STUDIES OH THE CONTROL OF LEAF SPOT DISEASES OF SESAME*(Sesamum indicum* L.) IN NIGERIA

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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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Date 20.12.93

CERTIFICATION

This thesis entitled 'STUDIES ON THE CONTROL OF LEAF SPOT DISEASES OF SESAME (*Sesamum indicum* L.) IN NIGERIA' by Mallam Bukar Jidda meets the regulations governing the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This work is dedicated to
Hajja Jaburam, Hajja Nana
and to the Memory of
Ashe Shuwa

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All praise is due to Almighty Allah for making it possible for me to conduct this study.

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ABSTRACT

Laboratory, glasshouse and field investigations were conducted to assess the effects of dry heat seed treatment, foliar-applied fungicides and inter- and intra-row spacings on leaf spot diseases of sesame induced by *Xanthomonas campesstris* pv. *sesasmi* and Cercospora *sesami* during the 1990 and 1991 wet seasons at Samaru. Four dry heat treatments were used to treat, the seeds and their effects assessed in laboratory, glasshouse and. field experiments. These were 100°C for 15min, 90°C for 24 h, 80°C for 72 h and 70°C for 96 h. The control received no heat treatment. For fungicidal control of leaf spot diseases, two fungicides, carbendazim + maneb and manco2eb were each used at two concentrations, 2.22 and 3.70 g a.i./l, and 5.04 and 7.04 g a.i./l respectiveiy, in the fieId- trials. The effect of plant spacing on leaf spot diseases of sesame was investigated in field trials by establishing three inter-row (50, 75 and 100 cm) and three intra-row (15, 20 and 25 cm) spacings.

In the laboratory studies, dry heat treatment at 90°C for 24 h resulted, in the lowest incidence of both fungi and bacteria. *Pseudomonas* sp., *Xanthamanas* campestris pv. *sesami* and *Macr-ophomina. phaseolina* were detected in seeds subjected to any of the treatments..

However, the occurrence of *Alternaria* spp., *Helminthosporim* Spp. *Aspergillus niger* and Curvularia sp. were not consistent with the treatments. Seed germination was adversely affected by heat treatment at 90°C for 24 h. however, germination was over 60% in all. cases.

Assessment of the effect of dry heat seed treatment in the glasshouse also indicated that 90°C for 24 h adversely affected sesame seedling emergence. Shoot length, stem diameter, root length as well as seedling blight severity of sesame seedlings were however not significantly affected by dry heat seed treatment -

The two-year field trials showed that dry heat seed treatment at 90°C, 80°C and 70°C for 24, 72 and 98 h, respectively,, significantly reduced both types of leaf spot disease incidence *and* severity, number of diseased leaves and number of leaves shed per plant in cultiver 69A-205. Significant effects of heat treatment on the magnitudes of these parameters for cultivars S5B-58 and E8 were found only during the 1991 field trial. Dry heat seed treatment did not significantly affect yield and yield components of sesame-

Field evaluation of foliar-applied fungicides showed that carbendazim + maneb and mancozeb significantly reduced the C*ercospora* leaf spot disease incidence and severity, number of diseased leaves and number of leaves shed per plant without significant effect on yield and yield components of sesame in both years. There were no significant differences among the. effects of the chemicals and their concentrations.

Investigation of the effect of inter—and intra-row spacings conducted during 1990 and 1991 field trials showed. significantly high disease incidence and severity, numbers of diseased leaves and leaves shed per -plant within closely spaced plants. Increase in intra-row spacings from 15 to 25 cm significantly increased, numbers of branches and capsules and seed weight per plant. While increase in inter-row spacings from 50 to 75 cm. increased seed weight per plot, further-increase in spacing reduced yield per plot due to decreased plant population. Both inter- and intra-row spacings did not significantly affect plant height and. height to the lowest capsules in both years. Effects of interactions between inter- and intra-row spacings on number of capsules per plant and disease severity were found to be significant.

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ABBREVIATIONS

a.i.	-	active ingredient
Anon.	-	Anonymous
^{o}C	-	degrees centigrade
cm	-	Centimeter
cv	-	cultivar
g	-	gramme (s)
ha	-	hactare
h	-	hour(s)
HR	-	Hypersensitive reaction
l	-	litre
Min	-	Minutes(s)
RCBD	-	Randomized Complete Block Design

1. INTRODUCTION

Sesame (*Sesamum indicum* L.) belongs to the division SPERMATOPHYTA, the sub-division ANGIOSPERMAE, the class DICOTYLEDONEAE, the order TUBIFLORAE, the family PEDALIACEAE and the genus *Sesamum* (Bruce, 1953: Hutchinson and Dalziel, 1963; Kumar *et al.*, 1967; Joshi, 1961; Purseglove, 1968 and Weiss, 1971). There are 16 genera in the Pedaliaceae family and 36 species in the genus *Sesamum*.

Linnaeus classified sesame into two different species, *Sesamum indicum* and *S. orientale*, but De Candolle combined the two species into one and used the name *Sesamum indicum*, so referring to the country of supposed origin. Sesamum is an annual, erect, herbaceous plant growing to the height of about 0.5 to 2 m, occasionally reaching 3 m (Weiss, 1971). The stems are simple or well branched with mostly one capsule per leaf axil, and are hairy with longitudinal furrows (Plate I).

Sesame is probably the most ancient oilseed known and used by man; so ancient that it is almost impossible to say with any degree of accuracy where and when its domestication took place (Weiss, 1971). Both India and Ethiopia have been proposed as sesame's centre of origin, but presently the opinions are more in favour of Ethiopia.



Plate I. A healthy sesame plant.

Purseglove (1968) and Weiss (1971) explained that due to more varied conditions, the African region is poor in different forms of *Sesamum indicum* but rich in species of the genus *Sesamum*. While the situation is just the opposite in India.

The crop is widely cultivated in the tropical, sub-tropical Asian and African countries, Russia, south and central America. Van Rheenen (1973) stated that sesame cultivation is mostly practised in countries with small peasant type of agriculture where manual harvesting of the crop is employed because mechanical method is difficult. The main producing countries are India, China, Mexico and the Sudan. In Africa, the main producers are Sudan, Uganda and Nigeria (Joshi, 1961; Weiss, 1971).

In Nigeria, the crop is grown mainly in the northern parts, particularly in the Benue area. However, the crop is generally cultivated wherever conditions are favourable. Other areas of its cultivation stretch from Gumel in Jigawa State, extending along Potiskum (Yobe state); Gwoza, Madagali and Lassa in Borno State; Yola and Mubi areas of Adamawa state; and into some parts of Bauchi State (Ingawa *et al.*, 1986). The crop is mostly grown as a mixture with cereals, particularly sorghum and millets.

Sesame grows on a variety of soils, preferably light, sandy soil; well-drained but capable of adequate water retention. It grows in areas with 400-500 mm of rainfall or less, that is just sufficient for seedlings to become well established. Sesame requires an average daily temperature of about 27°C for growth and fruiting, and a dry period for ripening (Godin and Spensley, 1971).

Approximately 0.5 million tons of sesame oil is produced annually world-wide (Weiss, 1971). Nigeria has about 60,000 hectares under cultivation, although total production is variable due to erratic rainfall which directly influences yields (Van Rheenen, 1973).

Sesame seeds produce high quality, odourless vegetable oil used in the European and other western countries for the manufacture of compound cooking fat, margarine and salad oils. It can also be utilized to a minor extent as a fixative for perfumes and various cosmetics; as a carrier for fat soluble substances in medicinal drugs such as penicillin and as a repellant in insecticides. The cake obtained after oil extraction, is used for animal feed, as supplementary food for humans and as a fertilizer. Sesame seed is a popular sweetmeat in Asia and Africa. In Nigeria the seeds are most commonly used

in soups. They can also be eaten raw or fried in form of cakes, or fried, pounded and mixed with sorghum or millet to a pastry.

Sesame is subject to attack by a number of diseases and insect pests. The diseases reported include *Alternaria* leaf spot (*Alternaria spp.*), *Cercospora* leaf spot (*Cercospora sesami* Zimm.), bacterial blight [*Xanthomonas campestris* pv. *sesami* (Sabet and Dowson) Dye], *Cylindosporium* leaf spot (*Cylindosporium* sp.), powedry mildew [*Leveillula taurica* (Lev.) Arn.] Root - and shoot rots induced by a complex of organisms, *Fusarium* wilt (*Fusarium* sp.) and leaf curl (a viral disease) (Bailey, 1966; Van Rheenen, 1973; Emechebe, 1980; Erinle, 1981; Akpa, 1985).

The important insect pests of sesame include the leaf - and pod-eating caterpillars, *Antigastra catalaunalis* Dup, the leaf - eating Sphinx moth, *Acherontia styx*, and the gall-midge, *Asphondylia sesami* Felt (Joshi, 1961).

Purpose of this study.

Foliar diseases of sesame are commonly referred to as leaf blight or leaf spots of sesame. The most important ones are the bacterial blight induced by *Xanthomonas*

campestris pv. *sesami* (Sabet and Dowson) Dye and *Cercospora sesami* Zimm. These are the most destructive foliage diseases of sesame in Nigeria causing severe defoliation during humid climate (Erinle, 1981; Akpa, 1985). Earlier work (Poswal and Misari, 1988) have shown that none of the 61 sesame cultivars/lines evaluated for field resistance was resistant to these foliar diseases. There is no doubt that these diseases have adverse effects on sesame production which obviously has bright future as source of vegetable oil production in Nigeria (Mijindadi, 1986). Investigation by Akpa *et al.* (1990) on control of bacterial blight of sesame by dry heat seed treatment did not give conclusive results, but indicated a possibility for disease control by this method. It was against this background that studies on effective control of these two diseases which are also reported to be seed-borne (Joshi, 1961; Rao and Durgapal, 1966; Akpa, 1985) were undertaken. In this investigation, three control methods were applied viz: dry heat seed treatment, foliar fungicidal sprays and manipulation of plant spacing. The objectives of the investigation include:

(i) to determine the level of seed contamination with a view to evaluating the effect of dry heat treatment for disease control or eradication of seed-borne infection;

(ii) to determine the appropriate dry heat treatment temperature for effective control of the diseases in the field;

(iii) to assess the efficacy of some fungicides for foliar-applied fungicidal control of these diseases; and

(iv) to determine the effect of inter- and intra-row spacings on the incidence and severity of leaf spot diseases in the field.

2. LITERATURE REVIEW

2.1 Economic Importance of Sesame Leaf Spot Diseases.

Two of the most important leaf spot diseases of sesame are the bacterial blight and *Cercospora* leaf spot. Sesame foliage diseases have been reported (Van Rheenen, 1973) to occur normally as a complex and is often difficult to acertain which individual disease was the most important. However, certain reports (Tarr,1949) have shown that bacterial blight was reponsible for severe damage and often complete loss of the crop under rain fed condition in the Sudan. The disease had become destroctive in many parts of India (Rao and Durgapal, 1966), young plants succumb to bacterial blight infection causing defoliation in Nigeria (Erinle, 1981; Akpa, 1985) or total yield loss (Vasudeva, 1961).

Cercospora leaf spot is a serious and widespread disease of sesame in India, occurring every year. Infact, it appears practically in all the areas wherever sesame is cultivated (Mohanty, 1958). It is estimated to cause up to 20% yield loss (Chowdhury, 1945). These foliar diseases are most damaging under conditions of high

rainfall, or where humidity and warm weather persist for long periods (Mathur and Swarup, 1965; Durgapal *et al.*, 1969; Vyas 1981).

2.2 Description of Disease Symptoms

Bacterial blight induced by *Xanthomonas campestris* pv. *sesami* appears during the rainy season when the crop is about 6-8 weeks old (Joshi,1961). Symptoms appear mainly on leaves and stems, though it affects all aerial parts of the plant (Miller and Pollard, 1976). Small, dark olive green, circular spots develop first turning light brown then to dark red brown later (Plate II), and can enlarge up to 3 mm diameter (Weber, 1973; CMI, 1979). The shape of the spots become irregular as size increases. Several spots may coalesce to form bigger irregular patches. The affected leaves ultimately wither and finally dry up.

Early infection is often noticed on cotyledonary leaves which results in their early shedding (Vyas, 1981). Generally, symptoms are more severe on young leaves than old ones (Chand *et al.*, 1970). The susceptibility of the younger leaves of sesame is said to be due to more stomata and higher nitrogen and moisture content than in older leaves (Shukla and Chand, 1975).



PLATE II. Symptoms (angular to irregular dark red brown interveinal lesions) of sesame leaf spot disease on the leaf surface.

The *Cercospora* leaf spot disease induced by *Cercospora sesami* manifests itself just before flowering time (Joshi, 1961). The first symptoms are the appearance of small light brown spots which later enlarge to form round to irregular, often angular and vein-limited spots. Individual spots can be up to 5 mm diameter, consisting of a pale grey centre bordered by a dark brown zone (Weber, 1973; CMI, 1979). The colour of the spots later become dark brown, several of which coalesce to give blight appearance. Leaves are shed in severe infection. In favourable conditions, the disease spreads to leaf petiole, stem and pods, producing linear dark coloured, deep seated lesions.

2.3 Survival and Dissemination of the Pathogens

Xanthomonas campestris pv. *sesami*, the bacterial blight pathogen, survives well on seed (Rao and Durgapal, 1966; Akpa, 1985) and is transmited by it from one area to another (Rao and Durgapal, 1966). It spreads within a crop by water splash and wind-driven rains. It can survive in seed up to 16 months and in soil up to 6 months (Habish and Hammad, 1971), its presence in seed, soil and crop debris serve as primary sources of inoculum to the crop in the following season.

Cercospora is internally as well as externally seed-borne (Nusbaum, 1941; Muller and Texera, 1941; Mathur and Kabeere, 1975), it survives on plant debris left after the harvest. The secondary spread occurs through air-borne spores (Mohanty, 1958). Possiblity of carry-over of the fungus in the field through mycelium and viable stomata in crop debris as well as in soil have been demonstrated (Rathaiah and Pavgi, 1976)

2.4 Control of Leaf Spot Diseases

There seems to be little or no published work on the control of leaf spot diseases of sesame in Nigeria. However, there have been some reports on control of these diseases in other parts of the world.

2.4.1 Dry heat treatment for plant disease control

This method is less effective than hot water both in heat exchange and in destroying micro-organisms. It may kill cells, in different manner than does moist air or hot water (Baker, 1962). The advantages are in the ease of its application and reduced seed injury when applied to destroy seed-borne pathogen. The method has been employed against various plant Pathogens. Umekawa and Watanabe (1987) reported that dry heat treatment of cucumber seeds for the control of leaf spot diseases, at $70^{o}C$ for 3 days gave excellent control of

Pseudomonas lachrymans and only slightly reduced percentage germination. Tanako *el al.*, (1985) obtained complete control of *Fusarium Solani* f.sp. *curcurbitae* by treatment of cucumber seeds for 3 days at 75°C or 2 days at 80°C without significant loss of germinability.

Complete control of *Colletotrichum capsici* infecting *Capsicum* seed was obtained by heat treatment at 85°C for 5 days, but germinaition was impaired (Tanako *el al.*, 1985). Dry heat treatment of TMV infected pepper at 76°C for 3 days (Berkmortel, 1979) or 70°C for 7 days (Rast and Stijger, 1987) was effective to free seed from the pathogen, but delayed seedling emergence and the number of seedlings suitable for further raising. However, seed germination was found to have improved in a similar experiment with pepper seeds infected by a yellow mosaic strain of CaMV when treated shortly after harvest at 70°C for 7days (Rast and Stijger, 1987). The improvement of germination by heat treatment was attributed to a dormancy-breaking effect, though no explanation was found in the literature.

Timietti and Garibaldi (1984) showed the eradication of *Pseudomonas syringae* pv. *phaseolicola* in bean seeds. They reported that infection was reduced by about 72-74% by hot air treatment at 50°C for 3 h.

In another experiment, Tanako *et al.* (1985) found that *Verticillium tricorpus* was eliminated from tomato seeds by dry heat treatment for 6 days at 75°C or 5 days at 80°C. However, some adverse effects on the initial growth of seedlings were observed. Green *et al.* (1987) reported that treatment of tomato seeds previously infected with tomato mosaic virus (ToMV) with dry heat (78°C for 2 days) eliminated the ToMV without detrimental effect on seed germination.

Sands *et al.* (1989) reported that the dry heat treatment (72°C for 7 days) of severely infected barley seeds by *Xanthomonas campetris* pv. *translucens* was sufficient to reduce infestation rate to about 14%. The germination of wheat and barley was reduced by dry heat but still remained above 80% after 7 days.

Report by Akpa *et al.* (1990) on the control of foliar diseases of sesame by dry heat seed treatment showed no significant effects on disease incidence and severity. The treatments however, did not adversely affect seed viability and seedling emergence.

2.4.2 Use of foliar funficides sprays.

Fungicides and to some extent bactericides have been tried successfully for the control of foliar diseases

of plants. For instance, Urdaneta and Mazzani (1976) have found that weekly foliar sprays of sesame for the control of bacterial blight with Cupravit and Difolatan lowered bacterial blight incidence and improved seed yield by 117.0 and 64.7% compared with the control. Poswal and Misari (1989) reported that out of the eight chemicals evaluated at three spraying regimes (5, 10 and 15 - day intervals), Triasyn and Benomyl were found to reduce the incidence of *Cercospora* leaf spot disease of sesame.

Foliar sprays of groundnut for the control of *Cercospora* leaf spot with Benlate (Aulakh and Sunar, 1973) and Carbendazim or Benomyl (Vaishnav *et al.*, (1982) reduced disease incidence and gave significant increase in number and weight of pods per plant. Kolte *et al.* (1978) reported excellent contorl of the disease when sprayed with Bavistin (0.05%) followed by Cercosin M (0.05%).

Difolatan and Dithane M-45 effectively controlled *Alternaria* and *Septoria* leaf spots and increased yield in tomato (Rajagopal and Vidlyasekaran, 1982). Blitox 50 was reported to be effective in controlling early blight of tomato caused by *Alternaria solani* (Kamlesh and Shekhawat, 1986).

Alternaria leaf spot of Safflower caused by *Alternaria carthani* was reported to be effectively controlled by Dithane M-45 (0.25%) and Bavistin (0.1%) and increased yield by 30.3 and 29.2% repectively (Patil and Jadhav, 1965)

Emechebe (1981) in a report of work conducted over a period of four years at Samaru, showed that brown blotch (*Colletotrichum capsici*) of cowpea was effectvely controlled at a 14-day spraying interval with Benlate, Delsene M and Dithane M-45.

2.4.3 Manipulation of Plant Spacing for disease Control

Cultural methods of disease control are aimed at eliminating the pathogen from the plant or from the area which the plants are growing (eradication), increasing or creating conditions unfavourable to the pathogen, and at obtaining pathogen-free propagative material (Agrios, 1988).

Cultural practices aimed at improving the vigour of the plant often help increase its resistance to pathogen attack. Thus, practices for which proper spacing of plants is one, will improve the growth of plants and may have a direct or indirect effect on the control of a particular disease. Proper spacing of plants in the

field or greenhouse prevents creation of high humidity conditions on the plant surfaces and inhibits infection by certain fungal and bacterial pathogens (Agrios, 1988). The plant foliage microclimate exerts a most important influence on infection by leaf spotting pathogens (Ranney *et al.*, 1971; Waggoner, 1965). Inter- and intra-row spacings affect the microclimate (Stevens, 1960) and coincidentally would alter the rate of disease spread. Vestal and Bell (1931) found an increase of leaf spot (*Cercospora beticola* Sak.) in sugar beet with closer plant spacing due to earlier development of infection foci in plots with close plant spacing. They did not consider the differences in rates of disease development.

Berger (1975) reported faster spread of *Cercospora apii* blight in celery in closer- than in wider-spaced plots, resulting in twice as much diesease in eight weeks. The lower incidence of disease in wide spacing plots was assumed to be from modified microclimatological effects rather than from diminished numbers of spore arrivals due to possible gradient effects.

Increase in fungal (*Alternaria longipes* and *Cercospora nicotianae*) leaf infection occurred with wider spacing than recommended spacing and applying balanced

fertilizer. While decreasing plant population and increased levels of fertiliser both increased the incidence of bacterium (*Erwinia carotovora*) Tanton and Abington, 1979).

Rao and Devadath (1977) reported that there was no significant effect of spacing on the incidence of bacterial streak of rice plant.

The incidence of yellows virus in sugar beet crop was reduced by increased density of plant population. Close planting increased the yield of sugar beet and reduced the losses caused by yellows virus (Blencowe and Tinsley, 1951) and yellow spot in pineaple (Linford, 1943). Similarly, close spacing reduced rosette disease incidence in groundnut (Booker, 1963; A'brook, 1964) and increased the yield of groundnuts. Spacing affects rosette incidence due to the influence of ground cover on the optomotor landing response of the winged aphids.

Huang and Hoes (1980) found that closer plant spacings (that is, higher plant desities) resulted in more efficient and faster *Sclerotinia* wilt spread in sun-flower, and a greater incidence and severity of wilt. Wide spacing promoted disease escape because of fewer

potential infection loci and because of decreased incidence in transmission. Hoes and Huang (1985) also reported that increase in inter-row spacing promoted plant vigor and increased the percentage of wilted productive plants. Increase in both inter- and intra-row spacings decreased the percentage wilted non-productive plants and increased yield.

Burdon and Chivers (1975) found that varying the plant density of *Lepidium sativum* had an effect on the frequency of primary infection loci of *Pythium irregulare* similar to that produced by varying the density of the inoculum.

2.4.3.1 Effect of plant spacings on yield and yield components

The yield per plant is controlled by many factors such as nutrients taken by the plants, its genetic constitution and environmental conditions. Under wide spacing the individual plant is subjected to lesser degree of competition from its counterparts due to more available space, but the plant population per unit area is reduced (Menon, 1967).

Yield/ha increases with increasing plant density until a level is reached which hardly exceeded as density increases further (Menon, 1967; Gerakris and Tsangarakis, 1969; Gupta, 1982; Katung, 1987).

Increase in inter-row spacings, thus, decreasing-plant population, progressively delayed flowering, and maturation and increased the number of branches and capsules per plant in sesame. This is probably due to the fact that under wider spacing the individual plants have more soil moisture and nutrients, and light due to more available space (Gupta, 1982). Effects on plant heights were inconsistent.

Weiss (1971) reported that growth characters of sesame such as number of branches, height of the plant and height of the first capsule from the ground varied little with the different plant population. This result agrees with earlier reports by Mazzani and Cobo (1956).

3. MATERIALS AND METHODS

3.1 Laboratory and Glasshouse Investigation of the Effect of Dry Heat Seed Treatment on Some Seed-seedling Parameters in Sesame.

3.1.1 Effect of dry heat seed treatment on level of seed contamination and seed viability in the laboratory.

3.1.1.1 Dry heat seed treatment

Three cultivars of sesame, namely 65B-58, 69A-205 and E8 were used for the investigation. Fifty-gram batches of seeds of each cultivar were evenly spread on glass plates and subjected to dry heat treatment in an electric oven (Gallenkamp, England) at 100°C for 15 min., 90°C for 24 h, 80°C 72 h and 70°C for 96 h; a batch of untreated seeds served as control, representing treatment A, B, C, D and E respectively.

3.1.1.2 Detection of seed-borne bacteria and fungi

Seeds from the five treatments were examined for seed-borne bacteria and fungi using the agar plate method of the Seed Health Testing Association (I.S.T.A., 1966). Sixty seeds of each cultivar were selected at random from the treatments. The seeds were surface sterilised by soaking in 0.1 M sodium hypochlorite solution for 5 min and rinsed thoroughly in three changes of sterile distilled water. Thirty seeds were plated on potato dextrose agar with streptomycin (PDAS) in three 9.0 cm

diameter Petri dishes for the detection of seed-borne fungi, while the other 30 were plated on nutrient agar (NA) in three Petri dishes for the detection of seed-borne bacteria. The seeds on PDAS were incubated at room temperature under alternating light (12 h) and dark (12 h) periods for 7 days. While seeds placed on NA were kept in an incubator at 27±2°C for 2-4 days with daily observation of the plates. After 3-4 days the number of infected seeds were counted and expreseed as a percentage of the total number of seeds plated out.

3.1.1.3 Determination of seed viability

Ten seeds of each cultivar in each of the treatments were plated on two layers of moistened filter papers placed in 9.0 cm diameter Petri dishes. The Petri dishes were arranged on a laboratory bench in a randomized complete block design (RCBD) with three replications for five days. Germination counts were taken at five days of incubation and expressed as a percentage of the total number of seeds.

3.1.2 Effect of dry heat seed treatment on seedling emergence, seedling vigour and seedling blight of sesame in the glasshouse

Ten seeds from each treatment were sown per 12 cm diameter plastic pot filled with heat-sterilized soil.

The pots for all treatments from the three cultivars were arranged in the glasshouse in a RCBD with three replications.

Records of seedling emergence were taken daily, with the final count taken at 12 days after sowing. Seedling emergence was expressed as a percentage of the total number of seeds sown per pot. After the final record of seedling emergence, the seedlings were thinned to five per pot.

At 35 days after seedling emergence, the soil was heavily watered and the seedlings were removed. Care was taken to avoid damage to the tap roots. All adhering soil particles were washed off and records of root, and shoot lengths and of stem diameter taken.

The severity of the leaf spot diseases was assessed using a visual scale of 1-5 as follows:

1-No leaf spots

2-Small (0.5-1.0 mm diameter) circular spots on leaf surfaces.

3-Large (3-5 mm diameter) irregular spots scattered over leaf surfaces.

4-Large coalesced spots covering large areas of leaves.

5-Leaves completely withered and dried-up.

3.2 Field Investigation of the Effect of Dry Heat Seed Treatment on Incidence and Severity of Leaf Spot Diseases of Sesame

The dry heat-treated seeds were sown in the field in the 1990 and 1991 wet seasons on 26 July and 28 June, respectively, on the flat along drills spaced 75 cm apart. The plots (size $4m^2$) were laid out in a RCBD with three replications. Plots were separated by a gap of 0.5 m and replications were separated by a 1.0 m gap. Calcium amonium nitrate (CAN) and single superphosphate (SSP) fertilizers were each band-applied two weeks after seedling emergence at 50 kg N and P_2O_5/ha, respectively. Plants were thinned to 20 cm apart, two weeks after seedling emergence.

The incidence and severity of leaf spot diseases were first assessed 21 days after seedling emergence and thereafter every 14 days. Assessment of disease incidence was done by counting the numbers of diseased plants per plot which were then expressed as a percentage of total number of plants per plot. The severity of leaf spot diseases was assessed as described in Section 3.1.2.

At harvest, yield and yield component records were obtained by counting the number of capsules and noting seed weight per plant and per plot; records of number

of branches, height to the lowest capsule and the plant height were also taken.

All the parameters assessed were based on five randomly selected plants per plot, with the exception of disease incidence which was based on the total number of stands per plot.

3.3 Field Evaluation of the Effect of Foliar Applied Fungicides on the Incidence and Severity of Leaf Spot Diseases of Sesame.

The cultivar used in this experiment was 69A-205. The experiments were laid out in a RCBD with three replications. The plot size was $4m^2$ separated by a 1.0 m gap.

Two fungicides, carbendazim + maneb (Delseme M, 74% W.P.; Du PonT) and mancozeb (Dithane M-45, 80% W.P.; Du PonT) were used at two levels : 2.22 and 3.70 g a.i./l, and 5.04 and 7.04 g a.i./l respectively. There was a control which received no fungicide spray. The foliar spraying commenced three weeks after seedling emergence, and was followed by three other sprays at fort-nightly intervals.

The assessment of incidence and severity of leaf spot diseases and all the other yield components was done as outlined above in Section 3.1.2. and 3.2

3.4 Field Evaluation of the effect of Inter- and Intra-row Spacings on the Incidence and Severity of Leaf spot Diseases of Sesame

The cultivar used in this study was 65B-58. The layout of the experiment was a split-plot design with three replications, with a main plot of three inter-row spacings (50, 75, 100 cm) and sub-plots of three intra-row spacings (15, 20, 25 cm). Nine plant densities were established by combining inter-row with the intra-row spacings. The intra-row spacings were established by sowing seeds along drills and thinning the plants to desired spacings, two weeks after emergence.

The assessement of incidence and severity of leaf spot diseases and all other parameters on yield was done as outlined above in Section 3.1.2. and 3.2

4. RESULTS.

4.1 Effect of Dry Heat Seed Treatment on the Level of Seed Contamination and Seed Viability in the Laboratory.

4.1.1 Detection of Seed-borne Bacteria and Fungi

The effects of dry heat seed treatment on the incidence of fungi and bacteria in sesame seeds are presented in Table 1. It showed that different dry heat treatment had significant (P=0.05) effects on the percentages of seeds infected by both bacteria and fungi. Seeds heat-treated at 90^{o}C for 24 h had the lowest incidence of infection while the check (untreated) seeds had the highest incidence of fungal and bacterial infections in all the cultivars (cv.)

The various fungi and bacteria detected in the heat-treated and untreated seeds are shown on Table 2. *Macrophomina phaseolina* colonies were found to be dominant over other fungi in all the treatments. Other fungi present in descending order of frequency of occurrence were *Aspergillus niger*, *Helminthosporium* spp., *Curvularia* sp. and *Alternaria* spp. *Cercospora sesami* could not be detected from the seeds.

Pseudomonas sp. and *Xanthomonas campestris* pv. sesami were present in all the treatments. The ratio of *X. campestris* pv. *sesami* to *Pseudomonas* sp. detected in the seeds was approximately 1:5.

Table 1. Effect of dry heat seed treatment on incidence of bacteria and fungi in sesame seeds.

	Percentages of seeds infected by[2]					
	Bacteria			Fungi*		
Treatment[1]	cv1	cv2	cv3	cv1	cv2	cv3
A	22.5	21.3	23.3	61.8a	59.8a	65.7a
B	18.3	16.2	18.6	26.2c	25.2c	28.oc
C	20.3	19.5	21.6	44.7b	41.8b	47.6b
D	23.2	23.5	25.8	49.8ab	46.8ab	52.7ab
E	25.8	26.1	28.4	64.7a	60.5a	67.4a
LSD (P=0.05)	ns	ns	ns	15.38	14.9	15.4

1: A=100°C for 15 min; B=90°C for 24 h; C=80°C for 72 h; D=70°C for 96 h; E=Control (No heat treatment).

2: Cv1 = 65B- 58; CV2 = 69A-205; CV3 = E8.

ns = Not significant

* Means followed by the same letter(s) in the same column are not significantly different at P=0.05 using Duncan`s Multiple Range Test (DMRT)

Table 2. List of Bacteria and Fungi associated with dry heat-treated and untreated sesame seeds.

Treatment[1]	65B-59	69A-205	EB
A	*Macrophomina phaseolina*	*M. phaseolina*	*M. phaseolina*
	Helainthosporium spp.	*A. niger*	*A. niger*
	Curvularia sp.	*Pseudomonas* sp.	*Pseudomonas* sp.
	Aspergillus niger	*X.c. pv. sesami*	*X.c.pv.sesami*
	Pseudomonas sp.		
	Xanthomonas campestris pv. sesami		
B	*M. phaseolina*	*M. phaseolina*	*M.phaseolina*
	A. niger	*Curvularia* sp.	*A. niger*
	Pseudomonas sp.	*Pseudomonas* sp.	*Pseudomonas* sp.
	X. c. pv.sesami	*X. c.pv sesami*	*X. c.pv. sesami*
C	*M. phaseolina*	*M. phaseolina*	*M. phaseolina*
	Helainthosporium spp.	*Curvularia* sp.	*Helainthosporium* spp.
	Curvularia sp.	*Helainthosporium* spp	*Pseudomonas* sp.
	Alternaria spp.	*A. niger*	*X.c.pv.sesami*
	Pseudomonas sp.	*Alternaria* spp.	
		Pseudomonas sp.	
	X.c. pv.sesami	*X.c. pv sesami*	

Table 2 Contd.

Treatment	65R-58	65A-295	58
D	*M. phaseolina*	*M. phaseolina*	*M. phaseolina*
	Curvularia sp.	*Helminthosporium* sp	*Curvularia* sp.
	Pseudomonas sp	*Pseudomonas* sp.	*Pseudomonas* sp
	X. c. pv. *sesami*	*X.c.* pv *sesami*	*X.c.* pv. *sesami*
E.	*M. phaseolina*	*M. phaseolina*	*M. phaseolina*
	Helminthosporium spp.	*Pseudomonas* sp.	*Curvularia* sp.
	A. niger	*X.c.* pv. *sesami*	*A. niger*
	Pseudomonas sp.		*Pseudomonas* sp.
	X.c. pv. *sesami*		*X.c.* pv. *sesami*

1: See Table 1 for explanation.

4.1.2 Determination of seed viability.

The results on the effect of dry heat seed treatment on sesame seed viability are presented in Table 3, while the combined data of the two-year tests are presented in Table 4. The percentage viability of seeds subjected to different dry heat treatments in both years differed significantly from one another. Seed viability was adversely affected by heat treatment at 90°C for 24 h; however, viability of seeds in all treatments was generally above 60%. Heat treatment at 70°C for 96 h significantly improved seed viability.

Table 5 shows the incidence of seed- and seedling-rots of sesame in the laboratory tests. All treatments, except seeds heat-treated at 90°C for 24 h showed seed- and seedling-rots. The highest incidence (43.3%) of seed-rot occurred in the untreated seeds of cv. 69A-205. Isolation made from the rotted seeds and seedlings gave *M.* phaseolina (43.4%), *Curvularia* sp. (3.9%) and *A. niger* (17.4%), while 35.5% of the rotting was due to bacteria. No bacteria or fungi were associated with the ungerminated seeds heat-treated at 90°C.

Table 3. Effect of dry heat seed treatment on sesame viability.

	% Seed viability for 1990*			%seed viability for 1991[2]		
Treatment[1]	cv1	cv2	cv3	cv1	cv2	cv3
A	96.7a	86.7b	93.3a	100.0a	83.3b	90.0ab
B	73.3c	66.7c	73.3b	63.3c	63.3c	60.oc
C	86.7b	90.0ab	86.7a	73.3b	80.0b	83.3b
D	100.0a	100.0a	96.7a	100.0a	100.0a	100.0a
E	93.3ab	93.ab	93.3a	100.0a	93.3a	83.3b
LSD(P=0.05)	1.23	0.68	1.46	0.60	0.73	1.33

1: See Table 1 for explanation

2: See Table 1 for names of cultivars
* Means followed by the same letter(s) in the same column are not significantly different at P = 0.05 using DMRT.

Table 4. Conbined table (1990 and 1991) on the effect of dry heat seed treatment on sesame seed viability.

	Percentage seed viability*		
Treatment[1]	65B-56	69A-205	E8
A	98.3b	85.oc	91.7b
B	66.3e	65.od	66.7e
C	80.0d	85.0c	85.od
D	100.0a	100.a	98.3a
E	96.7c	93.3b	88.3c
LSD(P=0.05)	0.92	0.72	1.39

1: See Table 1 for explanation
* Means followed by the same letter(s) in the same column are not significantly different at P = 0.05 using DMRT.

Table 5. Incidence of seed- and seedling-rot of sesame in seed viability test.

Treatment[1]	Percentages seed and seedling rots.*		
	65B-58	69A-205	E8
A	6.7bc	33.3a	26.7a
B	0.0c	0.0b	0.0b
C	16.7b	3.3b	16.7a
D	10.0bc	10.0b	16.7a
E	33.3a	43.3a	36.7a
LSD(P=0.05)	1.61	1.58	2.20

1: See Table 1 for explanation
* Means followed by the same letter(s) in the same column are not significantly different at P = 0.05 using DMRT.

4.2 Glasshouse Evaluation of the Effect of Dry Heat Seed Treatment on Seedling Emergence, Seedling vigour and Seedling Blight of Sesame.

4.2.1 Determination of seedling emergence and seedling blight.

The results showing the effects of dry heat seed treatment on seedling emergence and seedling blight of sesame are presented in Table 6. The percentage seedling emergence was reduced by dry heat seed treatment at 90°C for 24 h. The effect of heat treatment of seeds of cv.E8 on seedling emergence was statistically significant. Heat treatment at 70°C for 96 h gave the highest percentage emergence. The percentage seedling emergence of seeds from the control treatment was lower than those from heat-treated seeds, although seedling emergence was generally above 60%.

Differences between leaf blight severity in seedlings from heat-treated seeds and that in seedlings from the untreated seeds were not statsitically significant.

Table 6. Effect of dry heat seed treatment on seedling emergence and seedling blight of sesame in the glasshouse.

	% Seedling emergence			Seedling blight severity[2]		
Treatment[1]	cv1	cv2	cv3*	cv1	cv2	cv3
A	66.7	86.7	77.8b	1.37	1.07	1.13
B	60.0	66.7	64.4c	1.13	1.16	1.13
C	68.9	73.3	77.8b	1.20	1.20	1.16
D	77.8	80.0	88.9a	1.00	1.00	1.13
E	71.1	62.2	60.0d	1.23	1.13	1.30
LSD(P=0.05)	ns	ns	3.43	ns	ns	ns

1: See Table 1 for explanation
2: See Table 1 for names of cultivars
* Means followed by the same letter(s) in the same column are not significantly different at P = 0.05 using DMRT.

4.2.2 Determination of seedling vigour.

The results of the effect of dry heat seed treatment on some growth parameters of sesame seedlings are shown in Table 7. Dry heat seed treatment did not significantly affect shoot length, stem diameter and root length of sesame seedlings.

Table 7. Effect of dry heat seed treatment on sesame seedling vigour in the glasshouse.

	Shoot length (cm)[2]			Stem diameter (cm)			Root length (cm)		
Treatment[1]	cv1	cv2	cv3	cv1	cv2	cv3	cv1	cv2	cv3
A	20.2	19.0	21.7	0.23	0.22	0.24	11.6	8.2	10.0
B	17.8	12.5	20.0	0.27	0.18	0.24	8.3	6.0	10.2
C	18.2	18.6	20.8	0.24	0.24	0.23	10.1	7.5	6.1
D	17.7	18.2	18.1	0.20	0.28	0.20	6.9	6.7	8.1
E	17.5	17.2	18.4	0.22	0.22	0.23	10.6	8.9	8.3
LSD(P=0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns

1: See Table 1 for explanation

2: See Table 1 for names of cultivars

4.3 Field Evaluation of the Effect of Dry Heat Seed Treatment on the Incidence and Severity of Leaf Spot Diseases of Sesame

The incidences of the two leaf spot diseases of sesame during the 1990 and 1991 field trials are shown in Tables 8 and 9 respectively, while Table 10 shows combined data of these results. The results indicated that dry heat seed treatment significantly affected incidence of leaf spot diseases of sesame in both years. The differences in leaf spot disease incidence between different treatments were found to be significant at 5-9 weeks after sowing (WAS) in respect of cv. 69A-205 during 1990 field trial and 7-9 WAS in all the cultivars during 1991 fields trial. In both years, seedling from seeds treated at 90°C for 24 h and 80°C for 72 h showed significantly lower disease incidence.

The results for the 1990 and 1991 field trials on severity of the leaf spot diseases of sesame are presented in Tables 11 and 12 respectively, while combined data of these results are shown in Table 13. The results showed that there were significant differences in leaf spot disease severity between plants from seeds subjected to different dry heat treatments in respect of cv. 69A-205 during both 1990 and 1991 field trials. Dry heat seed treatment at 90°C, 80°C and 70°C for 24,72 and 96 h respectively, significantly reduced leaf spot severity in cv. 69A-205 at 7 and 9 WAS.

Table 8. Effect of dry heat seed treatment on the incidence of leaf spot diseases of sesame during the 1999 field trial.

	Disease incidence (%)[2] at:											
	3WAS			5WAS			7WAS			9WAS		
Treatment[1]	cv1	cv2	cv3	cv1	cv2*	cv3	cv1	cv2*	cv3	cv1	cv2*	cv3
A	10.3	8.2	10.4	47.7	50.3a	65.2	58.6	61.6a	76.2	67.2	69.2ab	82.9
B	9.5	9.9	8.6	41.4	33.3b	55.3	55.6	41.7b	75.6	66.7	51.4c	81.6
C	10.3	10.1	12.6	50.6	49.2ab	65.9	56.8	47.5ab	54.1	66.4	53.6bc	63.9
D	10.4	11.4	14.6	46.3	46.3a	62.0	56.7	54.3a	68.4	65.8	60.0b	71.5
E	13.6	12.3	15.8	52.1	53.1a	66.7	60.1	62.0a	76.9	72.1	75.4a	84.8
LSD(P=0.05)	ns	ns	ns	ns	8.45	ns	ns	10.6	ns	ns	9.57	ns

1: See Table 1 for explanation

2: See Table 1 for names of cultivars
WAS = Weeks After Sowing.
* Means followed by the names letter(s) in the same column are not significantly different at P = 0.05 using DMRT.

Table 9. Effect of dry heat seed treatment on the incidence of leaf spot diseases of sesame during the 1991 field trial.

	Disease incidence (%)[2] at:											
	3WAS			5WAS			7WAS*			9WAS*		
Treatment[1]	cv1	cv2	cv3	cv1*	cv2*	cv3	cv1	cv2	cv3	cv1	cv2	cv3
A	11.8	13.9	19.8	38.7c	43.9ab	49.1	44.1c	49.6ab	68.9a	47.3c	52.2ab	72.6a
B	9.8	10.2	10.8	37.0c	37.8b	38.7	43.5c	46.6b	40.3c	47.8c	50.9c	43.0c
C	12.5	10.0	17.1	46.9a	42.2ab	45.4	62.1b	47.8b	63.6ab	59.2b	51.1b	68.7b
D	11.9	11.6	12.9	47.2a	49.4ab	38.9	78.0a	53.7ab	51.0bc	74.8a	57.9ab	56.0bc
E	10.4	12.8	18.9	41.5b	50.4a	44.2	46.2c	68.8a	57.9bc	49.1bc	74.3a	63.2bc
LSD(P=0.05)	ns	ns	ns	2.25	4.83	ns	6.47	6.82	5.17	6.97	7.19	5.96

1: See Table 1 for explanation

2: See Table 1 for names of cultivars
WAS = Weeks After Sowing.
* Means followed by the names letter(s) in the same column are not significantly different at P = 0.05 using DMRT.

Table 10. Combined table on the effect of dry heat seed treatment on the incidence of leaf spot diseases of sesame in the 1990 and 1991 field trials.

	Disease incidence (%)[2] at:											
	3WAS			5WAS			7WAS*			9WAS*		
Treatment[1]	cv1	cv2	cv3	cv1	cv2	cv3	cv1	cv2	cv3	cv1	cv2	cv3
A	11.1	10.1	16.0	43.2	47.1	57.2	51.1b	55.6b	72.6a	57.4b	60.7b	77.8a
B	9.7	9.6	9.6	39.2	36.6	43.0	49.6a	44.2d	56.0c	57.4b	50.7c	62.3b
C	11.4	10.1	11.4	48.6	41.2	45.7	54.5b	47.7cb	59.9c	60.8b	52.4c	66.3b
D	11.1	11.5	13.1	46.8	47.3	50.0	62.4a	54.0bc	59.7c	70.2a	59.0b	63.8b
E	12.0	12.6	17.4	46.8	51.8	55.5	54.2b	65.4a	67.4b	60.6b	74.9a	74.0a
LSD(P=0.05)	ns	ns	ns	ns	ns	ns	3.24	8.71	2.59	3.50	8.34	2.48

1: See Table 1 for explanation

2: See Table 1 for names of cultivars
WAS = Weeks After Sowing.
* Means followed by the names letter(s) in the same column are not significantly different at P = 0.05 using DMRT.

Table 11. Effect of dry heat seed treatment on the severity of leaf spot diseases of sesame during the 1990 field trial.

	Disease incidence (%)[2] at:											
	3WAS			5WAS			7WAS			9WAS		
Treatment[1]	cv1	cv2	cv3	cv1	cv2	cv3	cv1	cv2*	cv3	cv1	cv2	cv3
A	1.10	1.00	1.00	1.40	1.50	1.60	1.50	1.60ab	2.10	1.70	1.80a	2.10
B	1.00	1.00	1.00	1.40	1.20	1.40	1.40	1.20c	2.00	1.60	1.40b	2.00
C	1.00	1.00	1.10	1.40	1.40	1.40	1.40	1.40bc	1.40	1.60	1.40b	1.50
D	1.00	1.00	1.10	1.30	1.40	1.50	1.30	1.40bc	1.70	1.60	1.40b	1.80
E	1.10	1.10	1.40	1.50	1.60	1.60	1.50	1.80a	2.00	1.70	1.90a	2.00
LSD(P=0.05)	ns	ns	ns	ns	ns	ns	ns	0.34	ns	ns	0.32	ns

1: See Table 1 for explanation

2: See Table 1 for names of cultivars
WAS = Weeks After Sowing.
* Means followed by the names letter(s) in the same column are not significantly different at P = 0.05 using DMRT.

Table 12. Effect of dry heat seed treatment on the severity of leaf spot diseases of sesame during the 1991 field trial.

	Disease incidence (%)[2] at:											
	3WAS			5WAS			7WAS			9WAS		
Treatment[1]	cv1	cv2	cv3	cv1	cv2	cv3	cv1	cv2*	cv3	cv1	cv2	cv3
A	1.03	1.07	1.07	1.16	1.17	1.32	1.43	1.40b	1.83	1.90	1.90	2.23
B	1.02	1.02	1.03	1.11	1.13	1.10	1.36	1.38b	1.46	1.86	1.80	1.96
C	1.04	1.04	1.02	1.24	1.12	1.30	1.47	1.26b	1.57	1.97	1.77	2.06
D	1.04	1.03	1.06	1.37	1.13	1.29	1.60	1.40b	1.67	2.13	1.86	2.13
E	1.03	1.06	1.08	1.10	1.16	1.33	1.37	1.60a	1.73	1.80	2.27	2.13
LSD(P=0.05)	ns	ns	ns	ns	ns	ns	ns	0.34	ns	ns	ns	ns

1: See Table 1 for explanation

2: See Table 1 for names of cultivars
WAS = Weeks After Sowing.
* Means followed by the names letter(s) in the same column are not significantly different at P = 0.05 using DMRT.

Table 13. Combined table on the effect of dry heat seed treatment on the severity of leaf spot diseases of sesame in the 1990 and 1991 field trials.

	Disease incidence (%)[2] at:											
	3WAS			5WAS			7WAS			9WAS		
Treatment[1]	cv1	cv2	cv3	cv1	cv2	cv3	cv1	cv2*	cv3	cv1	cv2*	cv3*
A	1.04	1.04	1.05	1.30	1.33	1.47	1.45	1.40b	1.95	1.80	1.87b	2.18a
B	1.03	1.03	1.02	1.24	1.19	1.26	1.39	1.25b	1.75	1.73	1.61c	1.98b
C	1.03	1.03	1.05	1.29	1.26	1.35	1.44	1.32b	1.49	1.79	1.59c	1.76c
D	1.03	1.05	1.04	1.35	1.37	1.39	1.45	1.37b	1.67	1.85	1.65c	1.99ab
E	1.04	1.06	1.08	1.30	1.38	1.47	1.44	1.80a	1.84	1.73	2.09a	2.09ab
LSD(P=0.05)	ns	ns	ns	ns	ns	ns	ns	0.33	ns	ns	0.17	0.17

1: See Table 1 for explanation

2: See Table 1 for names of cultivars
WAS = Weeks After Sowing.
* Means followed by the names letter(s) in the same column are not significantly different at P = 0.05 using DMRT.

The results for 1990 and 1991 field trials on number of diseased leaves and number of leaves shed per plant are presented in Table 14 while combined data of these results are presented in Table 15. The differences between the treatments in relation to number of diseased sesame leaves and number of leaves shed per plant were statistically significant in cv. 69A-205 in both years. Dry heat seed treatment at 90°C, 80°C and 70°C for 24, 72 and 96 h respectively effectively reduced number of leaves shed per plant, while seed treatment at 80°C for 72 h significantly reduced the number of diseased leaves per plant during the 1990 field trials.

Tables 16, 17 and 18 show the results for 1990 and 1991 field trials on yield and yield components of sesame. Statistical analysis of the data revealed that dry heat seed treatment did not significantly affect seed weight per plant or per plot, number of capsules, plant height, number of branches and height to the lowest capsules in both the 1990 and 1991 field trials.

Table 14. Effect of dry heat seed treatment on number of diseased sesame leaves and number of leaves shed per plant.

	1990 Field trial						1991 Field trial					
	Number of diseased leaves per plant			Number of leaves shed per plant[2]			Number of diseased leaves per plant			Number of leaves shed per plant[2]		
Treatment[1]	cv1	cv2*	cv3	cv1	cv2*	cv3	cv1	cv2	cv3	cv1	cv2*	cv3
A	7.9	9.7a	12.3	6.8	7.8b	10.7	8.3	10.3	11.7	6.9	9.4a	11.4
B	6.9	5.4bb	12.7	6.1	6.3c	9.6	7.7	7.9	8.7	6.2	7.2b	8.3
C	7.2	4.8b	5.6	6.3	6.3c	7.8	8.9	5.3	9.4	6.6	7.4b	8.0
D	7.8	5.4ab	9.3	6.3	6.2c	8.9	8.1	5.7	9.4	6.1	7.2b	8.3
E	8.5	9.1a	12.8	7.3	9.9a	10.7	9.3	9.9	12.0	7.2	10.3a	11.6
LSD(P=0.05)	ns	4.41	ns	ns	1.35	ns	ns	ns	ns	ns	1.97	ns

1: See Table 1 for explanation

2: See Table 1 for names of cultivars
WAS = Weeks After Sowing.
* Means followed by the names letter(s) in the same column are not significantly different at P = 0.05 using DMRT.

Table 15. Combined table on the effect of dry heat seed treatment on number of diseased sesame leaves and number of leaves shed per plant in the 1990 and 1991 field trials.

Treatment[1]	Numbers of Leaves[2]: With leaf spot/plant			Shed/Plant		
	cv1	cv2*	cv3*	cv1	cv2*	cv3*
A	8.1	10.0a	12.0a	6.8	8.7b	11.1a
B	7.3	6.2b	10.7ab	6.2	6.7c	9.0b
C	8.1	5.0b	7.5c	6.5	6.8c	7.9b
D	7.5	5.6b	9.9b	6.2	6.7c	8.6b
E	8.9	9.5a	12.4a	7.2	10.1a	11.3a
LSD	ns	2.23	2.21	ns	1.61	1.39

1: See Table 1 for explanation

2: See Table 1 for names of cultivars
WAS = Weeks After Sowing.
*: Means followed by the names letter(s) in the same colum are not significantly different at P = 0.05 using DMRT.

Table 16. Effect of dry heat seed treatment on yield of sesame.

	1990 field trial						1991 field trial					
	Seed weight/plant (g)[2]			Seed weight/plot(g)			Seed weight/plant(g)			Seed weight/plot(g)[2]		
Treatment[1]	cv1	cv2	cv3	cv1	cv2	cv3	cv1	cv2	cv3	cv1	cv2	cv3
A	10.7	6.9	8.0	514.7	361.2	417.7	17.5	13.7	10.5	604.6	446.2	452.6
B	7.6	6.9	6.0	427.8	328.9	311.3	9.0	7.0	6.8	450.4	342.9	409.8
C	8.2	7.4	9.5	401.3	437.2	550.2	10.5	8.7	13.9	462.7	413.0	469.0
D	7.6	7.2	6.6	398.7	421.6	363.9	13.7	13.0	15.4	570.6	481.5	549.1
E	7.3	6.6	8.4	339.1	388.9	497.6	13.4	15.7	14.1	575.8	568.1	556.5
LSD(P=0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

1: See Table 1 for explanation

2: See Table 1 for names of cultivars
ns = not significant

Table 17. Effect of dry heat seed treatment on yield components of sesame during the 1990 field trial.

Treatment[1]	Plant height(cm)[2]			Height to the lowest capsules (cm)			Number of branches per plant			Number of capsules per plant[2]		
	cv1	cv2	cv3	cv1	cv2	cv3	cv1	cv2	cv3	cv1	cv2	cv3
A	108.0	101.8	106.1	42.6	44.3	41.1	9.1	9.1	6.7	71.1	64.4	89.3
B	101.6	104.5	104.2	46.5	48.6	28.7	9.5	9.3	5.3	66.9	69.8	76.7
C	112.7	111.5	104.3	48.2	42.7	41.5	9.9	7.9	9.8	88.3	61.4	85.9
D	109.1	106.7	103.2	45.1	46.8	34.4	7.0	7.2	4.8	73.5	63.1	68.5
E	107.1	104.3	106.6	43.9	38.3	37.6	9.1	5.9	7.1	64.1	62.8	83.9
LSD(P=0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

1: See Table 1 for explanation

2: See Table 1 for names of cultivars
ns = not significant

Table 18. Effect of dry heat seed treatment on yield components of sesame during the 1991 field trial.

	Plant height(cm)[2]			Height to the lowest capsules (cm)			Number of branches per plant			Number of capsules per plant[2]		
Treatment[1]	cv1	cv2	cv3	cv1	cv2	cv3	cv1	cv2	cv3	cv1	cv2	cv3
A	150.3	141.3	130.7	50.8	50.0	51.7	9.7	8.3	6.01	22.4	122.5	94.0
B	148.2	136.5	148.3	45.7	44.3	49.7	8.7	7.8	5.3	121.1	118.6	136.9
C	138.8	138.8	136.3	43.7	46.8	57.7	11.3	7.2	6.2	116.5	117.0	120.3
D	132.5	135.0	145.5	44.3	40.2	40.7	8.7	8.2	5.4	116.8	118.1	104.0
E	141.3	137.7	151.2	47.7	43.0	47.2	9.0	8.2	6.7	115.4	114.3	135.6
LSD(P=0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

1: See Table 1 for explanation

2: See Table 1 for names of cultivars
ns = not significant

4.4 Field Investigation of the Effect of Foliar-Applied Fungicides on the Incidence and Severity of Leaf Spot Diseases, and on Yield and Yield Components of Sesame.

The effects of foliar-applied fungicides on the incidence of leaf spot diseases of sesame in 1990 and 1991 are summarized in Table 19 while the combined data of these results are presented in Table 20. The incidence of leaf spot diseases in unsprayed plants was higher than that of sprayed plants. The differences in disease incidence between the treated and untreated plants were significant at 7-9WAS and 5-9WAS during 1990 and 1991 field trials, respecitvely. Both carbendazim + maneb at 2.22 and 3.70 g a.i./l and mancozeb at 5.04 and 7.04 g a.i./l reduced incidence of leaf spot diseases of sesame in the field. The effects of the two chemicals did not differ significantly from each other.

The effects of foliar fungicidal sprays on severity of leaf spot diseases of sesame in 1990 and 1991 are presented in Table 21 while the combined data of these results is presented in Table 22. The differences in leaf spot disease severities between sprayed and unsprayed plants were significant at 7-9 WAS in both years. Both chemicals at both concentrations significantly reduced leaf spot disease severity.

Table 19. Effect of foliar-applied fungicides on the incidence of leaf spot diseases of sesame in 1990 and 1991 field trials.

Treatment	Dose (g a.i./l)	Disease incidence (%) in 1990 field trial				Disease incidence (%) in 1991 field trial.			
		3WAS	5WAS	7WAS$	9WAS$	3WAS	5WAS$	7WAS$	9WAS$
Carbendazim + maneb	2.22	4.5	30.1	32.4b	32.4b	7.9	30.1	37.5b	39.2b
	3.70	3.8	27.7	30.8b	30.8b	7.3	32.4b	37.4b	38.5b
Mancozeb	5.04	4.3	34.1	34.7b	34.7b	7.0	27.0b	33.5b	34.6b
	7.04	4.7	33.7	34.3b	34.3b	8.5	34.1b	39.6b	41.5b
Check	0.00	5.7	42.6	65.3a	78.8a	8.3	49.1a	50.9a	53.2a
LSD (P=0.05)		ns	ns	10.43	14.92	ns	6.38	5.85	7.8

WAS = Weeks After Sowing

$ Means followed by the same letter(s) in the column are not significantly different at P = 0.05 using DMRT.

Table 20. Combined table on the effect of foliar-applied fungicides on the incidence of leaf spot diseases of sesame in the 1990 and 1991 field trials.

		Disease incidence (%) at:			
Treatment	Dose(g a.i./l)	3WAS	5WAS*	7WAS*	9WAS*
Carbendazim + maneb	2.22	6.2	30.1b	35.0b	35.8b
	3.70	5.6	31.1b	34.1b	34.7b
Mancozeb	5.04	5.7	30.6b	34.1b	34.7b
	7.04	6.6	33.9b	37.0b	38.1b
Check	0.00	7.3	45.9a	58.1a	63.5a
LSD (P=0.05)		ns	5.12	5.60	7.59

WAS = Weeks After Sowing

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

Table 21. Effect of foliar applied fungicides on the severity of leaf spot diseases of sesame in the 1990 and 1991 field trials.

Treatment	Dose (g a.i./l)	Disease severity score: 1990 field trial				Disease severity score: 1991 field trial			
		3WAS	5WAS	7WAS$	9WAS$	3WAS	5WAS	7WAS$	9WAS$
Carbendazim + maneb	2.22	1.00	1.20	1.30b	1.30b	1.04	1.28	1.51b	1.52b
	3.70	1.00	1.20	1.30b	1.30b	1.04	1.22	1.39b	1.43b
Mancozeb	5.04	1.00	1.30	1.30b	1.30b	1.04	1.33	1.53b	1.53b
	7.04	1.00	1.30	1.30b	1.30b	1.02	1.27	1.45b	1.41b
Check	0.00	1.10	1.30	1.80a	2.50a	1.04	1.45	1.73a	2.02a
LSD (P=0.05)		ns	ns	ns	0.42	0.43	ns	ns	0.22	0.42

WAS = Weeks After Sowing

$ Means followed by the same letter(s) in the column are not significantly different at P = 0.05 using DMRT.

Table 22: Combined table on the effect of foliar-applied fungicides on the severity of leaf spot diseases of sesame in the 1990 and 1991 field trials.

		Disease severity score			
Treatment	Dose(g a.i./l)	3WAS	5WAS*	7WAS*	9WAS*
Carbendazim + maneb	2.22	1.03	1.26b	1.38b	1.40b
	3.70	1.04	1.22b	1.35b	1.36b
Mancozeb	5.04	1.04	1.32b	1.41b	1.43b
	7.04	1.02	1.31b	1.38b	1.38b
Check	0.00	1.05	1.39a	1.74a	2.24a
LSD(P=0.05)		ns	0.11	0.22	0.29

WAS = Weeks After Sowing

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

Table 23 shows the results for 1990 and 1991 field trials on numbers of leaves infected and leaves shed per plant, while Table 24 shows the combined data of the two year results. The number of diseased leaves and the number of leaves shed per plant were significantly higher in the unsprayed than the sprayed plants in both 1990 and 1991. Both concentrations of carbendazim + maneb and mancozeb reduced the number of leaves shed as well as the number of diseased leaves per plant.

The effects of foliar sprays on yield and yield components of sesame in 1990 and 1991 are shown in Tables 25 and 26, respectively. Foliar application of carbendazim + maneb at 2.22 and 3.70 g a.i./l or mancozeb at 5.04 and 7.04g a.i./l did not significantly affect seed weight per plant and per plot, number of capsules, plant height, number of branches and height to the lowest capsules of sesame in both 1990 and 1991 field trials.

Table 23. Effect of foliar-applied fungicides on number of diseased sesame leaves and number of leaves shed per plant.

Treatment	Dose (g a.i./l)	1990 field trial: Numbers of leaves* With leaf spot/plant	1990 field trial: Numbers of leaves* Shed/Plant	1991 field trial: Numbers of leaves* With leaf spot/plant	1991 field trial: Numbers of leaves* Shed/Plant
Carbendazim + maneb	2.22	4.1b	7.4b	8.5b	7.9b
	3.70	3.7b	7.0b	7.6b	7.4b
Mancozeb	5.04	3.9b	7.6b	8.1b	7.3b
	7.04	3.6b	7.3b	8.9b	6.8b
Check	0.00	10.2a	11.5a	12.5a	12.7a
LSD(P=0.05)		2.26	2.42	1.23	2.40

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

Table 24. Combined table on the effect of foliar-applied fungicides on number of diseased sesame leaves and number of leaves shed per plant in the 1990 and 1991 field trials.

		Numbers of Leaves	
Treatment	Dose(g a.i./l)	With leaf spot/plant*	Shed/Plant
Carbendazim + maneb	2.22	6.2b	7.6b
	3.70	5.6b	7.2b
Mancozeb	5.04	6.0b	7.5b
	7.04	5.6b	7.0b
Check	0.00	11.4a	12.1a
LSD(P=0.05)		1.20	1.57

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

Table 25. Effect of foliar-applied fungicides on yield and yield components of sesame during the 1990 field trial.

Treatment	Dose (g a.i./l)	Plant height (cm)	Number of branches/ plant	Height to the lowest capsule	Number of capsules/ plant	Seed weight/ plant (g)	Seed weight/ plot (g)
Carbendazim + maneb	2.22	90.9	5.1	46.2	36.6	3.9	236.4
	3.70	86.0	4.6	42.9	31.6	3.4	213.9
Mancozeb	5.04	85.9	5.1	40.9	43.7	4.4	229.0
	7.04	94.3	5.7	43.8	44.5	4.6	259.9
Check	0.00	97.5	4.9	51.1	37.9	4.1	242.0
LSD (P=0.05)		ns	ns	ns	ns	ns	ns

ns = not significant.

Table 26. Effect of foliar-applied fungicides on yield and yield components of sesame during the 1991 field trial.

Treatment	Dose (g a.i./l)	Plant height (cm)	Number of branches/ plant	Height to the lowest capsule	Number of capsules/ plant	Seed weight/ plant (g)	Seed weight/ plot (g)
Carbendazim + maneb	2.22	133.0	7.6	49.2	60.1	6.5	335.0
	3.70	132.7	6.7	54.8	80.7	7.6	351.0
Mancozeb	5.04	139.7	9.5	50.2	82.7	10.9	370.0
	7.04	140.7	8.1	51.0	89.9	10.2	417.0
Check	0.00	142.7	7.5	50.3	73.9	7.5	375.0
LSD (P=0.05)		ns	ns	ns	ns	ns	ns

ns = not significant.

4.5 Field Investigation of the Effect of Inter- and Intra-row Spacings on the Incidence and Severity of Leaf Spot Diseases of Sesame.

The effect of inter- and intra-row spacings on the incidence of leaf spot diseases of sesame in the 1990 and 1991 field trials are summarized in Table 27 while Table 28 present combined data for the 2 years. Inter-row and intra-row spacings did not significantly influence incidence of leaf spot diseases at the early stages of plant growth (3-5 WAS). However, effects of inter-row spacing became significantly pronounced at 7-9 WAS in the 1990 field trial, and at 5-9WAS in the 1991 field trial. Disease incidence was higher in closely spaced plants. Thus, inter-row spacings of 50 and 75 cm resulted in significantly higher incidence of leaf spot diseases than that in plants with a spacing of 100 cm. Similarly, closer intra-row spacings showed higher disease incidence but the effects were found to be statistically significant at 5-9 WAS in the 1991 field trial. A decrease in intra-row spacings from 25 to 15 cm significantly increased incidience of leaf spot diseases.

Table 27. Effect of inter- and intra-row spacings on the incidence of leaf spot diseases of sesame in 1990 and 1991 field trials.

	Disease incidence(%): 1990 field trial				Disease incidence(%): 1991 trial			
Spacing(cm)	3WAS	5WAS	7WAS$	9WAS$	3WAS	5WAS$	7WAS$	9WAS$
Inter-row								
100	10.2	55.6	62.0b	64.4b	12.0	53.7b	65.3b	69.1b
75	8.8	61.8	70.9a	72.7a	9.1	62.6a	73.5a	76.5a
50	10.3	70.8	83.6a	83.6a	10.0	65.8a	84.7a	86.5a
LSD(P=0.05)	ns	ns	7.22	7.14	ns	5.79	7.23	7.15
Intra-row								
25	9.9	59.6	69.8	71.5	10.7	58.3b	69.8b	71.9b
20	9.9	64.5	72.5	73.9	9.8	60.5ab	76.1ab	78.6b
15	10.0	64.9	75.6	76.5	10.0	64.6a	76.4a	81.2a
LSD(P=0.05)	ns	ns	ns	ns	ns	4.21	4.60	4.49

WAS = Weeks After Sowing

$ Means followed by the same letter(s) in the same column are not significantly different at P = 0.05 using DMRT.

Table 28. Combined table on the effect of inter- and intra-row spacings on the incidence of leaf spot diseases of sesame in the 1990 and 1991 field trials.

	Disease incidence (%) at:			
Spacing(cm)	3WAS	5WAS*	7WAS*	9WAS*
Inter-row				
100	11.1	54.7b	63.7b	66.3b
75	9.0	62.2a	72.2a	74.6a
50	10.2	68.3a	84.2a	85.1a
LSD (P=0.05)	ns	4.01	5.07	7.01
Intra-row				
25	10.3	58.9b	69.8b	71.7b
20	9.9	62.5ab	74.3ab	76.3ab
15	10.0	64.8a	77.0a	78.9a
LSD(P=0.05)	ns	5.26	5.66	7.16

WAS = Weeks After Sowing

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

Table 29 shows the effect of plant spacing on severity of leaf spot diseases of sesame in 1990 and 1991 while Table 30 shows the combined data of these results. The effects of inter-row spacings on leaf spot severity were significant at 9 WAS in the 1990 field and at 7-9 WAS in 1991. The effects of intra-row spacings were not statistically significant during the 1990 field trial. However, the analysis of data obtained in 1991 showed significant differences in severity of leaf spot diseases among intra-row spacings at 9 WAS. Generally, closer-spaced plants had higher leaf spot severity scores than wider-spaced plants. The interactions between inter- and intra-row spacings on leaf spot severity was significant at 9 WAS in 1990. Plants spaced 50 x 20 cm and 50 x 15 cm had the highest leaf spot severity. While the plants spaced 100 x 25 cm, and 75 x 15 cm had the lowest leaf spot severity scores.

The effect of plant spacing on number of diseased leaves and number of leaves shed per plant in 1990 and 1991 are presented in Table 31 while combined data of these results are shown in Table 32. Neither the inter- nor the intra-row spacings had significant effects on these two parameters in 1990.

Table 39. Effect of inter- and intra-row spacings on the severity of leaf spot diseases of sesame in the 1990 and 1991 field trials.

	Disease severity score:1990 field trial				Disease severity score:1991 field trial			
Spacing (cm)	3WAS	5WAS	7WAS	9WAS#	3WAS	5WAS	7WAS#	9WAS#
Inter-row								
100	1.03	1.40	1.59	1.90b	1.04	1.40	1.59c	1.92b
75	1.03	1.45	1.65	1.92b	1.04	1.41	1.69b	2.01b
50	1.04	1.46	1.76	2.39a	1.04	1.42	1.80a	2.51a
LSD(P=0.05)	ns	ns	ns	0.17	ns	ns	0.09	0.22
Intra-row								
25	1.03	1.40	1.59	1.84	1.03	1.40	1.63	1.90b
20	1.04	1.43	1.73	2.15	1.04	1.41	1.67	2.18ab
15	1.04	1.48	1.69	2.12	1.04	1.43	1.78	2.37a
LSD(P=0.05)	ns	ns	ns	ns	ns	ns	ns	0.27
LSD(P=0.05) Interaction	ns	ns	0.31		ns	ns	ns	ns

WAS = Weeks After Sowing

Means followed by the same letter(s) in the same column are not significantly different at P = 0.05 using DMRT.

Table 30. Combined table on the effect of inter- and intra-row plant spacings on the severity of leaf spot diseases of sesame in the 1990 and 1991 field trials.

	Disease Severity score at:			
Spacing (cm)	3WAS	5WAS	7WAS*	9WAS*
Inter-row				
100	1.03	1.40	1.59b	1.86b
75	1.04	1.43	1.67ab	1.96b
50	1.04	1.46	1.76a	2.45a
LSD(P=0.05)	ns	ns	0.15	0.12
Intra-row				
25	1.03	1.40	1.61b	1.87b
20	1.04	1.42	1.70ab	2.16a
15	1.04	1.46	1.73a	2.24a
LSD(P=0.05)	ns	ns	0.10	0.20

WAS = Weeks After Sowing

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

Table 31. Effect of inter- and intra-row spacings on number of diseased leaves and number of leaves shed per plant in 1990 and 1991 field trials.

	1990 field trial		1991 field trial	
	Numbers of leaves:		Numbers of leaves:	
Spacing(cm)	With leaf spot/plant	Shed/plant	With leaf spot/plant	Shed/Plant
Inter-row				
100	7.5	7.3	8.8	7.5
75	9.0	8.8	8.9	9.0
50	11.9	9.7	11.2	9.0
LSD(P=0.05)	ns	ns	ns	ns
Intra-row				
25	8.9	7.6	9.1b	7.2
20	9.6	8.6	9.5b	8.4
15	10.4	9.6	10.4a	9.8
LSD(P=0.05)	ns	ns	0.75	ns

Table 32. Combined table on the effect of inter - and intra-row spacings on number of diseased sesame leaves and number of leaves shed per plant in the 1990 and 1991 field trials.

	Numbers of Leaves*	
Spacing (cm)	With leaf spot/Plant	Shed/Plant
Inter-row		
100	8.2b	7.4b
75	9.0b	8.9ab
50	11.6a	9.4a
LSD(P=0.05)	2.56	1.61
Intra-row		
25	8.6b	7.4b
20	9.6b	8.5ab
15	10.4a	9.7a
LSD (P=0.05)	0.80	1.78

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

However, intra-row spacings significantly affected number of leaves with leaf spot per plant in the 1991. Decrease in intra-row spacings from 25 to 15 cm significantly increased number of diseased leaves per plant.

The effect of inter- and intra-raw spacing on yield and yield components of sesame in 1990 and 1991 are summarised in Tables 33 and 34 respectively, and the combined data of these results are presented in Table 35. Inter-row spacings did not significantly affect plant height, number of branches and height to the lowest capsule in both 1990 and 1991. Seed weight per plot was, however, significantly affected by inter-row spacing in the 1990. Increasing inter-row spacings from 50 to 75 cm increased seed weight per plot, but further increase to 100 cm decreased it.

Varying intra-row spacing significantly affected number of branches, seed weight per plant and number of capsules produced per plant in the 1990. Increasing plant spacings generally increased number of

Table 33. Effect of inter- and intra-row spacings on yield and yield components of sesame during the 1990 field trial.

Spacing(cm)	Plant height (cm)	Number of branches/ plant*	Height to the lowest capsules	Number of capsules/ plant*	Seed weight/ Plant (g)*	Seed weight/ plot(g)*
Inter-row						
100	116.3	10.0	34.5	93.4	14.9	361.0b
75	116.9	9.4	32.5	91.7	14.3	554.0a
50	115.1	9.5	32.7	102.5	17.6	539.0a
LSD(P=0.05)	ns	ns	ns	ns	ns	129.3
Intra-row						
25	116.0	11.0a	32.2	99.0a	17.0	471.0
20	115.2	9.0b	34.5	99.1a	15.9a	502.0
15	117.0	8.9b	32.9	89.5b	14.2b	461.0
LSD(P=0.05)	ns	1.65	ns	6.58	1.53	ns
LSD(P=0.05) Interaction		ns	ns	14.85	ns	ns

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

Table 34. Effect of inter- and intra-row spacings on yield and yield components of sesame during the 1991 field trial.

Spacing(cm)	Plant height (cm)	Number of branches/ plant	Height to the lowest capsule	Number of capsules/ plant	Seed weight/ Plant (g)	Seed weight/ plot(g)
Inter-row						
100	146.8	10.9	49.8	126.2	16.1	538.0
75	140.2	9.8	46.1	124.4	14.9	585.0
50	146.6	10.5	49.7	132.1	13.8	556.0
LSD(P=0.05	ns	ns	ns	ns	ns	ns
Intra-row						
25	144.4	11.6	48.9	139.1	14.2	546.0
20	146.1	9.8	48.6	131.8	17.0	558.0
15	143.1	9.7	46.1	115.7	13.6	561.0
LSD(P=0.05)	ns	ns	ns	ns	ns	ns

ns =not signifcant.

Table 35. Combined table on the effect of inter- and intra-row spacings on yield and yield components of sesame in the 1990 and 1991 field trials.

Spacing(cm)	Plant height (cm)	Number of branches/ plant*	Height to the lowest capsule	Number of capsules/ plant	Seed weight/ Plant (g)	Seed weight/ plot(g)*
Inter-row						
100	131.5	10.5	42.2	155.0	15.5	449.0b
75	128.5	9.6	39.3	108.0	14.6	549.0a
50	130.8	10.0	41.2	117.0	15.8	548.0ab
LSD (P=0.05	ns	ns	ns	ns	ns	104.0
Intra-row						
25	130.2	11.3a	40.6	117.0	15.6	505.0
20	130.6	9.4b	41.6	160.0	16.5	530.0
15	130.1	9.3b	40.5	103.0	13.9	531.0
LSD(P=0.05)	ns	1.38	ns	ns	ns	ns

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

branches per plant. Thus, increase in intra-row spacings from 15 to 25 cm significantly increased number of branches produced per plant. Increase in intra-row spacings also increased number of capsules and seed weight per plant in the 1990 field trial; but increase in plant spacings beyond 20 cm (intra-row) decreased seed weight per plant in the 1991 field trial, although the effect was not statistically significant. The interaction between inter- and intra-row spacings on number of capsules produced per plant was significant in the 1990 field trial. Interactions between inter-row spacings of 50 and 75 cm, and intra-row spacings of 15, 25 and 20 cm respectively, yielded more capsules per plant than all other interactions.

5. DISCUSSION

The present study has shown that dry heat seed treatment has significant effects on the incidence of seed-borne fungi and bacteria of sesame. Heat treatment at 90°C for 24 h reduced incidences of both seed-borne bacteria and fungi. In a related study, heat treatment at 72°C for 7 days sufficiently reduced incidence of *Xanthomonas campestris* pv. *translucens* in severely infested barley seeds (Sands *et al.*, 1989). However, complete eradication of seed-borne infection following heat treatment has been reported by some workers. Berkmortel (1979) reported that dry heat treatment of TMV infected pepper at 76°C for 3 days or 70°C for 7 days effectively freed seeds of the pathogen (Rast and Stijger, 1987). Dry heat treatment at 78°C for 2 days eliminated ToMV from tomato seeds (Green *et al.*, 1987), while heat treatment for 6 days at 75°C or 5 days at 80°C eliminated *Verticillium tricorpus* from tomato seeds (Tanako *et al.*, 1985). The persistence of both bacteria and fungi in the heat-treated sesame seeds in the present study suggests that they might be internally seed-borne.

Pseudomonas sp. was found to be dominant over *Xanthomonas campestris* pv. *sesami*. The ratio of occurrence of *X. c.* pv. *sesami* to that of *Pseudomonas* sp. was about 1:5. Similar findings were reported by Akpa (1985). He also stated that neither of the bacterial isolates evoked the HR on tobacco leaves. *X. c* pv. *sesami* however, produced blight symptoms when potted 6-8 weeks old sesame plants were sprayed with suspension of the bacterium using an atomizer. The fungi *Macrophomina phaseolina*, *Curvularia* sp. and *Helminthosporium* spp. isolated from the seeds in this present study were earlier reported by others elsewhere to be pathogenic on sesame (both as seed-borne and soil-borne fungi) resulting in seed-, seedling- and stem-rots (Anon, 1955; Poole, 1956; Kushi and Khare, 1979).

Cercospora sesami in the present study could not be isolated from sesame seeds using the general purpose medium, PDAS. However, attempts made at its isolation using specialized media, involving the incorporation of sesame leaf extract and carrot leaf extract in PDAS also proved abortive. Similar difficulties in isolation and culture of *Cercospora* spp. have been reported by several workers e.g. Miller (1969), Abdou and Cooper (1974), and Chen *et al.* (1979). The seed-borne nature of *Cercospora sesami* has, however, been reported previously

by much earlier workers such as Muller and Texera (1941), Nusbaum (1941). More recently Mathur and Kabeere (1975) reported the presence of *Cercospora sesami* in all four seed samples of sesame tested by both blotter and agar plating methods.

Dry heat seed treatment at 90°C for 24 h had significant adverse effect on seed germination. This impairment could be due to the heat intensity. Umekawa and Watanabe (1987) similarly reported reduction in percentage germination of cucumber seeds dry heat-treated at 70°C for 3 days. Also dry heat treatment of tomato and *Capsicum* seeds at 80°C and 85°C respectively, for 5 days, adversely affected seed germination (Tanako *et al.*,1985). On the other hand, the improvement of germination by heat treatment at 70°C for 96 h, in the present study, may be due to reduction in the incidence of seed-borne micro-organisms.

Control (untreated) seeds had lower percentage germination than treated seeds. The high incidence of seed- and seedling-rots in seeds from the control treatment might have been responsible for the observed lower percentage seed germination. These rot diseases

in the present study might not be unconnected with the presence of *M. phaseolina*, *A. niger* and *Curvularia* sp. as earlier reported by Kushi and Khare (1979).

Glasshouse assessment of the effect of dry heat seed treatment also showed that 90°C for 24 h adversely affected seedling emergence. In a similar work, Raat and Stijger (1987) observed delayed emergence and a reduction in the number of seedlings suitable for further raising when pepper was heat-treated at 76°C for 3 days. Tomato seeds treated at 75°C for 6 days or 80°C for 5 days also adversely affected initial growth of seedlings (Tanako *et al.*, 1985). It has been observed in this study, that untreated seeds showed lower percentages of seedling emergence. This was obviously due to high incidence of seed- and seedling-rots, providing support for the earlier results on germination tests in the laboratory.

Assessment of leaf spot disease severity at 35 days after sowing indicated that dry heat seed treatment did not significantly affect leaf spot severity of sesame

seedlings. No differences in disease severity between treatments were observed at this stage of growth. Also shoot length, stem diameter and root length were not significantly affected by dry heat seed treatment.

The incidence and severity of leaf spot diseases in the field were not significant in the early stages of plant growth. However, disease incidence increased rapidly at 5-7 WAS in densely populated plots which resulted in significant differences between treatments. Both disease incidence and severity in seedlings from seeds heat-treated at 90°C, 80°C and 70°C for 24, 72 and 96 h, respectively, were reduced. This reduction in disease incidence could be due to decrease in percentage of infected seeds that might have reduced source of primary inoculum. Dry heat treatment has been used on other crops to reduce incidence of seed-borne diseases (Timietti and Garibaldi, 1984; Sands *et al.*, 1989), while other workers have achieved complete control of seed-borne infection (Umekawa and Watanabe, 1987; Tanako

et al., 1985). The incidence and severity of leaf spot diseases, in the present study, varied to some extent among the cultivars. Cultivar E8 had the highest scores of both parameters.

Dry heat seed treatment at 90°C, 80°C and 70°C for 24, 72 and 96 h, respectively, significantly reduced number of leaves shed per plant, while treatment at 80°C for 72 h reduced the number of diseased leaves per plant in cultivar 69A-205. The significant reduction in these parameters was probably due to the reduced disease incidence and severity.

Dry heat seed treatment had no significant effects on yield components i.e. number of capsules, number of branches, plant height and height to the lowest capsules. Dry heat, seed treatment did not also affect seed yield in the field. These results suggest that effective heat treatment does not have adverse effects on yield and yield components of sesame.

The effects of foliar-applied fungicides were evaluated in field experiments. In this investigation, the incidence and severity of leaf spot diseases, number

of diseased sesame leaves and number of leaves shed per plant were the parameters used to assess the effectiveness of the fungicides. Both carbendazim + maneb and mancozeb significantly reduced the magnitude of these parameters. Similar results were reported by Urdenata and Mazzani (1976); they found that weekly foliar sprays of sesame for the control of bacterial blight with cuprevit and difolatan lowered blight incidence. Mancozeb was found to minimize *Alternaria* blight (Abraham *et al.*, 1976), *Phytophthora* blight (Vyas, 1981) and *Botryosphaeria* blight (Vyas and Shukla,1977) of sesame. *Cercospora* leaf spot of sesame was found to be reduced when sprayed with either benomyl or triasyn (Poswal and Misari, 1988). The disease incidence was, however, rapid and more severe in unsprayed plots which resulted in high rates of defoliation.

Both carbendazim + maneb and mancozeb did not have significant effect on the yield and yield components of sesame. This observation agrees with the findings of Tologbonshe (1983), who reported that there were no significant differences in mean total fruit yield, marketable fruit yield, total fruit number, number of

fruits per plant and average fruit weight between fungicide - treated egg plants and untreated plants for the control of *Cercospora* leaf spot disease.

The effects of inter- and intra-row spacings on the incidence and severity of leaf spot diseases of sesame were also investigated in the field. Decrease in both inter- and intra-row spacings increased disease incidence. The increase in disease incidence among closely spaced plants has been reported previously (Vestal and Bell, 1931; Berger, 1975). Also Huang and Hoes (1980) found that more efficient and faster *Sclerotinia* wilt incidence in sunflower occurred within close- than wide-spaced plants.

This study has shown that disease severities were significantly affected by the different inter- and intra-row spacings. Higher disease severity occurred among close- than wide-spaced plants. Close spacings create high humidity and high temperature, a condition favourable for foliar disease development (Berger, 1975). These effects further resulted in significant defoliation among closely spaced plants.

Close spacings, therefore, favour development and spread of leaf spot diseases of sesame.

Both inter- and intra-row spacings did not have any significant effect on sesame height and height to the lowest capsules. Increase in intra-row spacings from 15 to 25 cm, however, significantly increased number of branches produced per plant. Gupta (1982) similarly reported that varying intra-row spacings affected number of branches produced per plant. In the present study, inter-row spacing of 100 cm and intra-row spacing of 25 cm gave the higheet number of branches. This could be due to the fact that under wider spacing the individual plants are subjected to reduced competition for space, soil nutrient, soil moisture and light from their counterparts.

Varying inter-row spacings significantly affected seed weight per plot in sesame. Increase in inter-row spacings from 50 to 75 cm significantly increased seed weight per plot, but beyond that seed weight declined. Similarly, increase in intra-row spacings from 15 to 20 cm increased seed weight per plot. The distance between plants therefore, determines the amount of seed produced per plot, and since wider plant spacings tend to reduce plant population, they hence reduced seed weight per plot. However Mazzani and Cobo (1956)

reported that the effect of inter-row spacings on yield of branched sesame were more pronounced than intra-row spacings.

In the present study, increase in intra-row spacings from 15 to 20 cm increased both number of capsules and seed weight per plant, but inter-row distance beyond 50 cm resulted in reduced number of capsules as well as seed weight per plant. Other workers have similarly shown that reduction in plant spacings or increase in plant population increases seed yield (Menon, 1967; Gerakis and Tsangarakis 1969; Gupta, 1982; Katung, 1987). In other words yield per unit area increases with increasing plant density until a level is reached beyond which there would not be any yield increase.

6. SUMMARY AND CONCLUSION

This study entailed a two - year investigation on the control of leaf spot diseases of sesame induced by *Xanthomonas campestris* pv. *sesami* and *Cercospora sesami* at Samaru. Laboratory studies were conducted to assess the effect of dry heat seed treatment on the levels of seed contamination by seed-borne pathogens as well as the effect of heat treatment on seed viability. Glasshouse pot experiments were also conducted to determine the effect of dry heat seed treatment on seedling emergence, seedling vigour and seedling blight of sesame seedlings. Finally field trials were conducted in the 1990 and 1991 wet seasons to assess the effects of dry heat seed treatment, foliar-applied fungicides and inter- and intra-row spacings on leaf spot diseases of sesame. Disease incidence and severity, number of diseased leaves and leaves shed were the criteria used to assess the effectiveness of these methods on disease development and spread in the field.

In the laboratory studies, it was found that dry heat seed treatment at 90^{o}C for 24 h in all the three cultivars had the lowest incidence in both seed fungi and bacteria. The most dominant and consistent

isolates in all the heat-treated and untreated seeds were *Macrophomina phaseolina*, *Pseudomonas* sp., and *Xanthomonas campestris* pv. *sesami*. However, the occurrence of *Alternaria* spp. *Helminthosporium* spp., *Aspergillus niger* and *Curvularia* sp. were not consistent with the treatment. *Cercospora sesami* could not be isolated from the seeds, but spores were detected from teased infected sesame leaves.

The seed viability tests indicated that within each cultivar, percentages of seed viability were significnatly reduced by heat treatment at 90°C for 24 h. But the effect of 70°C for 96 h apparently improved seed viability. Generally seed viability was over 60%. Incidences of seed- and seedling-rots were observed. However, no bacteria or fungi were found associated with the ungerminated seeds heat-treated at 90°C for 24 h.

Glasshouse pot experiments showed that 90°C for 24 h seed treatment adversely affected seedling emergence. Dry heat seed treatment however, did not significantly affect shoot length, stem diameter and root length as well as seedling blight severity of sesame seedlings.

Field studies conducted to assess the effect of dry heat seed treatment on leaf spot diseases of sesame indicated that heat treatment at 90°C 80°C and 70°C for 24, 72 and 96 h, respectively, significantly reduced disease incidence and severity, and numbers of diseased leaves and number of leaves shed per plant in cultivar 69A-205 in both the 1990 and 1991 field trials.

Dry heat seed treatment did not significantly affect yield and yield components of sesame.

Of the four dry heat temperatures assessed for the control of leaf spot diseases of sesame, treatment at 90°C for 24 h achieved the best reduction of disease incidence and severity, but unfortunately, a lower percent viability compared with the other treatments. Heat treatment generally failed to eliminate seed-borne pathogens and free the crops from leaf spot diseases. However, it holds a promising future for the control of leaf spot diseases of sesame, since it reduced the levels of some disease parameters assessed. Further investigation may be required on continued manipulations of temperatures and exposure periods, with a view to arriving at a temperature-period combination that could effectively control disease and produce acceptable yields of sesame.

The effects of foliar-applied fungicides evaluated in the two-year field trials showed that carbendazim + maneb at 2.22 and 3.70 g a.i./l and mancozeb at 5.04 and 7.04 g a.i./l significantly reduced leaf spot disease incidence and severity as well as numbers of diseased leaves and number of leaves shed per plant compared with those of check (unsprayed plants). However, foliar application of these fungicides did not significantly affect yield and yield components of sesame. The reduction in disease incidence and severity without significant increase in sesame yield seems to suggest that a low disease pressure occurred in the study period. Therefore, same chemicals and same levels may be tried for severe epidemics.

The investigation of the effects of inter - and intra-row spacings on leaf spot diseases of sesame, in 1990 and 1991 field trials, showed that closely spaced plants had significantly higher disease incidence and severity as well as numbers of diseased leaves and leaves shed per plant, mostly at the later stages of plant growth.

Increase in intra-row spacings from 15 to 25 cm significantly increased numbers of branches and capsules, and seed weight per plant. While increase in inter-row spacings from 50 to 75 cm increased seed weight per plot, but further increase in spacing reduced it. Both inter- and intra-row spacings did not affect plant height and height to the lowest capsules. The effects of interactions between inter- and intra-row spacings on some of these parameters were found to be significant.

Inter- and intra-row spacings at 100 and 25 cm, respectively, were found to be unfavourable to leaf spot disease development and spread. However, yields obtained were lower than those from other spacings. To obtain relatively high yield and a low disease severity, 75 cm (inter-row) and 20 cm (intra-row) spacings may be used.

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