be the most threatening disease of sunflower (Sackston, 1981). This disease was responsible for poor to non-existing yields in the 1978 and 1979 cropping seasons in Florida (Green et al., 1984). Acimovic (1979) tested the Soviet sunflower cultivar VNINMK 8931 in Yugoslavia for pathogenicity and discovered that the disease developed slightly faster on the leaves than on the stems. The result also showed that A. helianthi was highly pathogenic on Helianthus annuus. Hence when the epiphytotics occurred in the field the leaves were the first to be killed followed by stems and then heads.

In a preliminary survey of leafspots of sunflower in South Africa, Holtzhansen (1980) observed a high degree of pathogenicity by Alternaria spp. Yield losses of 10-50% and total crop failure have been associated with Alternaria leafspots (Liu and Li, 1988). Green et al. (1984) also reported that only 20-50% seed yields of the projected 2,242 kg/ha were obtained as Alternaria blight became the most prevalent and most severe sunflower disease in commercial fields. Herr and Lipps (1982) also reported severe attack of sunflower leaves and stems by A. helianthi in Ohio

during the 1980 season resulting in extensive defoliation and lodging of plants. They further demonstrated that A. helianthi is pathogenic on 4-week old sunflower seedlings. Leafspot induced by A. helianthi have also been reported as an important foliar disease of sunflower in Vidarbha and that it assumed serious form from August to October resulting in severe foliar damage (Rant and Kale, 1976).

Mathur et al. (1978) in estimating losses due to Alternaria blight of sunflower showed that heavy disease appearance caused highly significant reduction in plant characters like height, stem girth, head diameter, seed weight as well as kernel and oil percentage. Artificial inoculation of 15-day old plants of susceptible cultivar EC 68414 with A. helianthi resulted in 100% mortality and a great reduction in yield per plant (Ghemawat et al., 1990). Jeffrey et al. (1985) also reported that inoculations of sunflower seeds with conidial suspension of A. helianthi resulted in the development of lesions on the stems and leaves of progeny plants proving its pathogenicity. Infection by A. helianthi has been shown to predispose sunflower plants to bacterial infection (Jones and Walt, 1988). A. helianthi in addition to reducing germinability of the seeds of sunflower induces seedling diseases and serve as a source of infection for grown up plants (Sharma, 1977).

2.1.7 Control of Alternaria Leafspots

Since it has been established that Alternaria helianthi is seed-borne, fungicidal seed treatments may limit the introduction of the disease to new areas. Neergaard (1977) stated that the commonly used fungicides for the control of Alternaria blight are maneb, Ziram and zineb and sometimes captan sprayed at 5-10 day intervals. Kolte et al. (1980) demonstrated in four wet season field trials that application of four foliar sprays of 0.3% mancozeb decreased A. helianthi infection of sunflower by 17-33% and increased seed yields by 43-65%. An evaluation of fungicides also showed that the best control of A. helianthi infection on sunflower was obtained with foliar sprays of Dithane M-45 (Mancozeb) and ziram followed by Fytolan (copper oxichloride), Dithane Z-78 (Zineb) and Macuprax (cupric sulphate + cufraneb (Bhaskaran and Kadaswamy, 1979). Agrawal et al. (1979) tested the efficacy of eight fungicides namely Dithane M-45 (75% zinc ion + manganese ethylene bis-dithio-carbanate), Zineb (75% Zinc ethylene bis-dithiocarbonate), Benlate (methyl 1-(butyl) carbamoyl-z-benzimidazol), Miltox (37.5% copper oxychloride + 12% zineb), Blitox-50 (50% copper oxychloride), Tecto-90 (90% thiabendazole), Bavistin (2-methoxy-carbamoyl-benzimidazol) and Calixin (N-tridecyl 1-2-6 dimethyl morpholine) for the control of A. helianthi and found that heavy infection occurred in the untreated check while Bavistin and Benlate were the most effective fungicides followed by Tecto-90 when sprayed at an interval of 10 days as prophylactic sprays or even after disease appearance.

Similarly Abraham et al. (1976) had reported effective control of Alternaria blight using Dithane M-45, Miltox and Benlate.

To determine the effect of seed-borne A. helianthi and seed-applied fungicides on emergence of sunflower seedlings, Jeffrey et al. (1985) found out that the mean stand in the no-fungicide-inoculated seed plots was significantly less than no-fungicide-uninoculated seed plots. They further showed that of the 8 fungicides tested in vitro, chlorothalonil and thiabendazole completely inhibited the growth of A. helianthi whereas in field seed-treatment test, only chlorothalonil provided consistent control of seedling blight as shown by the stand counts. Okoli et al. (1989) in evaluating seed dressing chemicals for the control of Alternaria blight of sunflower in Zaria, Nigeria discovered that the most promising chemicals at all concentrations (0.1%, 0.2% and 0.3% a.i) were Rovral TS, Lyrene, Fernasan D, Rovral and Marshall. According to them Bronocot was found to be phytotoxic.

The most effective methods of controlling seed-borne diseases of sunflower is by seed treatment. Seed treatment with fungicides which could protect the seedlings against infection by soil-borne inoculum for the first 3 weeks and subsequent disease occurrence will extremely be useful in the control of seed borne A. helianthi of sunflower. Nedeku et al. (1990) demonstrated that exposure to fungicides required for total killing of the pathogen varied from 45-180 minutes with Vinclozolin showing the highest fungicidal activity followed by Iprodione, Thiram and Captan in that order. Fivawo (1987) recommended seed-treatment using Captafol and

benomyl for the control of A. helianthi. In a paper disk bioassay (Jeffrey et al; 1985) discovered that growth did not occur on inoculated paper disks treated with thiabendazole or chlorothalonil at any concentration tested. They further showed that surfaces of untreated control disks were covered with growth of A. helianthi days after conidial suspension were placed on them. Green et al. (1984) suggested that in the absence of resistant cultivars and effective fungicides, varying the planting date appears to be the best control option.

3. MATERIALS AND METHODS

In line with the objectives of this study, laboratory, glasshouse and field experiments were designed and carried out during the 1991 and 1992 growing seasons at Samaru, Zaria.

3.1 ISOLATION OF THE PATHOGEN

Specimens of sunflower plants exhibiting leaf and stem spotting symptoms were collected, surface-sterilized with 1% sodium hypochlorite (Milton) solution in Petri dishes for 5 minutes and then rinsed in three changes of sterile distilled water (SDW). Some of the disinfected tissues were plated on Potato Dextrose Agar with Streptomycin (PDAS) in 9cm Petri dishes and incubated at $27^{\pm 2}$ °C under alternating light and dark periods. Some of the disinfected tissues were also placed in moist chambers for 48 hours at room temperatures. The moist chambers were prepared by placing two moistened sterile filter papers in sterile 9cm Petri dishes. Sterile microscope slides were placed on top of the moist filter papers. The disinfected tissues were then placed on top of the slides. The fungi isolated from the tissues were subcultured until pure isolates were obtained.

3.1.1 Seed Testing

One hundred seeds of each of 5 sunflower cultivars (Record, Isaanka, Chernenka, Funtua and Smena) were selected for the detection of seed-borne pathogens in the laboratory. These were

placed in Petri dishes using a pair of sterile forceps and surface disinfected with milton solution for 5 minutes. These were rinsed in 3 changes of SDW. The seeds were then plated on PDAS and incubated at $27^{\pm 2}$ °C. Isolated fungal pathogens were purified by repeated transfer of hyphal tips and were then identified under a compound microscope.

3.1.2 Pathogenicity Test

To obtain conidia of Alternaria helianthi for pathogenicity tests, 2-week old culture plates were flooded with 5ml of SDW. The fungal colonies were then brushed off gently with a sterile wire loop to dislodge the conidia. The resulting suspension was then passed through 2 layers of cheese cloth and the conidial suspension was used in spraying 3-week old plants.

Seeds of five sunflower varieties (Isaanka, Record, Smena, Chernenka and Funtua) were treated with metalaxyl+carboxin (Apron plus) at the rate of 1ga.i/Kg seed. These were sown in plastic pots in the glasshouse and watered daily. Three weeks after sowing, the seedlings were kept in a humid chamber for 24 hours to increase leaf turgor in order for stomata to open properly. They were then inoculated by spraying the stems and leaves with the conidial suspension using an atomizer. After inoculation, the plants were immediately covered with a clean polythene bag for 48 hours to maintain a relatively high humidity. Control plants were, however, sprayed with SDW. The plants were then taken to a glasshouse and watered regularly. Observations for disease

development were made on daily basis.

3.2 EFFECTS OF FUNGICIDE SEED TREATMENTS ON ALTERNARIA BLIGHT OF SUNFLOWER

The sunflower cultivar Record was used for this study. Five fungicides namely metalaxyl + carboxin, (Apron plus DS) benomyl (Benlate), mancozeb (Dithane M-45), carbendazin + maneb (Delsene M) and carbendazin + iprodione (Rovral TS) each at 3 different doses; 1, 2 and 5g a.i/kg of seed were evaluated during the 1991 and 1992 growing seasons both in the glasshouse and in the field. A control was included in which the seeds were not treated.

3.2.1 Glasshouse Experiment

For each treatment, 10 seeds were sown in 16cm diameter plastic pots already filled with rich top soil mixed with 3g NPK 15-15-15 and arranged in a Randomised Complete Block Design with three replications. These were watered regularly. Full seedling emergence was taken 12 Days after sowing (DAS). The resulting seedlings were thinned to five per pot 14 DAS. Root length, stem diameter, shoot length and incidence of seedling blight were taken 35 DAS.

3.2.2 Field Experiment

The field trials were carried out at the Institute for Agricultural Research Farm, Samaru (11° 6 N, 7° 38'E) during the 1991 and 1992 wet seasons. The trial was a Randomised Complete Block Design with three replications. The size of the plot was 5m

by 4 ridges spaced 75cm apart. One metre guard rows were maintained and planted with maize. Five seeds were sown per hill 30cm apart. Sowing during the 1991 growing season was done on 5th July while that of 1992 was on 2nd July. Full seedling emergence was taken 12 DAS. The seedlings were thinned down to two per stand two weeks after sowing (WAS). Seedling blight incidences were taken 30 DAS. The incidence and severity of Alternaria blight on 10 randomly selected plants per plot were first assessed 6 WAS and subsequently after every 2 weeks by counting the number of leaves infected, number of leaves shed and by scoring leaf spot severity based on a modified Allen et al.'s (1983) Scale of 1-6 as follows:-

1, No leaf infection;

2, 0-5% of leaf area covered by pin-point (1mm) to a few large (2mm) spots;

3, 6-25% of leaf area covered by large (3mm) spots;

4, 26-50% of leaf area covered by coalescing lesions;

5, 51-75% of leaf area covered by coalescing lesions; and

6, 76-100% leaf area covered by coalescing lesions or leaf completely killed.

At harvest, 13 WAS, yield data were obtained by recording plant height, head weight, head diameter and seed weight per plant and per plot.

3.3 EVALUATION OF FOLIAR FUNGICIDE SPRAYS FOR THE CONTROL OF ALTERNARIA BLIGHT OF SUNFLOWER

The cultivar Record was used for this experiment which was carried out on IAR farm Samaru. During the 1991 and 1992 growing seasons, three fungicides namely benomyl (Benlate), carbendazim + maneb (Delsene M) and mancozeb (Dithane M-45) were each evaluated at two doses; 0.6 and 0.7; 2.4 and 2.6 and 2.5 and 2.7 Kg a.i./ha respectively for their efficacy in the control of Alternaria blight and consequently their effects on yields of sunflower. The size of the plot was 5m by 4 ridges spaced 75cm apart. The design was a Randomized Complete Block Design with 4 replications Guard rows of 1m wide were planted with maize to absorb fungicide spray drift during foliar sprays. Sowing of seeds was done on 3rd July during both seasons. Five seeds were sown per hill 30 cm apart. The seedlings were thinned down to two per stand two weeks after sowing.

A pressurised CP3 Knapsack sprayer with yellow cone nozzle was used in spraying the fungicides. The control was not sprayed. Spraying was done at 6, 8 and 10 WAS. Records of seedling emergence at 10 DAS as well as seedling blight and damping-off incidence at 30 DAS were taken. Similarly number of infected leaves, defoliation counts and leaf spot disease severity were assessed as earlier described. Disease severity scores were taken one week after every spraying. At harvest, yield records comprising of plant height, head weight, head diameter and seed weight per plant as well as per plot were taken.

3.4 SCREENING SUNFLOWER VARIETIES FOR RESISTANCE TO ALTERNARIA BLIGHT

Five sunflower cultivars Isaanka, Smena, Funtua, Chernanka and Record were screened for resistance to Alternaria blight under natural field conditions during the 1991 and 1992 growing seasons at Samaru, Zaria. Five seeds of each variety were sown directly on two 5m ridge per stand 30cm apart. These were later thinned down to two 2 WAS.

The layout of the trial was a Randomized Complete Block design with 5 treatments and 4 replications. The size of the plots were two raised beds that were 5.0 by 0.75m with each plot separated by a 1m guard row. Records of seedling emergence, seedling blight incidence, disease severity scores as well as yield data were taken. Assessment of disease severity was conducted fortnightly beginning from 6 WAS. Leafspot disease severity was rated on a visual scale of 1-6 as described previously.

4. RESULTS

4.1 Isolation of Seed-borne Fungal Pathogens

Table 4.1 shows the list of the fungal pathogens isolated from the seeds of the 5 cultivars tested. The result shows that Alternaria helianthi was consistently associated with all the cultivars. Similarly, Macrophomina sp was associated with all the varieties except Record. Helminthosporium sp was associated with Smena, Funtua, Chernaanka and Record. Rhizopus sp and Penicillium sp were only associated with the variety Isaanka. Curvularia sp was found in the varieties Smena and Funtua while Fusarium sp was found associated with Isaanka and Funtua. Gleosporium sp and Aschochyta spp were only found in association with Record.

4.2 Pathogencity Test

The pathogenicity test conducted on the 5 varieties of sunflower showed that Alternaria helianthi was pathogenic on all the varieties. Spotting of the leaves and stems occurred simultaneously 8 days after inoculation. Few pin-point brown spots surrounded by yellow halos were first observed on the leaves which later enlarged to irregular dark brown spots. On the stems, the spots were fewer and appeared as tiny streaks or linear spots. These characteristic symptoms were similarly observed in the field (Plates I and II).

Table 4.1: List of Fungi Isolated from seeds of Sunflower

Variety	Associated Fungi
Chernaanka	Alternaria helianthi. Helminthosporium sp Macrophomina phaseolina
Funtua	Alternaria helianthi, Curvularia spp,Fusarium sp. Helminthosporium sp
Isaanka	Alternaria helianthi, Aspergillus niger, Fusarium sp; Penicilium spp; Rhizopus spp
Record	Alternaria helianthi, Aschochyta sp; Aspergillus spp; Gleosporium spp. Helminthosporium spp; Phoma spp; Rhizopus spp
Smena	Alternaria helianthi Aspergillus spp Curvularia spp; Helminthosporium spp; Macrophomina phaseolina



Plate 1: A healthy sunflower leaf (A) compared with an infected leaf (B) showing initial symptoms of Alternaria leafspots.



Plate 2: Advanced stages of Alternaria leaf spots of sunflower showing few large spots (left) and coalescing lesions (right)

4.3 Effects of Fungicide seed Treatments on Seedling Emergence and Growth of Sunflower in the Glasshouse During the 1991 and 1992 Wet Seasons

The results for the five fungicides evaluated during the 1991, 1992 and the two years combined are presented in Tables 4.3.1, 4.3.2 and 4.3.3 respectively. The results revealed that seed-treatment significantly increased seedling emergence and reduced seedling blight severity during the 1991 wet season (Table 4.3.1). Fungicide seed treatment also significantly increased seedling emergence during the 1992 wet season although it did not significantly reduce seedling blight incidence (Table 4.3.2). For the combined analysis (Table 4.3.3) seedling emergence was significantly increased by fungicide seed treatment. Metalaxyl + carboxin, Mancozeb and carbendazim + 1 prodione each at the rate of 1g a.i/kg seed gave the highest seedling emergence followed by metalaxyl + carboxin and mancozeb at the rate of 2g a.i/kg seed and then carbendazim + iprodione and carbendazim + maneb each at the rate of 2 and 5g a.i/kg seed in t hat decreasing order.

During the 1991 and 1992 seasons the seedling blight incidence in seedlings whose seeds were treated with fungicides were significantly lower than the untreated check. There was however no significant difference among the fungicides evaluated. A combined analysis also revealved that chemical seed treatemnt significantly lowered seedling blight incidence in relation to the check. Among the chemicals, carbendazim + maneb at 1g a.i/kg seed recorded significantly higher seedling blight incidence followed by benomyl at 2g a.i/kg seed, mancozeb and carbendazim + maneb each at

Table 4.3.1: Effect of fungicide seed treatment on seedling emergence, seedling blight and growth of sunflower in the glasshouse during the 1991 wet season

Fungicide	Dose (g a.i/kg seed)	Seedling emergence (%)*	Seedling blight incidence*	Root length (cm)	Shoot length (cm)	Stem diameter (cm)
Metalaxyl	1.0	93.3ab	0.3b	21.0	48.2	0.6
+Carboxin	2.0	96.7a	0.3b	15.7	49.9	0.5
	5.0	93.3ab	0.0b	19.9	45.9	0.5
Benomyl	1.0	80.0ab	0.3b	18.5	41.9	0.5
	2.0	80.0ab	0.3b	19.3	47.7	0.5
	5.0	96.7a	0.0b	16.9	45.3	0.5
Mancozeb	1.0	100.0a	0.3b	16.1	45.5	0.5
	2.0	93.3ab	0.3b	20.8	46.2	0.5
	5.0	83.3b	0.3b	17.9	43.0	0.5
Carbendazim	1.0	100.0a	0.0b	16.4	51.1	0.6
+iprodione	2.0	90.0a	0.0b	18.8	52.1	0.5
	5.0	93.3ab	0.0b	19.8	52.1	0.5
Carbendazim	1.0	83.3b	0.0b	17.2	49.4	0.5
+Maneb	2.0	96.7a	0.0b	15.3	48.7	0.5
	5.0	93.3ab	0.0b	21.0	47.7	0.5
Check	0.0	60.0c	1.7a	14.3	27.9	0.4
LSD (P = 0.05)		14.4	0.8	ns	ns	ns

* Means followed by the same letter(s) are not significantly different at P = 0.05

ns = not significant

Table 4.3.2: Effect of fungicide seed treatment on seedling emergence, seedling blight and growth of sunflower in the glasshouse during the 1992 wet season

Fungicide	Dose (g a.i/kg seed)	Seedling emergence (%)*	Seedling blight incidence*	Root length (cm)	Shoot length (cm)	Stem diameter (cm)
Metalaxyl	1.0	93.3a	0.0	21.8a	48.9a	0.7
+Carboxin	2.0	86.7a	0.0	21.2a	46.2ab	0.6
	5.0	76.7b	0.3	19.8a	45.4ab	0.6
	1.0	83.3ab	0.6	16.4c	41.8b	0.6
Benomyl	2.0	76.7b	0.3	17.9b	36.0c	0.6
	5.0	70.0b	0.3	22.0a	47.4a	0.6
Mancozeb	1.0	86.7ab	0.6	18.4b	35.9cd	0.5
	2.0	83.3ab	0.6	20.7a	43.2ab	0.6
	5.0	80.0ab	0.0	16.7c	34.8cd	0.6
Carbendazim	1.0	86.7ab	0.3	19.1b	30.4d	0.5
+iprodione	2.0	83.3ab	0.6	18.9b	32.4cd	0.5
	5.0	80.0ab	0.6	19.1b	37.3c	0.6
Carbendazim	1.0	76.7b	0.6	16.6c	33.4cd	0.6
+Maneb	2.0	73.4b	1.0	15.9c	30.7d	0.5
	5.0	76.7b	0.6	20.6a	40.4b	0.6
Check	0.0	51.1c	2.0	12.4d	28.3d	0.4
LSD (P = 0.05)		16.1	ns	2.3	5.7	ns

* Means followed by the same letter(s) are not significantly different at P = 0.05

ns = not significant

Table 4.3.3: Combined table of the effect of fungicide seed treatment on seedling emergence, seedling blight and growth of sunflower in the glasshouse during the 1991 and 1992 wet seasons

Fungicide	Dose (g a i/kg seed)	Seedling emergence (%)*	Seedling blight incidence*	Root length (cm)	Shoot length (cm)	Stem diameter (cm)
Metalaxyl	1.0	93.3a	0.3c	21.4a	48.6a	0.6
+Carboxin	2.0	91.7a	0.2c	18.5b	47.8a	0.5
	5.0	85.0ab	0.2c	19.8a	45.7ab	0.6
Benomyl	1.0	81.7b	0.5c	17.5b	41.8b	0.6
	2.0	80.3b	0.7c	18.3b	41.9b	0.5
	5.0	83.3ab	0.5c	19.4ab	46.4a	0.5
Mancozeb	1.0	93.3a	0.5c	17.3b	40.7b	0.5
	2.0	88.3ab	0.5c	20.8a	44.7ab	0.6
	5.0	81.7b	0.2c	17.3b	38.9b	0.5
Carbendazim	1.0	93.3a	0.2c	17.7b	40.8b	0.5
+iprodione	2.0	86.7ab	0.3c	18.9ab	42.2b	0.5
	5.0	86.7ab	0.3c	19.5a	43.8ab	0.5
Carbendazim	1.0	80.0b	0.8b	16.9bc	41.4b	0.6
+Maneb	2.0	85.0ab	0.5c	15.6c	39.7b	0.5
	5.0	85.0ab	0.3c	20.8a	44.1ab	0.5
Check	0.0	55.6c	1.8a	13.4d	28.1c	0.4
LSD (P = 0.05)		10.6	0.7	2.6	6.3	ns

* Means followed by the same letter(s) are not significantly different at P = 0.05

ns = not significant

1 and 2g a.i/kg seed. The lowest incidence were recorded by metalaxyl + carboxin at 2 and 5g a.i/kg seed, Mancozeb at 5g a.i/kg seed and carbendazim + iprodione at 1g a.i/kg seed.

While seed treatment had no significant effect on root and shoot lengths during the 1991 wet season, it did during the 1992 season. Root and shoot lengths during the 1992 season were significantly lower inthe untreated check compared with the fungicide seed treatments.

Stem diameters in the 1991 and 1992 wet season were not significantly increased by fungicide seed treaments in the glasshouse. A combined analysis revealed that except for stem diameter, there were significant differences between the untreated check and all the chemicals evaluated in relation to root and shoot lengths. Seed treatment with metalaxyl + carboxin at 1g a.i/kg seed produced seedlings with the highest root length and a correspondingly high shoot length and stem diameter. All the chemicals proved promising in enhancing seedling emergence and growth.

While seed treatment had no significant effect on root and shoot lengths during the 1991 wet season, it did during the 1992 season. Root and shoot lengths during the 1992 season were significantly lower in the untreated check compared with the fungicide treatments. Stem diameters in the 1991 and 1992 wet seasons were not significantly increased by fungicide seed treatments in the glasshouse. Metalaxyl + carboxin at the rate of 1g a.i/kg seed which gave the highest shoot length correspondingly

had the highest stem diameter. This was followed by seed treatment with benomyl at 5g a.i/kg seed.

4.4 Effects of fungicide Seed Treatment on Seedling Emergence, Alternaria Blight and on Yields of Sunflower

The results for the 1991, 1992 and the combined analysis are presented in Tables 4.4.1, 4.4.2 and 4.4.3 respectively.

4.4.1 Effects of Fungicides Seed Treatment on Seedling Emergence and Alternaria Blight of Sunflower During the 1991 Field Trial

During the 1991 field trial, fungicide seed treatment significantly increased seedling emergence (Table 4.4.1). Seed treatment with metalaxyl + carboxin at the rate of 1 and 2g a.i/kg seed gave the highest seedling emergence of 83.7 and 78.7 respectively. These were however not significantly different from seeds treated with carbendazim + iprodione at 1g a.i/kg seed and carbendazim + maneb at 2 and 5g a.i/kg seed. The untreated check was however not significantly different from seed treatment with benomyl at 2 and 5g a.i/kg seed and metalaxyl + carboxim at 5g a.i/kg seed.

During the 1991 field trial, the incidence of seedling blight in all the seedlings whose seeds were treated with fungicides were significantly lower than the untreated check. Seeds treated with carbendazim + maneb and mancozeb produced seedlings that were completely free from seedling blight. The untreated check had significantly higher seedling blight than the chemical treatment which were not significantly different from each other.

Table 4.4.1: Effect of fungicide seed treatments on seedling emergence and on Alternaria blight of sunflower during the 1991 field trial

Fungicide	Dose (g a.i/kg seed)	Seedling emergence (%)*	Seedling blight incidence*	No. of leaves Shed/Plant	Alternaria blight Severity**
Metalaxyl	1.0	83.7a	0.0b	7.0c	2.1c
+Carboxin	2.0	78.7a	0.0b	6.0c	2.1c
	5.0	46.3bc	0.3b	6.3c	2.2bc
Benomyl	1.0	54.0b	0.0b	10.0b	2.5b
	2.0	48.5bc	0.3	9.0	2.4b
	5.0	48.3bc	0.3	8.0bc	2.5b
Mancozeb	1.0	64.0a	0.0b	8.0bc	2.3bc
	2.0	58.3b	0.0b	8.0bc	2.3bc
	5.0	54.3b	0.0b	8.0bc	2.4b
Carbendazim	1.0	66.9a	0.3b	7.3c	2.4b
+iprodione	2.0	55.4b	0.0b	6.3c	2.3b
	5.0	56.7b	0.0b	6.3c	2.3b
Carbendazim	1.0	58.0b	0.0b	8.3bc	2.4b
+Maneb	2.0	60.0ab	0.0b	8.0bc	2.4b
	5.0	62.0ab	0.0b	8.0bc	2.4b
Check	0.0	37.0bc	2.3a	14.7a	3.0a
LSD (P = 0.05)		21.0	0.7	2.3	0.2

* Means followed by the same letter(s) are not significantly different at P = 0.05

** 1-6 scale in which 1 = No leaf infection and 6 = 76-100% leaf completely killed.

ns = not significant

During the 1991 field trial, seeds treated with metalaxyl + carboxin at 1 and 2g a.i/kg seed produced plants with the lowest Alternaria blight severity which is significantly lower than plants whose seeds were treated with benomyl, carbendazim + iprodione and carbendazim + maneb at all rates. The untreated check had significantly higher Alternaria blight than the treated plants. Incidentlly, the untreated check had the highest number of leaves shed prematurely which was signficantly different from the treated plants.

4.4.2 Effects of Fungicide Seed Treatment on Seedling Emergence, Seedling Blight Incidence and Alternaria Blight of Sunflower During the 1992 Field Trial

The result is presented in Table 4.4.2. In the 1992 field trial, fungicide seed treatment significantly increased seedling emergence. The best seedling emergence were observed in seeds treated with metalaxyl + carboxin at 1 and 2g a.i/kg seed and carbendazim + maneb at 2g a.i/kg seed. These were significantly better than those treated with benomyl, mancozeb ad carbendazim + iprodione at all rates but whose performance was not significantly different from each other. Seedling emergence in the untreated check was, however, significantly lower than all the chemicals evaluated.

During the 1992 field trial, all the fungicide seed treatments at all concentrations recorded seedling blight incidence that were not significantly different from each other and also from the untreated check.

Table 4.4.2: Effect of fungicide seed treatment on seedling emergence and on Alternaria blight of sunflower during the 1992 field trial

Fungicide	Dose (g a.i/kg seed)	Seedling emergence (%)*	Seedling blight incidence*	No.of leaves Shed/plant*	Alternaria blight Severity**
Metalaxyl	1.0	82.2a	1.7	12.0bc	2.0
+Carboxin	2.0	82.5ab	2.7	13.0b	1.8
	5.0	63.3c	3.7	13.3b	2.1
Benomyl	1.0	51.0c	3.0	13.7b	2.3
	2.0	55.4c	2.0	14.7b	2.3
	5.0	56.1c	3.7	15.5b	2.4
Mancozeb	1.0	72.0b	3.7	13.7	1.8
	2.0	70.1b	0.7	14.7b	2.1
	5.0	69.5b	0.7	14.7b	2.2
Carbendazim	1.0	75.9b	2.0	10.3c	2.3
+iprodione	2.0	71.8b	1.0	13.0b	2.0
	5.0	74.1b	1.0	14.3b	2.0
Carbendazim	1.0	52.7cd	0.7	14.7b	2.1
+Maneb	2.0	76.2ab	2.0	15.0b	2.2
	5.0	67.9b	2.7	14.7b	2.1
Check	0.0	41.4d	4.0	18.3a	2.5
LSD (P = 0.05)		12.4	ns	1.95	ns

* Means followed by the same letter(s) are not significantly different at α = 0.05

** 1-6 scale in which 1 = No leaf infection and 6 = 76 - 100% leaf completely killed

ns = not significant

In the 1992 growing season, there were no significant differences in Alternaria blight severity between plants whose seeds were treated with fungicides and those not treated. However, the untreated check gave the highest Alternaria blight severity. Incidentally the untreated check had a significantly .pn35 higher number of leaves shed prematurely than all the treated plar'-

4.4.3 Effects of Fungicide Seed Treatment on Seedling Emergence, Seedling Blight Incidence and Alternaria blight severity of sunflower during the 1991 and 1992 field trial

A combined analysis of the 1991 and 1992 field trials is presented in Table 4.4.3. The result showed that metalaxyl + carboxin at the rate of 1 and 2g a.i/seed gave the highest seedling emergence which were significantly different from all the other seed treatment fungicides. These were followed by metalaxyl + carboxin, crbendazim + iprodione at the rates of 5 and 2g a.i/kg seed respectively. The untreated check gave a significantly lower seedling emergence than all the fungicide seed treatments. On the whole, seedling emergence during 1991 wet season was not significantly different from that of 1992.

A combined analysis of the 1991 and 1992 growing seasons also revealed that planting without fungicide seed treatment resulted in significantly higher seedling blight incidence than those treated. Seed treatment with carbendazim + maneb at the rate of 1g a.i/kg seed and mancozeb at 2 and 5g a.i/kg seed produced the least seedling blight that was not significantly different from seed

Table 4.4.3: Combined table of the effect of fungicide seed treatment on seedling emergence and on Alternaria blight of sunflower during the 1991 and 1992 field trials

Fungicide	Dose (g a.i/kg seed)	Seedling emergence (%)*	Seedling blight incidence*	No. of leaves Shed/plant*	Alternaria blight Severity**
Metalaxyl	1.0	85.9a	0.8bc	8.3d	2.0c
+Carboxin	2.0	80.6ab	1.3bc	8.8d	1.9c
	5.0	73.5b	2.0b	9.8d	2.1c
Benomyl	1.0	58.9c	1.0bc	10.0c	2.2b
	2.0	57.2	1.8b	11.5	2.4b
	5.0	56.4	1.2b	10.7	2.5b
Mancozeb	1.0	63.2bc	2.2b	10.8c	2.0c
	2.0	59.3c	0.3bc	11.3bc	2.2b
	5.0	58.9c	0.3bc	12.3b	2.3b
Carbendazim	1.0	71.4b	1.2b	10.8c	2.4b
+iprodione	2.0	72.5	0.5bc	9.5d	2.1c
	5.0	65.4b	0.5bc	11.7b	2.1c
Carbendazim	1.0	55.3c	0.3c	11.5b	2.3b
+Maneb	2.0	68.1b	1.0bc	11.5b	2.3b
	5.0	65.0b	1.3b	9.2c	2.2b
Check	0.0	39.2d	3.2a	14.2a	2.8a
LSD	(P = 0.05)	11.7	1.4	1.4	0.3

* Means followed by the same letter(s) are not significantly different at P = 0.05

** 1-6 scale in which 1 = No leaf infection and 6 = 76-100% leaf completely killed

ns = not significant

treatment with metalaxyl + carboxin and carbendazim + iprodione at 2 and 5g a.i/kg seed.

The Alternaria blight severity for both 1991 and 1992 also showed that the untreated check had significantly higher Alternaria blight severity than the fungicide seed treatment. Seed treatment with metalaxyl + carboxim at 2g a.i/kg seed gave the least Alternaria blight severity. This was however, not .pn37 significantly lower than the rest of the fungicide seed treatments except benomyl at all rates, mancozeb at 5g a.i/kg seed and carbendazim + iprodione at 1g a.i/kg seed.

4.4.4 Effects of Fungicide Seed Treatment on Yield and Yield Components of Sunflower in the 1991 Field Trial

The effects of fungicides seed treatments on yield and yield components of sunflower were evaluated during the 1991 field trial. The result is presented in Table 4.4.4. The results showed that there were no significant differences among the treatments in relation to plant height, head diameter, head weight and seed weight. However, plant height, head diameter, head weight and seed weight per plant and per plot were lowest in the untreated check.

Table 4.4.4: Effect of fungicide seed treatment on yield and yield components of sunflower in the 1991 field trial

Fungicide	Dose (g a.i/kg seed)	Mean Plant height (cm)	Mean Head diameter (cm)	Mean Head Weight/ Plant (g)	Seed Weight/ plant (g)	Seed Weight/ plot (Kg)
Metalaxyl	1.0	1[illegible]5	17.6	90.3	48.6	2.2
+Carboxin	2.0	172.0	17.2	75.0	47.1	2.4
	5.0	165.3	15.7	67.1	54.0	2.2
Benomyl	1.0	153.3	15.3	81.9	29.3	2.0
	2.0	159.0	15.7	69.3	42.3	2.1
	5.0	161.0	15.8	75.9	47.5	1.7
Mancozeb	1.0	162.0	16 0	74.0	46.2	2.0
	2.0	168.7	17.0	84.9	51.3	1.9
	5.0	175.3	18.0	85.0	50.8	2.3
Carbendazim	1.0	166.7	16.0	63.6	46.2	1.8
+iprodione	2.0	164.0	14.9	72.5	44.4	2.1
	5.0	165.0	16.4	78.1	49.0	2.1
Carbendazim	1.0	168.0	17.3	75.3	46.0	2.1
+Maneb	2.0	161.0	17.7	70.3	51.6	2.2
	5.0	161.7	16.4	83.2	48.2	2.2
Check	0.0	147.3	12.4	41.5	27.0	1.2
LSD (P = .05)		ns	ns	ns	ns	ns

ns = not significant

4.4.5 Effects of Fungicide Seed Treatments on Yield and Yield Components of Sunflower in the 1992 Field Trial

The effects of fungicide seed treatments on yield and yield components of sunflower in the 1992 field trial is presented in Table 4.4.5.

Seeds treated with metalaxyl + carboxin at 5g a.i/kg seed produced the tallest plants but were however not significantly taller than those treated with mancozeb at 1g a.i/kg seed and metalaxyl + carboxin at 1 and 2g a.i/kg seed. Those treated with benomyl at all rates, carbendazin + iprodione at 1g a.i/kg seed and carbendazim + maneb at 5g a.i/kg seed were significantly lower than the rest of the fungicide treatments. The untreated check gave the least plant heights that were significantly shorter than the seed treatment chemicals.

Differences in the mean head diameter in all the treatments during the 1992 field trial were significant. Seed treatment with metalaxyl + carboxin at 5g a.i/kg seed produced plants with the largest heads but were not significantly different from those treated with metalaxyl + carboxin and mancozeb at 1 and 2g a.i/kg seed each as well as carbendazim + iprodione at 2 and 5g a.i/kg seed.

During the 1992 field trial there was also no significant difference in mean head weight/plant. However there were significant differences among the treatments in relation to seed weight/plant and per plot. Seed treatment with metalaxyl+carboxin at 5g a.i/kg seed produced plants with the highest yield per plant. These were however not significantly higher than those

Table 4.4.5: Effect of fungicide seed treatment on yield and yield components of sunflower in the 1992 field trial

Fungicide	Dose (g a.i/kg seed)	Mean Plant height (cm)	Mean Head diameter (cm)	Mean Head weight/ Plant (g)	Seed Weight/ plant (g)	Seed Weight/ plot (Kg)
Metalaxyl	1.0	150.7a	15.0a	78.1	44.9a	1.1a
+Carboxin	2.0	153.0a	15.7a	77.1	39.1a	0.8ab
	5.0	158.3a	16.2a	85.3	42.9a	0.9ab
Benomyl	1.0	126.7bc	13.4b	67.0	28.4bc	0.7b
	2.0	124.3c	14.1b	63.7	27.5c	0.6b
	5.0	123.7c	13.6b	65.0	29.5b	0.7b
Mancozeb	1.0	150.7a	15.4a	67.0	33.1ab	0.6b
	2.0	128.7b	15.4a	76.9	28.6b	0.7b
	5.0	129.3b	14.2b	70.4	27.5b	0.7b
Carbendazim	1.0	119.7c	12.5bc	63.7	27.5bc	0.6b
+iprodione	2.0	139.7b	14.8ab	68.8	32.9ab	0.7b
	5.0	136.3b	14.9ab	72.1	33.0ab	0.7b
Carbendazim	1.0	136.0b	13.0bc	70.0	32.7ab	0.7b
+Maneb	2.0	137.3b	14.1b	67.0	28.4bc	0.5b
	5.0	124.3c	13.8b	65.4	29.4bc	0.6b
Check	0.0	99.7d	11.6c	47.4	19.4c	0.3cd
LSD	(P = 0.05)	9.7	1.6	ns	12.0	0.3

* Means in a column followed by the same letter(s) are not significantly different at P = 0.05

ns = not significant

treated with metalaxyl + carboxin at 1 and 2g a.i/kg seed, mancozeb at 1g a.i/kg seed, carbendazim + iprodione at 2 and 5g a.i/kg seed and carbendazim + maneb at the rate of 1g a.i/kg seed. The result, however, showed that the untreated check produced lower seed weight per plant which was not significantly different from seed treatment with benomy (at 1 and 2g a.i/kg seed, carbendazim + maneb at 2 and 5g a.i/kg seed and carbendazim + iprodione at 1g a.i/kg seed. Similarly seed treatment with metalaxyl + carboxin at the rate of 1g a.i/kg seed produced plants with the highest seed weight per plot which was significantly higher than seed treatment with benomyl, Mancozeb and carbendazim + iprodione at all rates but not metalaxyl + carboxin at 2 and 5g a.i/kg seed. The untreated check gave the least seed weight per plot which was not significantly lower than seed treatment with carbendazim + maneb at 2g a.i/kg seed.

4.4.6 Effects of Fungicide Seed Treatment on Yield and Yield Components of Sunflower During the 1991 and 1992 Field Trials

A combined analysis of the effects of fungicide seed treatment on yield and yield components of sunflower during the 1991 and 1992 field trial is presented in Table 4.4.6. The result showed that seed treatments with metalaxyl + carboxin at 1g a.i/kg gave the tallest plants which were not significantly different from treatment with carboxin + metalaxyl at 2 and 5g a.i/kg seed, mancozeb at 1 and 2g a.i/kg seed and carbendazim + maneb at 2g a.i/kg seed. The untreated check gave the least plant height which

Table 4.4.6: A combined table of the effect of fungicide seed treatment on yield and yield components of sunflower in the 1991 and 1992 field trial

Fungicide	Dose (g a.i/kg seed)	Mean Plant/ height (cm)	Mean Head diameter (cm)	Mean Head weight/ Plant (g)	Seed Weight/ plant (g)	Seed Weight/ plot (Kg)
Metalaxyl	1.0	165.2	16.9a	83.7a	46.8a	1.7a
+Carboxin	2.0	160.8a	15.7ab	76.1a	43.1a	1.6a
	5.0	161.7a	14.9b	77.3a	47.1a	1.2b
Benomyl	1.0	136.8b	14.8b	68.8a	29.4b	1.2b
	2.0	137.7b	15.1b	70.5a	37.0a	1.2b
	5.0	143.8b	14.3b	63.6b	38.8a	1.4a
Mancozeb	1.0	156.2ab	15.7ab	70.6a	39.7	1.4a
	2.0	155.8ab	15.3b	75.2a	39.7a	1.3a
	5.0	145.3	15.7ab	74.3a	39.2a	1.5a
Carbendazim	1.0	144.2b	15.6ab	76.4a	42.6a	1.5a
+iprodione	2.0	141.8b	15.7ab	77.3a	38.7a	1.4a
	5.0	152.3b	15.7ab	75.5a	41.0a	1.6a
Carbendazim	1.0	152.2	15.1b	72.7a	39.3a	1.4a
+Maneb	2.0	157.3ab	15.9a	74.5a	40.0a	1.3a
	5.0	150.7b	15.5ab	74.3a	40.1a	1.4a
Check	0.0	123.5c	12.0c	44.5b	23.2b	0.8b
LSD	(P = 0.05)	12.3	1.7	16.9	10.6	0.4

* Means followed by the same letter(s) are not significantly different at P = 0.05

was significantly different from all the fungicides evaluated.

Also a combined analysis of the two field trials showed that seed treatment significantly increased head diameter. Seed treatment with metalaxyl + carboxin at 1g a.i/kg seed produced plants with the largest heads followed by seed treatment with metalaxyl + carboxin at 5 and 2g a.i/kg seed carbendazin + maneb at 2g a.i/kg seed, and mancozeb at 1g a.i/kg seed in that decreasing. These were however not significantly different from each other except seed treatment with benomyl at all rates which gave the least head diameter but which were not significantly different from those of carbendazim + iprodione and carbendazin + maneb at 5g a.i/kg seed. The untreated check, however, produced significantly smaller head diameter than all the fungicides evaluated.

The combined analysis also showed that head weight was significantly increased by seed treatment with fungicides Seed .pn43 treatment with benomyl at all rates gave the least head weight among the fugicides evaluated which was significantly different from the rest of the fungicides except the untreated check. Seed treatment with benomyl at 1g a.i/kg seed gave the least seed weight per plant which is significantly different from all the other fungicides but was, however, not significantly different from the untreated check.

Seed treatment with metalaxy + carboxin at 1g a.i/kg seed gave the highest yield per plot while seed treatment with benomyl at 1 and 2g a.i/kg seed gave one of the lowest among the fungicides

used. These were significantly lower than all the other seed treatment chemicals except seed treatment with metalaxyl + carboxin at 5g a.i/kg seed and the untreated check.

4.4.7 Correlation Analysis of Parameters used in Evaluating Seed Treatment Chemicals for the control of Alternaria Blight

The correlation analysis of parameters used in evaluating seed treatment chemicals for the control of Alternaria blight during the 1991, 1992 and the two years combined are presented in Tables 4.4.7, 4.4.8 and 4.4.9 respectively. During the 1991 season, there was a negative but significant correlation between Alternaria blight and seed weight per plant (r = -0.27) as well as seed weight per plot (r = -0.32). Similarly in 1992 there was a highly significant but negative correlation between Alternaria blight severity and seed weight per plant (r = -0.40) as well as seed weight per plot (r = -0.35). However, a combined analysis showed that there was a negative and non-significant correlation (r = -0.05) between these parameters. There was also a positive and significant correlation between Alternaria blight severity and the number of leaves shed prematurely during the 1991 (r = 0.24) and 1992 (r = 0.50) field trials. A combined analysis however showed that there was a positive correlation between Alternaria blight severity and number of leaves shed prematurely (r = 0.24) but was not significant. Also during the 1991 season, while there was a positive correlation between numbers of leaves shed prematurely (r = 0.36) and yield per plot, there was a

Table 4.4.7: Correlation analysis of parameters used in evaluating seed treatment fungicides for the control of Alternaria blight of sunflower during the 1991 field trial

Parameters	V1	V2	V3	V4	V5	V6	V7	V8	V9
Seed weight/plot (V1)	1.00								
Seed weight/plant (V2)	0.47*	1.00							
Head weight/plant (V3)	0.43*	0.75**	1.00						
No. of leaves shed (V4)	0.36*	0.40**	0.47**	1.00					
Alternaria blight/ severity (V5)	-0.32*	-0.27	-0.43**	0.24	1.00				
Head diameter (V6)	0.38*	0.50**	0.44**	0.40**	-0.29*	1.00			
Plant height (V7)	0.52*	0.25	0.34*	0.06	-0.31*	0.49**	1.00		
Seedling blight (V8)	-0.47*	-0.27	-0.38**	-0.55**	0.55**	-0.39**	-0.35*	1.00	
Seedling emergence (V9)	0.19	-0.07	0.05	0.09	-0.46**	-0.04	0.01	-0.29	1.00

*Significant (P = 0.05)
** highly significant (P = 0.01)

Table 4.4.8: Correlation analysis of parameters used in evaluating seed treatment fungicides for the control of *Alternaria* blight of sunflower during the 1992 field trial

Parameters	V1	V2	V3	V4	V5	V6	V7	V8	V9
Seed weight/plot (V1)	1.00								
Seed weight/plant (V2)	0.44**	1.00							
Head weight/plant (V3)	0.45**	0.30*	1.00						
No. of leaves shed (V4)	-0.45**	-0.60**	-0.51**	1.00					
Alternaria blight/ severity (V5)	-0.35*	-0.40*	-0.38**	0.50**	1.00				
Head diameter (V6)	0.54**	0.47**	0.50**	-0.54**	-0.52**	1.00			
Plant height (V7)	0.22	0.36*	0.35*	-0.41**	-0.30*	0.42**	1.00		
Seedling blight (V8)	0.03	-0.13	-0.16	-0.08	0.01	-0.05	0.16	1.00	
Seedling emergence (V9)	0.29	0.28	0.26	-0.27	-0.08	0.33*	0.13	-0.15	1.00

*Significant (P = 0.05)
** highly significant (P = 0.01)

Table 4.4.9: Combined correlation analysis of parameters used in evaluating seed treatment fungicides for the control of Alternaria blight of sunflower during the 1991 and 1992 field trial

Parameters	V1	V2	V3	V4	V5	V6	V7	V8	V9
Seed weight/plot (V1)	1.00								
Seed weight/plant (V2)	0.65**	1.00							
Head weight/plant (V3)	0.36**	0.59**	1.00						
No. of leaves shed (V4)	-0.66**	-0.38**	-0.03	1.00					
Alternaria blight severity (5)	0.19	-0.05	-0.29**	-0.24*	1.00				
Head diameter (V6)	0.61**	0.62**	0.48**	-0.33**	-0.12	1.00			
Plant height (V7)	0.59**	0.49**	0.32**	-0.54**	-0.01	0.53**	1.00		
Seedling blight (V8)	-0.53**	-0.40**	-0.25**	0.34**	-0.13	-0.37**	-0.24*	1.00	
Seedling emergence (V9)	-0.13	-0.09	0.07	0.19	-0.33**	-0.04	-0.09	0.02	1.00

*Significant (P = 0.05)
** highly significant (P = 0.01)

negative and highly significant correlation (r = -0.45) between these two parameters during the 1992 field trial. Similarly a combined analysis showed that the correlation between numbers of leaves shed per plant and yield is negative (r = -0.66) and is highly significant.

On the yield and yield components, the results showed that during the 1991 field trial, there was a positive and significant correlation between head weight and seed weight per plant (r = 0.75) as well as seed weight per plot (r = 0.43). Similarly, there was a positive and significant correlation between head weight and seed weight per plant (r = 0.29) as well as seed weight per plot (r = 0.36).

There was also a positive and significant correlation between head diameter and seed weight per plant (r = 0.38) as well as per plot (r = 0.38) during the 1991 wet season. Also during the 1992 season there was a positive and significant correlation between head diameter and seed weight per plant (r = 0.47)and per plot (r = 0.54).

While the correlation between plant height and yield per plant was positive but non-significant (r = 0.25) during the 1991 wet season, it was positive and highly significant (r = 0.36) during the 1992 season. There was a positive and significant correlation between plant height and seed weight per plot (r = 0.52) in the 1991 season but was not significant in the 1992 season. However, the combined analysis indicated that there was a positive and significant correlation between plant height and

yield per plant (r = 0.49) and per plot (r = 0.59).

4.5 EVALUATION OF FOLIAR FUNGICIDE SPRAYS FOR THE CONTROL OF ALTERNARIA BLIGHT OF SUNFLOWER

4.5.1 Effects of Foliar Fungicide Sprays on Alternaria Blight of Sunflower During the 1991 Field Trial

The effects of foliar fungicide sprays on Alternaria blight of sunflower during the 1991 field trial are summarised in Table 4.5.1. Fungicidal sprays significantly reduced Alternaria blight severity and numbers of leaves shed compared with the unsprayed check. There were however no significant differences between the fungicide doses with respect to their effects on blight severity and number of leaves shed prematurely. Foliar spray with carbendazim + maneb at 2.6kg a.i/ha resulted in the least defoliation and similarly the lowest Alternaria blight severity score. Foliar spray with benomyl gave a significantly higher Alternaria blight severity than the other two fungicides. The result also showed that there was no significant differences among the treatments in relation to seedling emergence and seedling blight incidence.

4.5.2 Effects of Foliar Fungicides Spray on Alternaria Blight of Sunflower During the 1992 Field Trial

The result of the effects of foliar fungicide spray on Alternaria blight of sunflower during the 1992 field trial is presented in Table 4.5.2. There were significant differences among the treatments in terms of mean number of leaves shed per plant and Alternaria blight severity. The unsprayed check had the

Table 4.5.1: Effects of foliar fungicidal sprays on Alternaria blight of sunflower during the 1991 field trial

Fungicide	Dose (Kg a.i/ ha)	Seedling emergence (%)	Seedling blight incidence	No. of leaves shed/ plant*	Alternaria blight serverity*
Benomyl	0.6	67.2	1.3	8.7b	2.4b
	0.7	72.3	0.3	8.0b	2.6b
Carbendazim	2.4	67.7	0.3	7.7b	1.7c
Maneb	1.6	69.7	0.0	6.3b	1.8c
Mancozeb	2.5	65.7	0.3	8.7b	2.1c
	2.7	69.2	1.0	8.3b	1.9c
Control	0.0	64.9	0.7	13.7a	3.0a
LSD (P = 0.05)		ns	ns	3.7	0.3

* Means followed by the same letter(s) are not significantly different at P = 0.05

ns = Not significant

Table 4.5.2: Effects of foliar fungicidal sprays on Alternaria blight of sunflower during the 1992 field trial

Fungicide	Dose (Kg a.i/ ha)	Seedling emergence (%)	Seedling blight incidence	No. of leaves shed/ plant*	Alternaria blight severity*
Benomyl	0.6	55.1	4.0	13.0b	1.4b
	0.7	60.9	3.7	14.7ab	1.4b
Carbendazim	2.4	50.8	2.7	11.7b	1.1c
+ Maneb	2.6	60.4	2.3	13.0	1.2bc
Mancozeb	2.5	63.9	3.3	12.7b	1.2bc
	2.7	50.3	3.0	11.7b	1.4b
Control	0.0	58.6	2.3	17.3a	1.7a
LSD (P = 0.05)		ns	ns	2.7	0.2

* Means followed by the same letter(s) are not significantly different at P = 0.05

ns = Not significant

highest defoliation which was significantly higher than all the fungicide sprays evaluated except benomyl at 0.7kg a.i/ha. Foliar spray with Carbendazim + maneb at 2.4kg a.i/ha and mancozeb at 2.7kg a.i/ha resulted in the lowest numbers of leaves shed prematurely and incidentally the lowest Alternaria blight severity.

4.5.3 Effects of Fungicide Sprays on Alternaria Blight of Sunflower in the 1991 and 1992 Field Trials

A combined analysis of the effects of fungicidal sprays for the control of Alternaria blight of sunflower is shown on Table 4.5.3. The result showed that the unsprayed check had the highest mean defoliation and highest Alternaria blight severity that differ significantly from all the fungicides Spraying with carbendazim + maneb at 2.4kg a.i/ha and 2.6kg a.i/ha gave the lowest number of leaves shed and incidentally the lowest Alternaria blight severity. Foliar spray with benomyl at 0.6kg and 0.7kg a.i/ha gave the highest Alternaria blight severity among the fungicides evaluated. These were significantly different from the rest of the fungicidal sprays.

4.5.4 Effects of Fungicide Sprays on Yield and Yield Atributes of Sunflower During the 1991 Field Trial

In the 1991 field trial, spraying with fungicides significantly increased yield components of sunflower compared with the unsprayed check (Table 4.5.4).

Table 4.5.3: Combined table of the effects of fungicide sprays on Alternaria blight of sunflower in the 1991 and 1992 field trial

Fungicide	Dose (Kg a.i/ ha)	Seedling emergence (%)	Seedling blight incidence	No. of leaves shed/ plant*	Alternaria blight severity*
Benomyl	0.6	61.1	2.7	10.7b	1.8b
	0.7	66.6	2.0	11.5b	1.6b
Carbendazim	2.4	59.2	1.5	9.7b	1.4c
+ Maneb	2.6	65.1	1.2	9.7b	1.4c
Mancozeb	2.5	64.8	1.8	10.5b	1.6bc
	2.7	59.7	2.0	10.2	1.5bc
Control	0.0	61.7	1.5	15.5a	2.3a
LSD (P = 0.05)		ns	ns	2.3	0.2

* Means followed by the same letter(s) are not significantly different at P = 0.05

ns = Not significant

Table 4.5.4: Effects of foliar fungicidal sprays on yield and yield components of sunflower during the 1991 field trial

Fungicide	Dose (Kg a.i/ ha)	Plant height* (cm)	Head diamter* (cm)	Head weight* (g)	Seed weight/* plant (g)	Seed weight/ plot* (kg)
Benomyl	0.6	157.0a	14.0a	57.4a	32.3bc	1.9ab
	0.7	160.0a	13.5a	60.8a	30.8bc	2.4a
Carbendazim	2.4	164.0a	15.4a	72.2a	45.6a	3.1a
+ Maneb	2.6	168.3a	15.3a	63.3a	44.7a	2.8a
Mancozeb	2.5	164.7a	14.6a	65.4a	44.7a	2.8a
	2.7	168.0a	15.2a	61.5a	37.6ab	3.0a
Control	0.0	135.3b	10.2b	29.6b	21.8c	1.1b
LSD (P = 0.05)		12.67	2.33	16.78	13.3	0.9

* Means followed by the same letter(s) are not significantly different at P = 0.05

Fungicidal spray with carbendazim + maneb at 2.6 kg a.i/ha produed the tallest plants, followed by spray with mancozeb at 2.7kg a.i/ha and 2.5kg a.i/ha and carbendazim + maneb at 2.4kg a.i/ha. Spraying with benomyl gave the shortest plants among the fungicide regimes. There, were however, no significant difference among the fungicide regimes but the unsprayed check was significantly lower.

Also during the 1991 field trial, fungicide sprays significantly increased head diameter. Fungicide spray with carbendazim + maneb at 2.4Kg a.i/ha gave the best head diameter. This was, however, not significantly better than all the other fungicide spray regimes. The unsprayed check had significantly smaller heads than all the other fungicide sprays.

Fungicide spray during the 1991 also signigicantly increased head weights in sunflower. The heaviest heads were obtained from plants sprayed with carbendazim + maneb at 2.4Kg a.i/ha followed by Mancozeb at 2.5kg a.i/ha carbendazim + Maneb at 2.6kg a.i/ha mancozeb at 2.7kg a.i/ha, benomyl at 0.7 and 0.6kg a.i/ha in that order. The differences among the fungicide regimes were however not significant but were significantly higher than the unsprayed check.

In the 1991 field trial, seed weight per plant and per plot were significantly increased by fungicidal spray. Fungicide spray with carbendazin + Maneb at 2.4kg a.i/ha gave the best yield per plant which was not statistically higher than all the fungicide sprays except benomyl at both 0.6 and 0.7kg a.i/ha and the

unsprayed check. Similarly, the best yields per plot were obtained from plants sprayed with carbendazim + maneb at 2.4kg a.i/ha. The unsprayed check had a significantly loweryield/plot than all hte fungicide spray regimes except benomyl at 0.6kg a.i/ha.

4.5.5 Effects of Foliar Fungicidal Sprays on Yield and Yield Components of Sunflower During the 1992 Field Trial

During the 1992 field trial, fungicide sprays toa large extent increased plant height, head diamter, head weight, and yield per plant as well as per plot (Table 4.5 5).

Spraying with carbendazim + maneb at 2.6kg a.i/ha gave the plants that were significantly taller than all the fungicide sprays except carbandazim + maneb and mancozeb at 2.4 and 2.5kg a.i/ha respectively. The unsprayed check produced plants that were significantly shorter than all the fungicide regimes evaluated.

Fungicide spray with carbendazim + Maneb at 2.4kg a.i/ha gave the largest head diameter which was significantly different from plants sprayed with benomyl and mancozeb. The unsprayed check gave the smallest heads which differ significantLy from all the fungicides evaluated.

Fungicide spray with carbendazim + maneb at 2.6kg a.i/ha gave the heaviest heads that differed significantly from all the other fungicide regimes evaluated.

Seed yield per plant was significantly increased by fungicide spray with carbendazim + maneb at 2.4kg a.i/ha giving

Table 4.5.5: Effects of foliar fungicidal sprays on yield and yield components of sunflower during the 1992 field trial

Fungicide	Dose (Kg a.i/ ha)	Plant height* (cm)	Head diameter* (cm)	Head weight* (g)	Seed weight/* plant (g)	Seed weight/ plot* (kg)
Benomyl	0.6	132.6b	15.3b	56.9c	40.9bc	0.9
	0.7	137.3b	14.5b	72.1b	39.3bc	1.2
Carbendazim	2.4	145.0ab	16.0a	73.7b	55.3a	1.9
+ Maneb	2.6	150.7a	14.3b	80.1a	43.7ab	1.0
Mancozeb	2.5	150.0a	14.1b	67.4bc	42.8ab	1.1
	2.7	142.0b	14.6b	62.3c	49.6ab	1.5
Control	0.0	116.3c	11.3c	43.9d	27.8c	0.7
LSD	(P = 0.05)	8.9	0.7	5.7	13.6	ns

* Means followed by the same letter(s) are not significantly different at P = 0.05
ns = Not significant

the highest. The control had significantly lower yields than all fungicide sprays evaluated except benomyl at 0.6 and 0.7kg a.i/ha. The yields per plot was however not significantly different among the treatments.

4.5.6 Effects of Foliar Fungicidal Sprays on Yield and Yield components of Sunflower in the 1991 and 1992 Field trials

The combined analysis of the effects of foliar fungicide sprays on yields and yield attributes of sunflower in 1991 and 1992 is presented in Table 4.5.6 The unsprayed check produced plants with significantly lower plant height, head diameter, head weight and seed weight per plant and per plot. There were significant differences among the fungicides with respect to plant height, head diameter, head weight and consequently yield per plant and per plot. Carbendazim + maneb at 2.6kg a.i/ha gave the tallest plants that differ significantly from the rest of the fungicide sprays except carbendazim + maneb at 2.4kg a.i/ha.

Fungicide spray with carbendazim + maneb at 2.4kg a.i/ha gave the biggest heads while benomyl gave the least among the fungicides evaluated. The unsprayed check however had significantly lower head diameter than all hte fungicide spray regimes. The combined analysis also showed that the heaviest heads were obtained from plants sprayed with carbendazim + maneb at 2.4kg a.i/ha which was significantly different from all the other fungicides tried. The unsprayed check gave the least head weight.

Table 4.5.6: A combined table of the effects of foliar fungicidal sprays on yield and yield components of sunflower during the 1991 and 1992 wet seasons

Fungicide	Dose (Kg a.i/ ha)	Plant height* (cm)	Head diamter* (cm)	Head weight* (g)	Seed weight/* plant (g)	Seed weight/ plot* (kg)
Benomyl	0.6	140.3a	12.5b	56.3bc	38.0b	1.5ab
	0.7	145.6ab	14.0b	61.0b	40.2b	1.4ab
Carbendazim	2.4	150.7ab	15.7a	72.9a	50.4a	2.5a
+ Maneb	2.6	159.7a	14.8ab	60.1b	42.8ab	2.0ab
Mancozeb	2.5	153.8ab	14.3b	62.4b	40.4b	1.8b
	2.7	155.0ab	14.9ab	61.9b	38.5b	2.3a
Control	0.0	125.8c	10.8c	50.4c	24.8c	0.9c
LSD (P = 0.05)		7.8	1.2	8.9	9.5	0.6

* Means followed by the same letter(s) are not significantly different at P = 0.05

The result also showed that yield per plant and per plot were significantly increased. The highest yields were obtained from plants sprayed with carbendazim + maneb at 2.4 and 2.6kg a.i/ha as well as Mancozeb at the rate of 2.7kg a.i/ha. The control generally gave the lowest yields compared to the various fungicide regimes evaluated.

4.5.7 Correlation Analysis of Parameters Used in Evaluating the Effects of Fungicidal Sprays on Alternaria Blight

The results of the correlation analysis for 1991, 1992 and the two years combined are presented in Tables 4.5.7, 4.5.8 and 4.5.9 respectively. During the 1991 season there was a negative and significant correlation between Alternaria blight severity and head diameter (r = -0.78), head weight per plant (r = -0.76) and seed weight per plant (r = -0.57). Thus as Alternaria blight severity increased these parameters significantly decreased. There was, however, a positive and highly significant correlation between Alternaria blight severity and numbers of leaves shed prematurely. Thus as Alternaria blight increased, number of leaves shed also increased significantly. Also there was a negative and significant correlation between numbers of leaves shed prematurely and head diameter (r = -0.57) as well as with seed weight per plant (r = -0 28) and per plot (r = -0.53).

During the 1992 wet season there was also a negative and significant correlation between Alternaria blight severity and head diameter (r = 0.86) as well as with head weight per plant (r = -0.91), seedling blight incidence (r = -0.39), plant height (r

Table4.5.7: Correlation analysis of parameters used in evaluating fungicides sprays for the control of Alternaria blight of sunflower during the 1991 wet season

Parameters	V1	V2	V3	V4	V5	V6	V7	V8	9
Head diameter (V1)	1.00								
Seedling emergence (V2)	0.28	1.00							
Alternaria blight severity (V3)	-0.78**	-0.17	1.00						
Nos. of leaves shed (V4)	-0.57**	-0.37	0.8**	1.00					
dead weight/plant (V5)	0.69**	-0.18	-0.75**	-0.52**	1.00				
Seed blight (V6)	-0.04	-0.41*	0.02	0.29	0.12	1.00			
Seed weight/Plant (V7	0.62**	-0.13	-0.57**	-0.28	-0.70**	0.39*	1.00		
Seed weight/plot (V8)	0.81**	0.26	-0.76**	-0.53*	0.68**	0.03	0.59**	1.00	
Plant height (V9)	0.79**	0.30	-0.76**	-0.67**	0.62**	-0.20	0.34	0.77**	1.00

*Significant (P = 0.05)
** highly significant (P = 0.01)

Table 4.5.8: Correlation analysis of parameters used in evaluating fungicidal sprays for the control of Alternaria blight of sunflower during the 1992 wet season

Parameters	V1	V2	V3	V4	V5	V6	V7	V8	V9
Head diameter (V1)	1.00								
Seeding emergence (V2)	-0.21	1.00							
Alternaria blight severity (V3)	-0.86**	0.15	1.00						
Nos of leaves shed (V4)	-0.70**	0.14	0.62**	1.00					
Head weight/plant (V5)	0.82**	-0.19	-0.91**	-0.72**	1.00				
Seedling blight (V6)	0.28	0.24	-0.39	-0.24	0.35	1.00			
Seed weight/Plant (V7)	0.60**	-0.02	-0.57**	-0.56**	0.49*	0.21	1.00		
Seed weight/plot (V8)	0.50*	-0.37	-0.24	-0.24	0.26	-0.20	0.28	1.00	
Plant height (V9)	0.67**	0.24	-0.66**	-0.70**	0.71**	0.46*	0.47*	0.06	1.00

*Significant (P = 0.05)
** highly significant (P = 0.01)

Table 4.5.9: A combined correlation analysis of parameters used in evaluating fungicide sprays for the control of Alternaria blight of sunflower during the 1991 wet season

Parameters	V1	V2	V3	V4	V5	V6	V7	V8	V9
Head diameter (V1)	1.00								
Seedling emergence (V2)	0.10	1.00							
Alternaria blight severity (V3)	-0.52*	0.33*	1.00						
Nos of leaves shed (V4)	-0.47**	-0.46**	-0.14*	1.00					
Head weight/plant (V5)	0.71**	-0.28	-0.69**	-0.26	1.00				
Seedling blight (V6)	0.06	-0.43**	-0.66**	0.54*	0.33*	1.00			
Seed weight/plant (7)	0.56**	-0.22	-0.58**	-0.07	0.63**	0.40**	1.00		
Seed weight/Plot (V8)	0.50**	0.49**	0.24	-0.71**	0.19	-0.62**	0.06	1.00	
Plant height (V9)	0.60**	0.49**	0.06	-0.81**	0.37*	-0.38*	0.12	0.70**	1.00

*Significant (P = 0.05)
** highly significant (P = 0.01)

= -0.66) and seed weight per plant (r = 0.57). A combined analysis of the two years similarly showed that as Alternaria blight severity increased, plant height, head diameter, head weight and seed weight per plant reduced significantly (Table 4.5.9). Similarly there was a negative and significant correlation between the numbers of leaves shed per plant and head diameter (r = -0.46) as well as with seed weight per plot (r = - 0.71). There was however a positive and significant correlation between head, diameter and head and seed weight per plant.

4.6 EVALUATION OF SUNFLOWER VARIETIES FOR RESISTANCE TO ALTERNARIA BLIGHT

4.6.1 The Incidence and Severity of Alternaria Blight on 5 Varieties of Sunflower in the 1991 Field Trial

The incidence and severity of Alternaria blight of sunflower in the five varieties during the 1991 field trial is presented in Table 4.6.1. The results showed that the variety, Funtua had the highest seedling blight incidence which was significnatly different from the other varieties and incidentally it had the lowest seedling emergence. There were no significant differences among the varieites with respect to seedling emergence, number of leaves shed prematurely and Alternaria blight severity score. However, Chernaanka recoreded the lowest seedling blight incidence, numbers of leaves shed per plant as well as Alternaria blight severity.

Table 4.6.1: The incidence and severity of Alternaria blight on 5 varieties of sunflower during the 1991 field trial

Variety	Seedling emergence (%)	Seedling blight incidence*	No of leaves shed/plant	Alternaria blight severity
Isaanka	51.8	0.0b	10.5	3.1
Smena	57.1	0.3b	10.5	3.1
Funtua	47.8	1.3a	10.3	3.0
Chernaanka	62.1	0 0b	9.5	2.9
Record	64.7	0.0b	10.8	3.1
LSD (P = 0.05)	ns	0 [illegible]	ns	ns

* means followed by the same letter(s) are not significantly different at P = 0.05

ns = not significant at P = 0.05

4.6.2 The Incidence and Severity of Alternaria Blight on 5 Varieties of Sunflower in the 1992 Field Trial

During the 1992 field trial, the differences among the varieties in relation to seedling emergence, numbers of leaves shed prematurely and Alternaria blight severity were statistically significant (Table 4.6.2). Funtua gave the highest seedling emergence which was significantly higher than the other varieties. This was followed by Record which was not significantly different from Isaanka, Smena and Chernaanka. There were however no significant differences among the varieties in relation to seedling blight incidences. Record, however, gave the least seedling blight incidence while Isaanka gave the highest.

The numbers of leaves shed prematurely per plant were statistically significant. Smena recorded the highest numbers of leaves shed and incidentally the highest Alternaria blight incidence followed by Isaanka, Funtua and then Record in that order. Chernaanka had the least numbers of leaves shed which differ significantly from the rest of the varieties except Record.

4.6.3 The Incidence and Severity of Alternaria Blight on 5 Varieties of Sunflower in the 1991 and 1992 Field Trials

A combined analysis on the incidence and severity of Alternaria blight of sunflower on 5 varieties is presented in Table 4.6.3. The result showed that Record had the highest seedling emergence which did not differ significantly from Funtua and Chernaanka. Smena gave the least seedling emergence which was not significantly different from Isaanka. The differences among

Table 4.6.2: The incidence and severity of Alternaria blight o 5 varieties of sunflower during the 1992 wet season

Variety	Seedling emergence (%)	Seedling blight incidence*	No of leaves shed/plant	Alternaria blight severity
Isaanka	56.0b	3.5	13.5ab	3.2b
Smena	50.3b	2.8	15.3a	3.4a
Funtua	74.3a	2.3	12.8ab	2.9c
Chernaanka	57.8b	2.5	9.8c	2.9c
Record	59.3b	1.8	11.8bc	3.0c
LSD (P = 0.05)	14.2	ns	2.7	0.2

* means followed by the same letter(s) are not significantly different at P = 0.05

ns = not significant

Table 4.6.3: A combined table of the incidence and severity of Alternaria blight on 5 varieties of sunflower during the 1991 and 1992 field trial

Variety	Seedling emergence* (%)	Seedling blight incidence*	Nos of leaves shed/plant*	Alternaria blight severity*
Isaanka	53.9b	1.8	12.0a	3.2ab
Smena	53.7b	1.5	12.9a	3.3a
Funtua	61.0a	1.4	11.5ab	2.9b
Chernaanka	59.9a	1.3	9.6b	2.9b
Record	62.0a	0.9	11.3ab	3.0b
LSD (P = 0.05)	6.4	ns	1.9	0.1

* means followed by the same letter(s) are not significantly different at P = 0.05

ns = not significant at P = 0.05

the varieties in relation to seedling blight was not sigrificant, however, Chernaanka gave the least. While Smena gave the highest Alternaria blight severity and incidentally the highest numbers of leaves shed per plant, Chernaanka recorded the least with the lowest numbers of leaves shed. The differences in Alternaria blight severity between Smena and Isaanka did not differ significantly but were significantly higher than Funtua, Chernaanka and Record.

4.6.4 Yield and Yield Components of 5 Varieties of Sunflower During the 1991 Field Trial

When the yield and yield parameters were compared, there was no significant differences among the varieties in relation to plant height, head diameter, head weight, seed weight per plant and per plot during the 1991 field trial (Table 4.6.4).

4 6.5 Yie.. and Yield Components of 5 Varieties of Sunflower During the 1992 Field Trial

During the 1992 wet season there were significant differences among the varieties with respect to plant height, head diamater, head weight and seed weight per plot (Table 4.6.5). Chernaanka produced the tallest plant and was significantly different from Smena and Isaanka but not Funtua and Record.

Funtua had the largest head diameter which differ significantly from Isaanka, Smena and Record but not Chernaanka.

Also during the 1992 field trial, Funtua gave the highest seed weight per plant and consequently the highest seed weight per

Table 4.6.4: Yield and yield components of 5 varieties of sunflower during the 1991 field trial

Variety	Plant height (cm)	Head diameter (cm)	Head weight (g)	Seed weight/ Plant (g)	Seed weight/plot (kg)
Isaanka	127.0	14.0	55.3	31.9	0.3
Smena	122.6	13.2	47.3	24.3	0.2
Funtua	127.8	13.0	56.2	33.3	0.3
Chernaanka	120.8	11.5	62.5	35.2	0.4
Record	130.0	13.6	59.6	33.8	0.3
LSD (P = 0.05)	ns	ns	ns	ns	ns

ns = not significant

Table 4.6.5: Yieldand yield components of 5 varieties of sunflower during the 1992 field trial

Variety	Plant height (cm)	Head diameter (cm)	Head weight (g)	Seed weight/ Plant (g)	Seed weight/plot (kg)
Isaanka	126.3b	10.9bc	42.8c	42.1	0.4b
Smena	126.5b	10.1c	36.7c	26.7	0.4b
Funtua	130.0ab	13.7a	65.6a	47.0	0.7a
Chernaanka	134.3a	13.1ab	71.7a	45.1	0.6ab
Record	130.5ab	11.7b	55.5b	38.7	0.5ab
LSD (P = 0.05)	4.7	1.4	7.7	ns	0.2

* means followed by the same letter(s) are not significantly different at P = 0.05

ns = not significant

plot. The differences among the varieties in relation to seed weight per plant were however not statistically significant. Chernaanka gave higher yield per plot than Isaanka, Smena and Record. On the other hand a combined analysis showed that differences among the varieties in relation to their yields and yield components were significant statistically (Table 4.6.6).

The results also indicated that while seedling emergence and Alternaria blight severity during the 1991 were significantly lower than those of 1992, the differences between 1991 and 1992 in relation to head weight, seed weight per plant and per plot and numbers of leaves shed prematurely were not statistically significant.

4.6.6 Yields and Yield Components of 5 Varieties of Sunflower in the 1991 and 1992 Field Tials

A combined analysis showed that in the 1991 and 1992, gthe differences among the varieties in relation to their yields and yield components were not significant (Table 4.6.6).

4.6.7 Correlation Analysis Used in Screening 5 Sunflower Varieties

The results of the correlation analysis during the 1991, 1992 and the two years combined are presented in Tables 4.6.7, 4.6.8 and 4.6.9 respectively. The results showed that there were negative andnon-significant correlation between Alternaria blight severity and head weight (r = -0.25), seed weight per plant (r = -0.18) and seed weight per plot (r = -0.18) during the 1991

Table 4.6.6: A combined table of the yield and yield components of 5 varieties of sunflower during the 1991 and 1992 field trials

Variety	Plant height (cm)	Head diameter (cm)	Head weight (g)	Seed weight/ Plant (g)	Seed weight/plot (kg)
Isaanka	126.6	12.5	49.1	37.0	0.2
Smena	124.5	11.7	42.0	25.5	0.1
Funtua	128.9	13.4	60.9	40.2	0.2
Chernaanka	127.5	12.3	67.1	40.1	0.2
Record	130.3	12.6	57.6	36.3	0.2
LSD (P = 0.05)	ns	ns	ns	ns	ns

ns = not significant

Table 4.6.7: Correlation analysis of parameters used in evaluating sunflower varieties for resistance to Alternaria blight in 1991 field trial

Parameters	V1	V2	V3	V4	V5	V6	V7	V8	V9
Seedling emergence (V1)	1.00								
Head weight/plant (V2)	0.09	1.00							
Seed weight/plot (V3)	0.03	0.96**	1.00						
Seed weight/plant (V4)	0.03	0.96**	1.00	1.00					
Alternaria blight (V5)	0.06	-0.25	-0.18	-0.18	1.00				
Nos of leaves shed (V6)	0.13	0.54*	0.58**	0.58**	-0.19	1.00			
Head diameter (V7)	0.08	0.55*	0.59**	0.59**	0.21	0.43	1.00		
Plant height (V8)	0.37	0.39	0.43	0.43	-0.08	0.45*	0.06	1.00	
Seedling blight incidence (V9)	-0.41	0.01	-0.02	-0.02**	-0.41	0.14	-0.03	0.03	1.00

*Significant (P = 0.05)
** highly significant (P = 0.01)

Table 4.6.8: Correlation analysis of parameters used in evaluating sunflower varieties for resistence to Alternaria blight in 1992 field trial

Parameters	V1	V2	V3	V4	V5	V6	V7	V8	V9
Seedling emergence (V1)	1.00								
Head weight/plant (V2)	0.47*	1.00							
Seed weight/Plant (V3)	0.49*	0.45*	1.00						
Seed weight/Plant (V4)	0.50*	0.52*	0.57**	1.00					
Alternaria blight (V5)	-0.52*	-0.84**	-0.38	-0.29	1.00				
Nos. of leaves shed (V6)	-0.31	-0.59**	-0.57**	-0.24	0.65**	1.00			
Head diameter (V7)	0.52**	0.86**	0.4_	0.45*	-0.77**	-0.46*	1.00		
Plant height (V8)	0.28	0.65**	0.23	0.23	-0.58**	-0.46*	0.44	1.00	
Seedling blight incidence (V9)	-0.33	-0.26	-0.13	-0.15	0.30	0.22	-0.24	-0.23	1.00

*Significant (P = 0.05)
** Highly significant (P = 0.01)

Table 4.6.9: Combined correlation analysis of parameters used in evaluating sunflower varieties for resistance to Alternaria blight in the 1991 and 1992 field trial

Parameters	V1	V2	V3	V4	V5	V6	V7	V8	V9
Seedling emergence (V1)	1.00								
Head weight/Plant (V2)	0.20	1.00							
Seed weight/plot (V3)	-0.08	0.56**	1.00						
Seed weight/plant (V4)	0.25	0.77**	0.27	1.00					
Alternaria blight (V5)	-0.26	-0.45*	-0.10	-0.21	1.00				
Nos of leaves shed (V6)	-0.05	0.02	-0.19	0.23	0.35*	1.00			
Head diameter (V7)	0.22	0.61**	0.51**	0.44**	-0.22*	-0.10	1.00		
Plant height (V8)	0.33*	0.41*	0.07	0.40*	-0.19	0.21**	0.51**	1.00	
Seedling blight incidence (V9)	-0.13	-0.10	-0.59**	0.13	0.12	0.38**	-0.27	0.13	1.00

*Significant (= 0.05)
** highly significant (P = 0.01)

season. However, during the 1992 wet season, there was a negative and significant correlation between Alternaria blight severity and head weight (r = -0.84). There was also a negative but non-significant correlation between Alternaria blight severity and seed weight per plant (r = -0.38) as well as per plot (r = -0.29). A combined analysis similarly showed that as Alternaria blight severity increased among the varieties, head diameter correspondingly and significantly decreased. The pn77 combined analysis also showed that there was a positive and highly significant correlation between head diameter and head weight (r = 0.61), seed weight per plant (r = 0.44) and per plot (r = 0.51).

5. DISCUSSION

Many seed-borne pathogens have been known to be associated with sunflower seeds. The results of this study showed that Alternaria helianthi along with other fungi like Macrophomina phaseolina and Helminthosporium spp were more frequently associated with sunflower seeds tested. A. helianthi was consistently isolated and this further confirmed the seed-borne nature of the pathogen as reported by Herr and Lipps (1982) and Acimovic (1979) who demonstrated that the introduction of Alternaria blight from one country to another was from infected seeds.

Studies on the pathogenicity of A. helianthi on the five sunflower varieties showed that all were susceptible, producing prominent chlorotic halos and fleckings on the leaves and stems respectively as observed previously by Herr and Lipps (1982) and Acimovic (1979). Acimovic (1979) however noticed these symptoms two days after inoculation. In this study the characteristic symptoms appeared eight days after inoculation. The delay might have been due to a reduction in incubation time of the pathogen due to unfavourable weather conditions. Herr and Lipps (1982) had shown that a reduction in incubation period of the pathogen slowed down symptom expression. However, the affected plant tissues eventually withered and died. The reason for the withering of the plant parts may be due to the production and accumulation of some toxic secretions by the fungus into the plant tissues over a long time. Barash and Mor (1981) have reported the production of

zinniol, a phytotoxic compound secreted by A. dauci on blighted carrot leaves.

Many seed-borne pathogens are harboured within the various tissues of the seed and therefore successful seed treatment is largely dependent on the ability of the seed dressing chemical to penetrate. Neergaard (1977) had pointed out that there is generally a clear correlation between the amount of seed-borne inoculum and the dosage of chemical required. From the results of the evaluation of seed dressing chemicals in enhancing seedling emergence and the control of Alternaria blight both in the glasshouse and in the field, it is obvious that fungicide seed treatment gives a better seedling emergence and control of Alternaria blight thereby increasing yields when compared with the plants grown from untreated seeds.

In the glasshouse fungicide seed treatment significantly increased seedling emergence and reduced seedling blight incidence. A combined analysis showed that metalaxyl + carboxin, mancozeb and Carbendazim + iprodione at 1g a.i/kg seed each gave the best seedling emergence which are more economical in terms of quantity of fungicides used compared with higher doses that did not comparatively enhance high percentage seedling emergence. The combined analysis also showed that metalaxyl + carboxin and carbendazim + iprodione at 1g a.i/kg seed similarly gave the best seedling blight control. This suggests their superiority in increasing seedling emergence and control of seedling blight. Hence plants emerging from seeds treated with fungicides were

usually able to survive post-emergence infections as most fungal isolates are seriously damaging at pre-emergence (Mathieson and Rush, 1991).

In the glasshouse except for stem diameter, fungicide seed treatment significantly increased root and shoot length development with metalaxyl + carboxin giving the best results. Thus good seedling emergence affects subsequent growth parameters of sunflower. Fungicide seed treatment, however, does not appear to have a significant effect on stem girth. The performance of metalaxyl + carboxin at 1 and 2g a.i/kg seed appeared to be consistent in enhancing seedling emergence both in the glasshouse and in the field while mancozeb at 5g a.i/kg seed did not give an appreciable seedling emergence both in the glass house and in the field. The superiority of metalaxyl + carboxin is an indication of the combined effect of systemic and protectant qualities of the product. Mancozeb at 5g a.i/kg seed appeared to have exhibited some toxicity considering its consistently poor effects on seedling emergence, seedling blight incidence and even on some growth parameters like plant height and head diameter. However, it was more satisfactory than the untreated check.

Disease severity in most of the trials in the 1991 wet season was significantly higher than that of 1992. Differences in the weather condition might have been responsible. It is likely that the very high rainfall and relative humidity in August, 1991 might have favoured the pathogen more, compared with that of 1992 (Appendix II). Agrawat et al. (1979) and El Baradi (1973) had

reported that the pathogen is very destructive under high temperature and humidity. Even though the disease severity scores appear to be low, not a very correct picture of the disease could be assessed as this is the average of readings taken at 6, 8 and 10 WAS. In terms of yield and yield components, fungicide seed treatment is shown to have increased yield and yield components. Seed treatment with metalaxyl + carboxin gave the highest yield followed by benomyl. A combined analysis of the 1991 and 1992 results showed that there was a positive and significant correlation between yield and plant height as well as head diameter. Similar correlations have been reported in sunflower by Alba and Greco (1979). The yields of 1991 were significantly higher than those of 1992. It should be noted that yield is a result of the interaction of several physiological and growth characteristics of the plant and factors that determine it are therefore complex. Therefore differences in the yields between the two cropping seasons may probably not be attributed to disease severity alone. Other factors such as temperature, rainfall, pests, and nutrition that have serious effects on the physiology and growth of plants may be responsible. Ogunremi (1979) had attributed poor performance of sunflower in the rainforest belt of Nigeria in terms of yield to harsh weather caused by excessive rainfall and constantly high relative humidity. The weather records in Samaru during the 1992 cropping season showed that there was a relatively high rainfall and humidity up to September compared with that of 1991 where high rainfall was only

recorded in July and August (Appendix II). These factors might have been responsible for the differences in the yields of 1991 and 1992 wet seasons.

It is clear from the results of the evaluation of the effect of foliar fungicide sprays for the control of Alternaria leaf spots of sunflower during the 1991 and 1992 field trials that three foliar fungicide applications at two-week intervals starting 6 WAS significantly reduced Alternaria blight severity and numbers of leaves shed prematurely. This resulted in increased yields compared with the unsprayed check. The results showed that as Alternaria leaf spots increased, the numbers of leaves shed prematurely also increased. This might be as a result of the fact that in severely infected plants, greater leaf surface area is invaded by the pathogen. This makes it possible for the continuous liberation of spores and their deposition on leaves in the immediate surrounding resulting in greater numbers of infected leaves and consequently premature defoliation as a result of reduced photosynthetic ability. Fungicidal spray of carbendazim + maneb at 2.4, 2.6 Kg a.i/ha almost consistently resulted in the least Alternaria leaf spot severity and consequently the least numbers of leaves shed prematurely. Egington et al. (1980) noted that systemic fungicide sprays have curative and post-infection action. The mancozeb a non-systemic fungicide, was less effective than the systemic fungicides. This is in concert with the findings of Prawat et al. (1979) but in contrast with that of Kolte et al. (1980) and Baskharan and Kadaswamy (1979) both of

whom reported that mancozeb and bavistin were the most effective foliar fungicide in surpressing Alternaria leaf spots. Broscious and Kirby (1988) have similarly reported that fungicide spray with mancozeb to control Alternaria leaf spots, is known to result in less defoliation in alfalfa than those of benomyl. The excellent performance of carbendazim + maneb may be attributed to the fact that it has systemic (carbendazim) and protectant (maneb) qualities. Delp (1980) had recommended the use of companion fungicides with different modes of action as the most effective chemical control of diseases so as to avoid the emergence of resistant strains. Such a combination of carbendazim + maneb has been found very effective in the control of Cercospora on sugar beets in Greece (Delp, 1980).

It is also likely that because the fungicide sprays were applied during the rainy season, non-systemic fungicides like mancozeb might have been washed off on rainy days and hence their effectivenes became reduced. Woodcock (1971) had demonstrated that increased rainfall is known to reduce effectiveness of non-systemic fungicides by gradual attrition of the fungicide deposits by wind and rain water through hydrolysis.

Fungicide sprays with carbendazim + maneb generally resulted in the best yields which also suggests that foliar spray for the control of Alternaria leafspots could equally result in higher yields. The significant differences between the fungicide sprays and unsprayed check in effective control of the disease therefore suggest that fungicide application is necessary to increase yields

of sunflower. It is however recognised that yield is a complex parameter and therefore also influenced by factors other than disease. Alternaria leaf spot severity and yields in 1991 growing season were significantly higher than that of 1992. Seasonal changes in weather condition during the period of the study could have caused the observed seasonal variation in the severity of the disease. The relatively higher rainfall, mean temperature and relative humidity in August, the peak period of luxuriant vegetative growth during the 1991 compared to 1992, might have been more favourable for disease development hence higher leafspot severity in the 1991 than in the 1992 season. However, the continous heavy rains in September during the 1992 season could also have been reponsible for the low yields as observed by Ogunremi (1979).

The results of the screening of the five varieties of sunflower for resistance to Alternaria blight showed that all the varieties were susceptible to attack by A. helianthi, though of low severity. The low disease severity might perhaps be due to the average of the scores taken at 6, 8 and 10 WAS. It should however be noted that the, disease severity increaed with age. During the 1991 season, no significant differences were observed among the varieties in terms of Alternaria blight severity. Earlier studies of the resistance of sunflower cultivars, hybrids and lines to the attack of A. helianthi have shown slight differences among tested materials (Acimovic, 1979). However during the 1992 wet season, the differences among the varieties in terms of the disease

severity appeared to be significant. Similar significant results have been reported by Carson (1985). This suggests that it is however possible to find some sources of resistance to the pathogen among the varieties tested. However, continuous screening for resistance would be required to make a definite conclusion on the possibility of using such materials. Even the combined analysis showed that there were some significant differences among the varieties in terms of Alternaria blight severity which did not significantly increase yield and yield components. A significant (P = 0.05) interaction between the varieties and years was detected in a combined analysis for Alternaria blight severity. This result is consistent with the findings of Carson (1985). This indicates that expression of resistance is environmentally dependent and that caution should be exercised in interpreting disease reaction from a single environment. Thus increased replication and sampling of environment would be required to detect small differences in levels of Alternaria leaf spot resistance among sunflower varieties.

The combined analysis for the 1991 and 1992 also showed that there were no significant differences in the yield and some yield components of the varieties. This perhaps suggests that the usefulness of these levels of resistance in reducing disease losses is not quite known. For instance Chernaanka which may be rated as one of the most resistant varieties because of its lowest Alternaria blight severity score did not produce significantly

higher yields than the other varieties. In the same manner, Smena which could be rated the most susceptible did not produce significantly lower yields than the other varieties. Yields were however negatively correlated with Alternaria blight severity indicating that a delay in the disease spread within a variety could result in higher yields. The search for better sources of resistance to Alternaria blight should therefore continue.

6. SUMMARY AND CONCLUSION

During the 1991 and 1992 wet seasons, some aspects of Alternaria blight of sunflower were studied in the laboratory, glasshouse and the field. Laboratory studies showed that the pathogen is seed-borne. Inoculation of 3-week old sunflower seedlings with the conidial suspension of Alternaria helianthi showed that all the five sunflower varieties evaluated were susceptible.

Five seed treatment fungicides namely metalaxyl + carboxin, mancozeb, carbendazim + maneb, carbendazim + iprodione and benomyl each at 1, 2 and 5g a.i/kg seed were evaluated in the glasshouse and in the field. Fungicide seed treatment did not significantly increase root and shoot length in the glasshouse during the 1991 field trial but it did in the 1992 trial. Metalaxyl + carboxin was the most effective. Field evaluation of the fungicides as seed treatment generally indicated that seedling emergence was significantly increased while seedling blight incidence, number of leaves shed prematurely and Alternaria blight severity were significantly reduced during the 1991 wet season in comparison with the untreated check. However, only seedling emergence was significantly increased and number of leaves shed reduced during the 1992 season. Seed treatment with metalaxyl + carboxin at 1 and 2g a.i/kg seed gave the best seedling emergence and control of Alternaria blight, a result consitent with that of glass house. A positive and significant correlation in relation to fungicide seed treatment was found between Alternaria blight severity and

number of leaves shed during the two cropping seasons. Seed treatment with fungicides also significantly increased yields compared with the untreated check, with the highest yields produced by plants grown from seeds treated with metalaxyl + carboxin at 1g a.i/kg seed.

Three fungicides, benomyl, carbendazim + maneb and mancozeb each at two doses, were evaluated for their efficacy as foliar sprays in the control of Alternaria blight during the 1991 and 1992 wet seasons. The foliar sprays significantly reduced Alternaria blight severity and number of leaves shed. While the unsprayed check gave the highest Alternaria blight severity and consequently the highest number of leaves shed. During the two wet seasons, fungicidal spray of carbendazim + maneb at 2.4Kg a.i/ha gave the lowest Alternaria blight severity followed by benomyl at 0.6Kg a.i/ha. The effects of foliar fungicide spray on yield and yield components of sunflower were significantly different from those of the unsprayed check but there were generally no significant differences among the spray concentrations. However, spraying with carbendazin + maneb at 2.4kg a.i/ha generally resulted in the greatest yields. The effectiveness of this foliar applied fungicide is likely due to its systemic and protectant qualities.

Whereas the differences among the five varieties of sunflower screened for resistance to Alternaria blight in respect of seedling emergence, number of leaves shed and Alternaria blight severity were not significant in 1991, those of 1992 were

statistically significant. While Chernaanka and Funtua recorded the least Alternaria blight severity and number of leaves shed, Smena recorded the highest of these. Similarly, during the 1991 wet season, there were no significant differences among the varieties in relation to yield but this was however significant during the 1992 season with variety Funtua producing the greatest yields.

From the studies on Alternaria blight of sunflower in the laboratory, glasshouse and in the field it can be concluded that A. helianthi, the causal agent of the disease, is seed-borne and that it is pathogenic on the five sunflower varieties screened. Although fungicides effectively reduced seed and plant infection and foliar attack by the pathogen and increased yields, they should not however, be completely relied upon as a control strategy. Integration with other disease management strategies such as timely planting and harvesting and general crop management practices are recommended for growers of sunflower to realise the maximum economic returns of the crop. In addition, breeding programmes should be intensified to develop new cultivars with appreciable levels of resistance to the disease and of acceptable agronomic qualities to the farmers.

Even though the disease severity is observed to have advanced with age, further studies are however required to establish the correlation between disease severity and yields and to determine the definite period or stage of growth most importantly affected by the disease.

REFERENCES

Abraham, K.J., Menon, M.R. and Nair, M.C. (1976). Comparative efficacy of fungicides in the control of Alternaria blight of sunflower. Madras Agric. Journ. 63: 421-423.

Acimovic, M. (1979). Pathogenicity of Alternaria helianthi (Hansf.). Tub. and Nish. in sunflowers and other plant species. The sunflower Newsletter 3: 10-12.

Acland, J.D (1977). An introduction to the production of field and plantation crops in Kenya, Tanzania and Uganda. FAO/Longman 252 pp.

Agrawat, J.M., Mathur, S.J. and Chippa, H.P. (1979). Chemical control of Alternaria leafspot of sunflower Ind. J. Mycol. and Plant Pathol. 9(1): 79-80.

Allen, S.J.; Brown, J.F. and Kochman, J.K. (1983). Production of inoculum and field assessment of Alternaria helianthi on sunflower. Plant Disease 67: 565-568.

Anon. (1980). Food and Agricultural Organisation of the United Nations FAO production year book 34: 131.

Anon (1986). Sunflower variety improvement. Report of the legumes and oilseeds research programme. I.A.R. Samaru.

Alba, E. and Greco, I. (1979). An analysis of the association factors influencing seed yield in sunflower (Helianthus annuus L.) The sunflower Newsletter 3(2): 13-15.

Arthur, A.P. and Campbell, S.J. (1979). Insect pests of maturing sunflower heads and parasites of the sunflower moth in Saskatchewan and Alberta. The sunflower Newsletter 3(1): 15-18.

Barash, I. and Mor, H. (1981). Production of zinniol by Alternaria dauci and it's phytotoxic effect on carrot. Physiol. Plant Pathol. 19: 7-16.

Barron, G.C. (1968). The genera of hyphomycetes from soil. Williams and wilkins Co. 364 pp.

Bekesi, P; Voros, J. and Calvert, O.H. (1970). Macrophomina phaseolina in Hungary damaging sunflower. Plant Disease Reporter 54(4): 286-287.

Benson, L. (1959). Plant classification. D.C. Health & Co. Lexington 688pp.

Bhaskaran, R. and Kadaswamy, T.K. (1979). Evaluation of fungicides for the control of Alternaria leaf spot of sunflower. Indian J. Agric. Sci. 49(6): 480-482.

Broscious, S.C. and Kirby, H.W (1988). Economic evaluation of fungicides for control of Alfalfa foliar diseases. Phytopathology 78(7): 934-939.

Bruwer, J.J., Boshorf, B.V.D.; Hugo, F.J.C.; Fuls, J; Hawkins, C; Walt, A.N; Du plessis, L.M. and Engerbrech, A. (1981). The utilization of sunflower oil as renewable fuel for diesel engines. The sunflower Newsletter 5(1): 19.

Carson, M.L. (1985). Reactions of sunflower inbreed lines to two foliar diseases. Plant Disease. 69(11): 986-987.

Chapman, S.R. and Carter, L. P (1976). Crop production Principles and practices. W.H. Freeman & Co. Sanfrancisco, 566pp.

Clements, F.E. and Shear, C.L. (1954). The genera of fungi. Hafner Publ. Co. New York 430pp.

Cobley, L.S. (1976). An introduction to the botany of tropical crops. Longman 371pp.

Delp, C. (1980). Coping with resistance to plant disease control agents. Plant Disease 64(7): 625.

Edgington, L.V.; Martin, R.A. Bruin, G.C. and Parson, I.M (1980). Systemic fungicides: A perspective after ten years. Plant Disease 64: 19-23.

El baradi, T.A. (1973). Sunflower (Review article). Tropical Abstr[illegible] 28(5): 309-313.

Fivawo, N.C. (1987). Diseases and pests of sunflower in Tanzania. Taro Newsletter. 2(3): 6-8.

Genung, W.G. and Green, V.E. (1984). Insect pests of sunflower in Florida. A comparison of two seasons and three geographic areas. The sunflower Newsletter 17(2&3): 22-28.

Ghemawat, M.S; Sahu, B.K.; Agrawat, J.M. (1990). Yield losses in sunflower due to Alternaria helianthi (Hansf.). Tub & Nis. Rev. Plant Pathol. 69(7): 518.

Green, V.E.; Yang, S.M. and Simone, G.W. (1984). Sunflower diseases in Florida. International sunflower Newsletter 7 (2&3): 6-9.

Herr, L.J. and Lipps, P.E. (1981). Occurence of Alternaria helianthi on sunflower in Ohio. Phytopathelogy 71: 880 (Abst.).

Herr, L.J. and Lipps, P.E. (1982). Alternaria helianthi on sunflower in Ohio. Plant Disease 66: 509-512.

Holtzhausen, M.A. (1980). Leaf spot of sunflower in South Africa caused by Alternaria zinniae. Rev. Plant pathol. 59(12): 574 (Abst.).

Jaap, J.L (1979). Sunflower role in developing countries. The sunflower Newsletter 3(3): 5-7.

Jeffrey, K.K.; Lipps, P.E. and Herr, L.J. (1985). Seed treatment fungicides for control of seed-borne Altenaria helianthi on sunflower. Plant Disease 69: 124-126.

Joly, P. (1967). Key for determination of the most common species of genus Alternaria Nees WILTSH. EMEND. Plant Disease Reporter. 51(4): 296-298.

Jones, B.L. and Walt, L. (1988). Occurence of sunflower stalk rot incited by Erwinia carotovora in South Africa. Plant Disease 72(11): 994.

Kolte, S.J.; Balasubrahmanyan, N; Tewari, A.N. and Awasthi, R.P (1980). Field performance of fungicides in the control of Alternaria blight of sunflower. Indian J. Agric. Sci. 49(7): 555-559.

Lamboll, D. (1987). A note on virus diseases of sunflower in Tanzania Oilcrops Newsletter No. 4: 96-98.

Lipps, P.E. and Herr, J.L. (1986). Reactions of Helianthus annuus and H. tuberosus plant introductions to Alternaria helianthi. Plant Disease 70:831-835.

Liu, L. and Li, X. (1988). The geographical distribution of sunflower diseases in China. Plant pathol. 37(4): 470-474.

Martin, J.H.; Leonard, W.H and Stamp, D.L. (1976). Principles of field crop production. Macmillan Co. New York. 988pp.

Masefield, G.B.; Wallis, M; Harrison, S.G. and Nicholson, B.E. (1975). The Oxford University Press 206pp.

Mathieson, J.T. and Rush, C.M. (1991). Influence of temperature and five fungicides on Rhizoctonia root rot of hard red winter wheat. Plant Disease 75(10): 983-986.

Mathur, S.J.; Prassad, N.; Agrawat, J.M. and Chippa, H.P. (1978). Estimation of losses due to Alternaria blight of sunflower. Indian J. Mycol. and Plant Pathol. 8: 15.

Moris, J.B., g, S.M. and Wilson, L. (1983). Reaction of Helianthus spp to Alternaria helianthi. Plant Disease 67:538-540.

Nedelcu, L.; Alexandri, A.A. and Baicu, T. (1990). Pathogenicity of some isolates of Sclerotinia sclerotiorum and their behaviour towards some fungicides. Rev. Plant Pathol. 69(8): 594 (Abst.).

Neergaard, P. (1977). Seed pathology Vol. I. Macmillan Press Ltd. 839 pp.

Nyvall, R.F. (1979). Field crop diseases Handbook. AVI Co. 436pp.

Ogunremi, E.A. (1979). Effect of sowing date on sunflower (Helianthus annuus L.) performance in south western Nigeria. The sunflower Newsletter 3(4): 15-19.

Okoli, C.A.N; Erinle, I.D.; Poswal, M.A.T., Misari, S.M., Emechebe, A.M. (1989). Screening seed treatment chemicals for the control of Alternaria blight. Legumes and Oilseed Research Programme. Cropping Scheme Meeting, IAR.

Pirone, P. (1978). Diseases and pests of ornamental plants. John Willey & Sons New York. 566pp.

Purseglove, J.W. (1974). Tropical Crops dicotyledons. Longman, London 719pp.

Rant, J.G. and Kale, K.B. (1976). Screening of sunflower genotypes to leafspot and blight diseases. Oilseeds J. 3 (1&2): 23-24.

Richardson, M.J. (1979). An annotated list of seed-borne diseases. Phytopathological papers No. 23 pp 104-106.

Sackston, W.E. (1979). Treatment with Ridomil to control downy mildew of sunflowers. The sunflower Newsletter 3(4): 7-8.

Sackston, W.E. (1981). The sunflower crop and disease: Progress, problems and prospects. Plant Disease 65: 643-648.

Sackston, W.E (1987). Sunflower diseases with special reference to tropical and subtropical areas. Rev. plant pathol. 66(5): 215.

Shane, W.W.; Baumer, J.S. and Sederstrom, S.G. (1981). Alternaria helianthi: a pathogen of sunflower new to Menisota. Plant Disease 65: 269-271.

Sharma, A.D. (1977). Studies on seed microflora of some medicinal plants. Indian. J. mycol. and plant pathol. 7(2): 147-149.

Thuri, J.M.; Bock, K.R; Woods, R.D (1979). Distribution, host range and some properties of a virus disease of sunflower in Kenya. Tropical Pest Management 33(3): 202-207.

Tosi, L; Zazzerini, A. (1990). Septoria helianthi El & Kell, a new parasite of sunflower in Italy. Rev. plant pathol. 69(7): 518 (Abst.).

Weiss, E.A. (1966). Sunflower trials in Western Kenya. East Africa Agric. & for. J. 31(4): 340-3407.

Woodcock, D. (1971). Chemotherapy of plant disease progress and problems. Chemistry in Britain 7(10): 415-420.

Woldekidan, T (1986). Achievements in sunflower pathology in Ethiopia from 1981/82-1985/86. Oilcrops Newsletter No. 3 pp 10-11.

Yayock, J.Y.; Ajayi, O.; Karikari, S.K. and Owonubi, J.J. (1986). Oilseed crops. In International drought symposium on food grain production in Semi-arid region of sub-saharan Africa, Nairobi, Kenya, 19-23 May, 1986 pp 23-24.

Appendix 11: Weather records in Samaru during the 1991 and 1992 cropping seasons

1991 Month	Rainfall (mm)	Mean Temperature (oC) max.	Mean Temperature (oC) min.	Relative humidity % 10 am	Relative humidity % 4pm	Sunshine hr	Wind speed (Km/hr)
July	189.6	28.1	20.0	80.3	69.9	5.7	145.8
August	329.0	27.9	19.7	84.4	72.5	5.0	117.2
September	51.2	31.3	20.0	72.8	58.8	8.1	94.6
October	28.7	32.0	18.3	66.0	40.0	8.5	76.9
1992							
July	240.6	28.4	20.6	82.3	68.1	6.3	146.8
August	288.1	27.5	20.0	83.0	74.4	5.0	147.2
September	234.7	29.4	19.6	78.7	64.3	4.1	93.9
October	39.9	31.5	17.7	61.1	43.1	9.1	69.0

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