INFLUENCE OF THE METABOLITES OF THREE *PAECILOMYCES* SPECIES ON THE GERMINATION AND SEEDLING DEVELOPMENT OF TWO GHANAIAN MAIZE VARIETIES (ABELEEHI AND OBAATANPA)

A THESIS PRESENTED BY

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DECLARATION

I, the undersigned, ANDREW AMEGBEDZI MINAMOR, author of this thesis, do hereby declare that the work presented in this thesis:

INFLUENCE OF THE METABOLITES OF THREE PAECILOMYCES SPECIES ON THE GERMINATION AND SEEDLING DEVELOPMENT OF TWO GHANAIAN MAIZE VARIETIES ABELEEHI AND OBAATANPA

was done entirely by me in the Department of Botany, University of Ghana, Legon from September 1993 to October 1995. This work has never been presented either in whole or part for any other degree of this University or elsewhere.

.....

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UNIVERSITY OF GHANA - LEGON

.....

(Professor G.T. Odamtten)

SUPERVISOR

DEDICATION

To Audrey and Wilhemina that they grow to fear the Lord, for the fear of the Lord is the beginning of Wisdom.

ABSTRACT

The mycoflora of two recently-developed maize (*Zea mays L*) varieties Abeleehi and Obaatanpa have been studied under varying ambient equilibrium relative humidities ERH's (55, 60, 65, 70, 75, 80, 85, 90 and 95%) representative of the Ghanaian ambient conditions.

The potential pathogenicity of selected contaminating fungal species (*A. alutaceus, = A. ochraceus, Fusarium, moniliforme, Penicillium digitatum, Peacilomyces carneus, P. puntoni* and *P. varioti*) was also tested under laboratory, field and greenhouse conditions.

Finally, the fungal succession or phenology of the species encountered in the rhizosphere and non-rhizosphere soil containing treated maize grains (Abeleehi and Obaatanpa varieties) treated with conidia/mycelium or culture filtrate of the three *Paecilomyces* species (*P. carneus, P. puntoni* and *P. varioti*) was studied.

About thirty (30) and twenty-eight (28) species of fungi belonging to the genera *Aspergillus, Penicillium, Curvularia, Chaetomium, Cladosporium, Emericella, Eurotium, Fusarium, Paecilomyces, Mucor, Neurospora* and *Rhizopus* were isolated from Abeleehi and Obaatanpa varieties respectively at ERH's 55-95%. *Aspergillus* species (*Aspergillus candidus, A. effusus, A. fumigatus, A. giganteus, A. niger, A. ochraceus, (= A. alutaceus), A. sulphureus, A. tamarii, A. ustus, A. versicolor, A. wentii* and *Aspergillus* sp) predominated over the others followed by *Penicillium* (*Penicillium brevi-compactum P. critinum, P. verrucosum, P. digitatum, P. expansum, P. funiculosum, P. glabrum and P. nigricans).* Fungi belonging to the other genera encountered were *Curvularia, Paecilomyces, Chaetomium, Cladosporium, Emericella, Eurotium, Fusarium, Mucor.* The species diversity was influenced by grain variety and the ERH at which the grains were stored. *Aspergillus flavus* was ubiquitous and was encountered in all

grains stored at 55-95% ERH. *Fusarium moniliforme* was isolated from some grains incubated at 65-95% ERH. Xerophilic or xerotolerant fungal species like *Aspergillus fumigatus*, *A. alutaceus* (= *A. ochraceus)*, *A. giganteus*, *Paecilomyces carneus*, *P. puntoni* and *P. varioti* were isolated at 55-65% ERH in both grain varieties.

The best vegetative growth (radial) of selected species was influenced by both the medium and temperature of incubation. *Paecilomyces carneus* grew best at 30^{0}C, *P. puntoni* at 30-35^{0}C and *P. varioti* at 30^{0}C. All the *Paecilomyces* species, however, could grow well at 40^{0}C. *Aspergillus* species tested (*A. flavus*, *A. giganteus*, *A. alutaceus*) grew best at 30^{0}C and remained depressed in growth at 40^{0}C; so did *Penicillium digitatum* and *Fusarium moniliforme*.

The three *Paecilomyces* species produced their toxic metabolites in 2 days and their undiluted culture filtrates depressed seed germination of 'Abeleehi' and 'Obaatanpa' by 10-75% (depending on fungal species and period of incubation). This inhibitory effect was gradually removed with increasing dilution (up to 1:10$^v/_v$). There were varietal differences in the response of the germinating grains to the toxic metabolites of *P. carneus*, *P. puntoni*, and *P. varioti.* Undiluted culture filtrate of the listed three *Paecilomyces* species also severely depressed length of the emerging radicles of 'Abeleehi' and 'Obaatanpa' by 45-90% but this inhibition was gradually removed by increasing dilution of the culture filtrates (up to 1:10$^v/_v$ dilution).

The inhibition of seed germination and radicle development by culture filtrate of the three *Paecilomyces* species was not confined to maize only as their adverse effect on seed germination and radicle development was reproduced in vitro using tomato (*Lycopersicon esculentum* Mill var. Owusu-Bio and Wosowoso) and pepper (*Capsicum annuum L*). In this instance, the inhibitory principle was still potent even at 1:10$^v/_v$ dilution level.

Culture filtrate of *Aspergillus alutaceus* (= *A. ochraceus*) at the highest concentration depressed seed germination of Abeleehi and Obaatanpa varieties by 50-70% and reduced radicle length by 60-90%. The inhibitory effect was gradually removed by increasing dilution (up to 1:10$^{v}/_{v}$). Similarly, *F. moniliforme* and *P. digitatum* had the same deleterious effect on germination and radicle development of 'Abeleehi' and 'Obaatanpa' maize varieties. Seed germination was depressed 50-70% and radicle length by 40-90% when the undiluted culture filtrate of *F. moniliforme* and *P. digitatum* were applied to the grains. In all instances, the inhibitory effect was gradually removed by increasing dilution of the culture filtrates.

There were varietal differences between the three *Paecilomyces* species in their effect on vegetative growth and dry matter accumulation of Abeleehi and Obaatanpa maize varieties. Metabolites of *P. carneus, P. puntoni* and *P. varioti* variably depressed plant height, leaf width, leaf length, dry matter accumulation, (dry weight of root and shoot systems) as well as chlorophyll a and b contents of Abeleehi and Obaatanpa varieties cultivated in the field and under green house conditions. The maize cobs obtained from the field plants infected with *Paecilomyces* species were diminutive with fewer and smaller grains in the cob as compared to the control.

Culture metabolites of *P. carneus, P. puntoni* and *P. varioti* reduced by 2-3 times diameter of roots of the seedlings of Abeleehi and Obaatanpa although the endodermis and pericycle were clearly formed and demarcated in both the control and treated seedlings. The pith parenchyma was thinly lignified and 2-3 times narrower in diameter in the treated plants exposed to the three *Paecilomyces* species; pro - and metaxylem vessels were about 2 times

wider in the control seedlings and the phloem and xylem regions of the roots of the treated plants were reduced in number and size.

Maize grains (Abeleehi and Obaatanpa varieties) inoculated with three *Paecilomyces* species influenced the rhizosphere mycoflora and their succession profile. Generally, the species of fungi that were stimulated, depressed or eliminated varied from one grain variety to another growing either in the field or under greenhouse conditions. *Aspergillus flavus, A. niger, A. alutaceus, (= A. ochraceus)* and *A. versicolor* remained viable in the rhizosphere soil inspite of the presence of the inhibitory principles exuding from the *Paecilomyces* species; *Penicillium citrinum* could tolerate the same metabolites while *P. digitatum, P. brevi - compactum* did not grow very well in competition with the three *Paecilomyces* species. Population of other fungi encountered belonging to the genera *Cladosporium, Fusarium, Mucor, Scopulariopsis, Trichoderma* and Yeast declined with time. *Cladosporium herbarum, F. moniliforme, Mucor* sp, *Rhizopus oryzae* and *T. viride* survived in the treated soil in competition with the metabolites of the *Paecilomyces* species. The practical implication of these findings are discussed and future studies suggested.

I. INTRODUCTION AND LITERATURE REVIEW

Maize (*Zea mays. L*) is an important cereal grains in Africa ranking as high as rice as a staple food. In Ghana, maize is an important crop cultivated throughout the country with varying degrees of success depending on edaphic and climatic factors. The areas of maize cultivation in Ghana include the whole of Southern Ghana, Ashanti, Brong Ahafo, the Northern regions and parts of the Upper Region. Intensive commercial production of maize is however found in the (a) Somanya District of the Eastern Region. (b) the midland maize belt of Ashanti and Brong Ahafo Regions. (c) The Ho-Kpandu District of Volta Region and Central Region. Elsewhere substantial amounts may be produced but are mainly used for home consumption.

Being a seasonal crop, especially in West Africa, maize is stored as dry grains and forms an enormous reserve of food. The Ghana Food Distribution Corporation has two warehouse in the Greater Accra Region Kaneshie warehouse and Supreme warehouse at Tema. Balduzzi warehouse at Kumasi, G.N.T.C. warehouse at Sunyani, Galvanised I warehouse at Koforidua, Office warehouse at Cape Coast. The rest are Air Force Warehouse at Takoradi, Office warehouse at Ho, GRPC warehouse at Bolgatanga and office warehouses at Wa and Tamale respectively.

However, considerable amount of grains in storage are attacked by a variety of insects, fungi and other bioderioagents. Losses in storage due to insects and fungi is estimated at 25 - 30% of the annual harvest (Rawnsley, 1969 Adams 1977)

The role of fungi in quality deterioration of grains is well - documented in developed countries Bothast et al.1979; Christensen and Kaufmann, 1965; 1969) but there is limited information regarding fungal flora of maize in West Africa and the role such fungi play. Broad-

bent, et al (1969) provided an extensive list of fungi associated with maize stored in Nigeria. Later, Oyeniran (1973 a,b) extended the list by eleven fungal species belonging to the genera *Aspergillus* and *Penicillium*.

Two ecological categories of fungi that invade seeds are FIELD FUNGI and STORAGE FUNGI. Field fungi are those that invade seeds on the developing plants in the field. They may be saprophytes (eg *Alternaria tenuis*, *Cladosporium herbarum, Epicoccum nigrum*) or in some seed pathogens fungi (eg *Fusarium moniliforme* and *Verticillium alboatrum).*

Storage fungi are those that contaminate stored products. Most of them are able to grow without free water. Most of the storage flora are species of *Aspergillus* and *Penicillium*. Some fungi (*Aspergillus*, *Penicilliun* etc can survive in seeds as long as 4-8years (Neergard, 1983).

In Ghana, 42 fungal species belonging to 12 genera(*Aspergillus, Chaetomium, Cladosporium, Curvularia, Emericella, Eurotium, Fusarium, Mucor, Neurospora, Paecilomyces, Penicillium* and *Rhizopus*.) have been isolated from different local maize varieties. (Danquah, 1973; Odamtten, 1986). *Aspergillus* species predominated followed by *Penicillium*. Mislevic and Tuite (1962) also found that the predominant fungi in store dent maize were *Penicillium* species (*P. brevi-compactum, P. cyclopium* and *P. viridicatum*).

Several isolates obtained by Richard, Tiffany and Pier (1969) from mouldy maize samples collected in Central Iowa, U.S.A were mainly species of *Aspergillus* and *Penicillium* in lesser quantities species of *Chaetomium, Fusarium, Nigrospora, Rhizopus* and *Trichothecium.*

Most of the seed-transmitted pathogens are fungi. Some are easily detected, others occur but cannot be revealed by conventional testing procedures. To survive in seeds most fungi must be able to withstand dehydration. Xerophilic or xerotolerant fungi are characteristically capable

of producing abundant xerotolerant propagules such as chlamydospores conidia or other dormant structures, including dormant mycelium, sclerotia etc. Examples include species of

Paecilomyces, Alternaria Cercospora, Curvularia, Dreschlera and *Stemphylium* (Neergaard 1983).

Metabolites of these fungi may have beneficial or adverse effects on plant growth including suppression of seed germination, malformation and retardation of growth of seedlings (Leelavathy, 1969; Narain and Prakash, 1968); (Odamtten and Clerk, 1985, 1988) root growth promoters (Kimura et al, 1992 a,b). Fungi involved are members of the *Aspergillus, Penicillium, Alternaria* etc. The association of such seed-borne fungi with stored grains may result in serious reduction in crop yield in the field by seeds infected with pathogenic seed-borne fungal species.

The increased attempt by man to cultivate new varieties of crops more suited to his climate has necessitated breeding programmes that require crossing of local varieties with imported grain varieties which are not indigenous to Africa. The attendant problem is the production of new varieties whose versatility in terms of drought tolerance, yield and susceptibility to local indigenous diseases have not been thoroughly investigated prior to introduction of the crop to the farmers.

Recently, a new storage problem of maize grains has been reported in certain parts of Africa (Tyler, 1992) called Stackburn. Maize grains stored in woven polypropylene bags in the warehouse heated (up to $> 40^{0}$C) and caused discolouration of the seed coat and germ region turning from white to varying shades of brown. These grains are subsequently downgraded and

disposed of cheaply. This constitute a great loss to the farmer and the warehousing agent and above all a great threat to food security in Africa.

The European Community is funding a collaborative research (EC Contract TSD3 CT 920097) to establish the causes and prevention of stackburn in sub-saharan Africa including Ghana, Zimbabwe, Mozambique, Angola and Tanzania with inputs from two European Countries, Britain (Natural Resources Institute) and Portugal (IICT, CEFA).

As part of the ECDGXII Maize Stackburn Project, in Ghana, we looked at the resident mycoflora of two newly developed maize varieties on the market, Abeleehi and Obaatanpa and their influence on the storage potential of the two maize varieties.

An exhaustive search through the pertinent literature revealed that no detailed study has ever been made in West Africa to elucidate the adverse effect of the *Paecilomyces* species associated with stored maize grains not excepting the two-newly developed varieties. Furthermore, the effect of the metabolites of these species on seeds and other economic crops such as pepper and tomato earmarked for long term storage has hitherto received limited attention.

This thesis reports the effect of some of the seed-borne fungi (*Paecilomyces carneus, P. puntoni, P. varioti*) isolated from Abeleehi and Obaatanpa on the seed germination, radicle development and field and greenhouse performance of Abeleehi and Obaatanpa. The influence of the *Paecilomyces* species on seed germination of pepper and tomato as well as phenology of the rhizosphere mycoflora of Abeleehi and Obaatanpa were also studied.

II. MATERIALS AND METHODS

(i) MATERIALS

The fungal species, *Aspergillus flavus, A, giganteus, A. ochraceus, (=A, alutaceus) Fusarium moniliforme, Paecilomyces carneus, P. varioti, Penicillium digitatum* and *P.expansum* used in these investigations were isolated from maize grains and the air at Kaneshie Warehouse and Supreme Warehouse at Tema.

The maize varieties used Abeleehi and Obaatanpa were purchased from Aglow Seed Company Accra.

The soil used for greenhouse experiment was obtained from the Botanical gardens. Black polythene bags (35cm x 20.3 cm) were used for sowing the maize.

A plot of land in front of the Carpenter's Workshop in Botany Department, University of Ghana, Legon was ploughed for planting maize for the field work.

(ii) GENERAL METHODS

Mycoflora of maize grains Abeleehi and Obaatanpa varieties incubated at 55-95% ERH for 36 days at 28-31^{0}C

(a) Maize samples kept under humidity chamber

Maize samples of Abeleehi and Obaatanpa varieties were kept at 55,65,75,85 and 95% Equilibrium Relative Humidity (ERH) provided by glycerol; water mixtures and at temperature of 28-31^{0}C for 36 days.

b Direct - Plating Method

The maize grains were surface - sterilized by washing in Milton's reagent (1% sodium hypochorite + 16.5% sodium chloride) for 5 min. and then rinsed with three changes of sterile water. Sodium hypochlorite treatment was used with the aim of reducing or removing completely external saprophytes which compete with pathogens. Ten surfaced - sterilized grains were placed on either Sabouraud Dextrose Agar (Oxoid CM41) Dichloran Glycerol Agar, DG18 (Oxoid CM 727) in Petri plates without further treatment. The plates containing Sabouraud's Agar and DG18 were incubated until fungi grew. There were 25 replicates for each grain variety.

C. Identification of Fungi

Fungi encounted in these investigations were identified by their colour, culture and morphological characteristics using the conventional identification manuals of fungi by;

Barnett and Hunter (1972), Ellis and Ellis (1988),

Funder (1953), Gilman (1957),

Ramirez (1982), Samson and Reenen-Hoeskstra (1988)

and Smith (1960).

Where necessary, the identification of the fungi were confirmed by my supervisor.

D. Serial-Dilution Method

A 10g sample of the grains was weighed and transferred aseptically into 100ml 0.1% Peptone in 250ml Erlenmeyer flasks and then shaken in Gallenkamp Model Orbital shaker at 140rev/min for 30 mins. From this stock suspension serial dilution method was employed up to $1:10^{v}/_{v}$ and spores were raised either in Sabouraund's Agar (Oxoid CM 41) or Oxytetracycline GlucoseYeast Extract Agar (Oxoid CM 545). The objective of using two media is to recover a wider range of fungal species from the incubated grain.

The plates were incubated at 28-31°C until fungi grew (7-14 days).

E. Maintenance of Stock Cultures

Stock cultures of *A. flavus, A. giganteus, A. ochraceus, (= A. alutaceus) F. moniliforme, P. carneus, P. varioti, Penicillum digitatum* and *P. expansum* were maintained on slopes of Potato Dextrose Agar, slants in MaCartney tubes and sub-cultured every two weeks.

F. Preparation of Media

The composition of media used were as follows:

(i) Czapek-Dox Agar

$NaNo_3$ - 20g; KCI - 0.5g; M_gPO_4 - 0.5g

$FeSO_4 + 7H_2O$-01g; K_2SO_4, $7H_2O$ - 0.35g;

Sucros - 30.0g, Agar - (12-15)g PH 6.3,

Sterile distilled water - 100ml

(ii) Potato Dextrose Agar

200g of peeled potato were boiled in 500ml of water, strained and made up to 1000ml; 20g glucose and 20g Agar were added.

(iii) AND (iv) MAIZE MEAL AGAR PREPARED FROM EITHER ABELEEHI OR OBAATANPA

200g maize blended and 500ml of distilled water added. This was heated for a few minutes. The suspension was filtered through Buchner funnel to obtain a near clear solution. 20g of glucose and 20g Agar were added and made up to 1 litre with sterile distilled water.

(v) MALT EXTRACT AGAR

Maltose	52.2%
Dextrose	19.1%
Sucrose	1.8%
Dextrin	15.0%
Other carbohydrate	3.8%
Protein	4.6%
Ash	1.5%
Water	2.0%
Agar	(15 - 20)g.

(vi) MODIFIED COOK'S MEDIUM (AFTER COOKE, 1954)

Dextrose - 10g; Peptone, - 5g, KH_2Po_4 - 1g

$MgSO_4$ - $7H_2O$ - 0.5g; Rose bengal - 0.035g;

Streptomycin - 0.35g; Agar - (10 - 15)g

Sterile distilled water - 1000ml.

G Method of Inoculation

Two diameters at right angles to each other were drawn at the bottom of the Petri dishes (9.0cm) with grease pencil after the agar medium has set. Each plate was held in inverted position, the lid was removed and the plate inoculated at the intersection of the two diameters with conidia on 2mm Agar disks at the tip of a flamed - sterilized innoculation pin. The lid was placed back and the plates incubated in the inverted position. This method of inoculation completely obviated the usually sprinkling of powdery spores of *Penicillium* and *Aspergillus* species on plates inoculated in the upright position. In the case of *Paecilomyces* and *Fusarium* species, the agar disks bearing the inoculation was placed directly at the centre of the plate. The plates were inoculated in triplicate for each species and were incubated at 18°, 30°, 35° and 40°C.

H. Assessment of Growth

Fungal Cultures

Vegetation growth in liquid medium was assessed by estimating the dry weight of harvested mycelium at the end of the incubated period. Mycelium collected on a previously weighed and dried Whatman No.1 filter paper was dried at 80°C for 24h. The filter paper carrying the dried mycelium was then weighed after it has been allowed to cool in a desiccator.

Growth of cultures on solid media in Petri dishes was assessed by measuring width of culture along two diameters for 7 days.

I Seed Viability Test

Maize seeds completely free from fungal attacks were used in the viability test. Fifty seeds each of Abeleehi and Obaatanpa varieties were cut longitutdinally to expose the germ region and then placed in sterile Petri dishes containing Tetrazolium Chloride solution. There were five replicates for each maize variety. The plates were incubated in total darkness for at least three hours. Thereafter the number of seeds showing characteristics pinkish colour in the germ region were counted and percentage viability calculated.

J In vitro studies on the effect of Fungal Metabolites on Germination and Radicle Development

Liquid static culture filtrate of the local isolates of *Aspergillus flavus*, *A giganteus*, *A. ochraceus, (A. alutaceus)*, *Fusarium moniliforme*, *Paecilomyces carneus*, *P. puntoni*, *P. varioti*, *Penicillium expansum*, *P. digitatum* were obtained by raising the listed fungi (aliquot of 1.2 - 1.8 x 10^5 spores/ml per flask) in either 30ml of Potato Dextrose Broth (PDB), Maize Meal Broth (MMB) prepared from both Abeleehi and Obaatanpa varieties. The mycelium was harvested after 2,4 and 8 days at 28 - 31°C. Vegetative growth of the fungi was assessed by the convetional dry weight method and the cultural filtrates stored separately in 500ml Erlenmeyer flasks covered with black polythene bags for immediate use.

The pH of the filtrates were taken before and after each pre-determined incubation period using TOA pH meter HM - 60s (TOA Company Japan). The culture filtrates were used either undiluted or diluted (1:1. 1:2, 1:5 and 1:10 $^{v}/_{v}$). About 10 grains of either Abeleehi or Obaatanpa varieties were placed on sterile filter paper in 9.0cm petri dishes moistened with 10 ml distilled water (control) or with 10 ml of culture filtrate of the listed fungi diluted (1:1. 1:2, 1:5 and 1:10 $^{v}/_{v}$) as above. There were 250 grains for each dilution level of culture filtrates and period of growth (2,4, 8 days) of the repective fungi. Percentage germination was calculated after 5 days incubation at 28 - 31°C and the length of radicle noted. The length of the radicles (hypocotyl) are given as ratio ($^{o}/_{o}$) to those of the control seedlings in distilled water (Kimura *et al 1992a).*

The above experiment was repeated this time using only culture filtrate of the three *Paecilomyces* species. Seeds of pepper (*Capsicum annuum L*) and tomato (*Lycopersicon*

esculentum var Wosowoso and Var. Owusu Bio) were used for the bioassay on the effect of the culture filtrate on seedlings in distilled water (Kimura *et al* 1992 a).

K. Influence of Fungal Metabolites on Vegetative Growth and Dry Matter Accumulation by Maize Seedlings

(i) Field Studies

Healthy surface - sterilized grains of Abeleehi and Obaatanpa were inoculated with mycelium/spore suspension of the respective 7 days old culture of *P. carneus, P. puntoni and P. varioti*. A small superficial slit was made in the germ region of the grain and the inoculum (about 1.8 - 2.8 x pores/ml) applied directly into the slit. The inoculated grains were incubated in Petri dishes for 24h at 30^{0}C to allow the grains to take th fungus. The grains were then sown in the field plot at the recommended spacing of holes 25 cm apart in rows 90cm apart. There were 50 replicates per treatment. Records of plant height, leaf width (at the broadest point) and leaf length were taken after 7, 21, 35, 42 and 56 days growth.

(II) Greenhouse Studies

Black polythene bags (35cm x 20.3cm) served as pot for soil which were seeded with five grains of either Abeleehi and Obaatanpa varieties and then thinned to two per bag after germination. The soil in each bag was moistened with either 20-30ml undiluted culture filtrate of either *P. carneus, P puntoni or P. varioti* initially at two days intervals for 2 weeks and thereafter at weekly intervals. There were 50 replicates per treatment. The germinating seedlings were kept in the greenhouse exposed to the normal day/night regime at 28-31^{0}C. Measurement of stem height, leaf width, leaf length dry weight of shoot, leaf and root systems

were made after 7, 21 35, 42 and 56 days. The dry weight of plant parts were determined by keeping them at 80^0C for 48h and then weighed after cooling.

L Chlorophyll content

About 100ml of 80% acetone extract of maize leaf (2g wt) was filtered through Whatman No. 1 filter paper in Büchner funnel. The colour of the resultant liquid was read on Shimadzu Spectrophotometer at 663nm and 645nm using 80% acetone as blank. Chlorophyll concentration was calculated as follows:

Chlorophyll a = 12.7 x Absorption at 663nm - 2.69 x Absorption at 645 (mg/1).

Chlorophyll b = 22.2 x Absorption at 645nm - 4.67 x Absorption at 663 (mg/1).

Total Chlorophyll = 20.2 x Absorption at 6 45nm + 8.02 x Absorption at 663 (mg/1).

M Anatomical Studies

The structure of the root of seedlings growing under the influence of the metabolites of the three *Paecilomyces* species in the field was studied. Sliding microtome (Reichert Nr. 15917, Austria) sections were stained temporarily in aniline chloride and permanently with safranin and fast green following the procedure of Purvis et al (1966).

N Effect of Culture Filtrates on Germination and Radicle Development of Maize Grains (BLOTTER TEST METHOD)

Ten surface-sterilized grains were placed on sterile Whatman's No.1 filter paper in 9.0cm Petri dishes. The filter papers were moistened with 5ml of appropriate dilutions of the cultured filtrate. There were 25 replicates (250 grains) for each treatment. Sterile distilled water served as control.

The plates were incubated in darkness for 5 days at 28-31^{0}C. Two maize varieties Abeleehi and Obaatanpa were used for the germination tests.

The lengths of the emerging radicles were measured and dry weight determined at 80^{0}C for 24h for each treatment. Tables of values shown at the appropriate places in the text present the mean values obtained from the readings taken.

O Preparation of Polythene Bags and Field for Growing of Seeds

The soil used in this investigation is a sandy loam (C, 0.8%, N, 0.1%, pH (H_2O) 5,2). The soil was mixed thoroughly, air-dried, sieved (<2mm) to collect unwanted particles before transferring into polythene bags (35 x 20.3 cm) provided with holes for drainage. Forty polythene bags were filled to about 3/4 full making sure that the same amount of soil was found in each polythene bag. Washed coarse sand was spread over the surface of the soil to prevent compaction of the soil surface during watering. Thereafter, the soil was moistened daily with tap water before planting and placed in the greenhouse.

A plot of land (80 x 50m) in front of the carpenter's workshop in Botany Department University of Ghana was weeded and ploughed. The plot was left for three (3) days before sowing the grains at the recommended spacing for maize grains (seed holes 25cm apart in rows 90cm apart).

P Isolation of Rhizosphere and Non-Rhizosphere Fungi

Rhizosphere and non-rhizosphere fungi were isolated initially and after 14,28,42 and 56 days growth of seedlings. The conventional serial dilution plate method (Waksman 1922) was used to isolate the fungi from both the rhizosphere and non-rhizosphere soil using Cooke's medium (Cooke, 1954)

Samples of rhizosphere soil (1g) from two plants were collected at each pre-determined harvest of 14,28,42 and 56 days. The samples were selected according to the table of random numbers set out for the potted seedlings. A quantity of root (roots of two seedlings) material was used after shaking off excess soil to allow only an adequately rich suspension adhering to the roots for serial dilutions up to $1:10^5$.

Samples of non-rhizosphere soil were collected by removing 2.5cm core of the top soil with sterile No.6 Cork borer (1cm in diameter).

Q Methods of Sterilization

Maize grains were surface sterilized with 2% sodium hypochlorite for 5 min. The grains were then rinsed in three changes or more sterile distilled water.

All media, conical flasks, MaCartney tubes pipettes were sterilized by autoclaving for (1.5 mins at 121^0C steam pressure of $1.1kgt/cm^2$).

Cotton wool plugs, filter papers were temporarily covered with grease paper to prevent penetration by any condensed water during autoclaving.

Slides cleaned with detergent and thoroughly rinsed under running water and then in distilled water were stored in 90% ethyl alcohol and sterilized by flaming just before use.

Forceps and inoculating needles and loops were flamed - sterilized by heating in an electric-oven at 165^{0}C for 6h.

The inoculation room was sterilized by spraying with 5% dettol solution immediately before use.

R Experiment Precautions

1. Glassware was scrupulously kept clean. Glassware which had already been cleaned with water and detergents was rinsed several times with tap water and distilled water and allowed to drain before use.
2. Petri dishes were sterilized by putting them in canisters and then put in the oven at 105^{0}C for 8h, removed and allowed to cool before use.
3. All the media including filter papers were sterilzed at steam pressure of 1.1kgt/cm^2 in the autoclave (121^{0}C for 15 min.).
4. Inoculation room was sprayed with 5% dettol. All tables were wiped with 95% ethanol, loop, scapel were all flamed on spirit burner lamp before use.

III. EXPERIMENTAL PROCEDURE

A. Mycoflora of Maize Grains Abeleehi and Obaatanpa Varieties Incubated at 55-95% ERH for 36 days at 28-31°C

Seeds of cereal grains and legumes harvested from the field harbour both field fungi (mycoflora contaminating seeds in the field before harvest) and storage fungi (those fungi that become resident during post-harvest storage of seeds). These two categories of fungi have been known to shorten the shelf-life of stored seeds; reducing seed viability, nutrient content and imparting toxic metabolites into the seed to mention but a few.

In this chapter mycoflora of two newly developed maize varieties Abeleehi and Obaatanpa was assessed under environmental conditions representative of the local Ghanaian tropic condition (ERH's 55, 65, 75, 85 and 95% and temperature 28-31°C) provided by glycerol; water mixtures. The methods employed are described under the Materials and General Methods section (ii) (a) & (b). Results obtained are presented in Table 1.

B. Radial Growth of Three *Paecilomyces* species Isolated from Abeleehi and Obaatanpa Varieties on Five Different Media.

Many fungal species were isolated from both maize varieties in chapter A. Of interest, however, were three Xerophilic *Paecilomyces species (P. carneus P. puntoni, P. varioti)* which are being recorded for the first time on stored Ghanaian maize varieties. These fungi could be of pathological importance if their metobolites affect the viability and germination capacity of grains of Abeleehi and Obaatanpa used as seed maize in the next planting season.

There is hardly any information in the pertinent literature on the physiological condition for optimal growth of these species isolated in Ghana. In this Chapter five different natural and

synthetic mycological media (Czapek-Dox Agar, Maize Meal Agar (Abeleehi), Maize Meal Agar (Obaatanpa), Malt Extract Agar and Potato-Dextrose Agar) were tested for ability to support optimal growth of the *Paecilomyces species* at different temperature (18^0, 30^0, 40^0 and 45^0C). Radial growth in 7 days on agar was measured along two diameters marked at the bottom of the Petri plates (see Materials and General methods, section (ii) (h). Results obtained are presented in figs. 1 to 3 and Appendices la to lf.

C. Radial Growth of Three *Aspergillus* spp Isolated From Abeleehi and Obaatanpa Varieties on Five Different Media

The experiments in Chapter B were repeated this time using three *Aspergillus species (A. flavus, A. giganteus, A alutaceus (= A. ochraceus)* which were also isolated from the two maize varieties. The pathological importance of fungi in stored seeds cannot be confined to the genus *Paecilomyces* only. *Aspergillus* species are ubiquitous affecting the viability of stored seeds of several unrelated general of crops (Christensen, 1972, Neergaard, 1983). The experimental methods used were same as used in chapter B. Results are summarised in figs 4 to 6 and Appendices la to le.

D. Radial Growth of *Penicillium digitatum* and *Fusarium moniliforme* Isolated from Abeleehi and Obaatanpa Varieties on Five Different Media.

Radial growth on agar as a measure of vegetative growth on five different natural and synthetic media was used to determine near optimal conditions for growth of *Paecilomyces* and *Aspergillus* species which were encountered as storage fungi in Abeleehi and Obaatanpa maize varieties. In order to augment the information obtained in chapter B, C and D, experiments carried out in chapter B,C, and D were repeated using *Penicillium (P. digitatum, P. expansum)*

and *Fusarium (F. moniliforme)* species equally of pathological importance in seed storage. Results obtained are presented in figs. 7 to 8 and in Appendices la to lf.

E. In Vitro Studies on the Effect of Metabolites of Three *Paecilomyces* Species on Germination and Radicle Development of Abeleehi and Obaatanpa Varieties

Metabolite of fungi may have either beneficial or adverse effect on the germination and radicle development of seedlings. In this chapter, the effect of the metabolites of three *Paecilomyces species* were used to prepare varying dilutions (undiluted - $1:10^{v}$) of germinating medium)for testing germination capacity of grain of Abeleehi and Obaatanpa varieties. The method of production of metabolites, the blotter test method, and the assessment of the effect of the metabolites on radicle development are spelled out under the Materials and General Methods section ii (n). Results obtained are presented in figures 9 to 16 and in plates 5 to 10.

F. IN Vitro Studies on the Effect of Metabolites of some *Aspergillus species* on Germination and Radicle Development of Abeleehi and Obaatanpa Varieties.

Experiments carried out in chapter E were repeated using metabolites of *Aspergillus* species (*A. flavus, A. giganteus* and *A. alutaceus (= A. ochraceus)* prepared according to the methods described in the Materials and General methods section (ii) (n). The percentage germination and length of radicle obtained (measured as % of the control) are presented in fig 20 and in Tables 2 to 3.

G. In Vitro Studies on the Effect of Metabolites of *Penicillium digitatum* and *Fusarium moniliforme* on Germination and Radicle Development of Abeleehi and Obaatanpa Varieties

This chapter was a logical sequel to studies already carried out in chapters E&F to complete the effect of metabolites of selected fungal species (isolated from Abeleehi and Obaatanpa varieties) on the germination and radicle development of maize. The procedure and methods used were exactly as stated in chapters E and F. Results obtained are presented in Tables 2 and 3.

H. Influence of Metabolites of *Paecilomyces species* on Germination and Radicle Development of *Capsicum* annum and *Lycopersicon esculentum*.

In chapter E the culture metabolites of the three *Paecilomyces* species variably depressed germination and radicle development of Abeleehi and Obaatanpa varieties. In this chapter the experiments in chapter E were repeated this time using seeds of two vegetables, pepper (*Capsicum annuumL*) and tomato (*Lycopersicon esculentum* Mill) to see if the depressive effect of the metabolites of the three *Paecilomyces spp* would have same or similar effects on the germination and radicle development of the selected vegetable seeds. Results obtained are presented in Table 4.

I. Influence of Metabolites of *Paecilomyces* species on Vegetative Growth and Dry Matter Accumulation and Chlorophyll content of Abeleehi and Obaatanpa Varieties

In vitro studies in chapter E-H have demonstrated that metabolites of *Paecilomyces* species have indeed variable adverse effect on the germination and radicle development of Abeleehi and Obaatanpa maize varieties. In this chapter studies were carried out in the field and

under greenhouse conditions to ascertain the effect of the metabolites and the mycelium of the three *Paecilomyces* spp on vegetative growth and dry matter accumulation by maize seedlings.

The grains sown in the field were inoculated with mycelia/conidia of the test fungi before seeding in soil. (see Materials and General Methods section1), whereas those kept in the greenhouse were provided with pre-determined volumes (20-30ml) of metabolites of the fungi at varying intervals (see Materials and General\Methods section K(ii)). The dry weight of the root and shoot systems of the seedlings were determined at varying intervals (7,21,35,42 and 56 days) by the oven-dry method (see Material and General Methods section K(i) & (ii). In the case of the field experiment the seedlings were left long enough for three months to bear cobs and the yield and dimensions of the cobs determined. The Chlorophyll content of the leaves of the seedling was also estimated (see Materials and General Methods section J). Results obtained are presented in Figs. 23 to 25 and in Table 5.

J. Rhizosphere and Non-Rhizosphere Fungi Associated with Seedlings of Abeleehi and Obaatanpa Varieties Treated with Mycelium/Metabolites of *Paecilomyces species*

Phenology of rhizosphere fungi is characteristics of seedlings of a particular species and may vary from one crop to another. Would the rhizosphere mycoflora of maize grains inoculated with *Paecilomyces* species influence the vegetative growth and dry matter accumulation by Abeleehi and Obaatanpa varieties in soil? The phenology of rhizosphere and non-rhizosphere mycoflora of Abeleehi and Obaatanpa treated with *Paecilomyces* spp was followed for up to 56 days using the decimal serial dilution method on Cookes medium (Cooke, 1954). Results obtained are presented in Tables 6 to 21.

K. Preliminary Studies on the Anatomy of Maize seedling Growing under the Influence of the Metabolites of *Paecilomyces* spp

In chapter 1 seedlings growing under the influence of *Paecilomyces* spp became diminutive and had a slower dry matter accumulation rates. Anatomy of transverse sections of the roots were studied to provide clues as to the nature of effect of the metabolites on the growing seedlings. Transverse sections of the root tissues were cut by a sliding microtome (Reichert Nr 15917 Austria) and double stained using the method of Purvis et al (1966). Plates 15 a,b and 16 a,b shows results obtained.

IV RESULTS

A. Mycoflora of Zea Mays Var Abeleehi and Obaatanpa Incubated at ERH 55-95% for 36 days at 28 - 31°C

The list of seed-borne fungi isolated from the two maize varieties is presented in Table 1. About thirty different seed-borne fungal species were isolated from Abeleehi and twenty eight from Obaatanpa variety at the varying equilibrium relative humidities (55,60,65,70,75,80,85,90,95%) at which the grains were stored.

Aspergillus species (A. candidus, A. effusus, A. fumigatus,A. niger,Aalutaceus (= A. ochraceus), A. sulphureus, A tamarii, A. ustus, A. versicolor, A. wentii and Aspergillus sp 1) predominated over other species encountered followed by *Penicillium (P. brevi compactum, P. citrinum, P. verrucosum, P. digitatum, P. expansum, P. funiculosum, P. glabrum, P. nigricans and Penicillium* sp). Fungi of other genera (*Curvularia, Paecilomyces, Chaetomium Cladosporium, Emericella, Eurotium, Fusarium, Mucor, Neurospora* and *Rhizopus*) were also isolated.

The species diversity was influenced by grain variety and the ERH at which they were incubated. *A. flavus* was ubiquitous and was isolated from both Abeleehi and Obaatanpa stored at ERH 55-95%; *Fusarium moniliforme* was encountered at ERH 65-95%. Xerophilic species like *A. fumigatus, A. giganteus, A. alutaceus, (= A. ochraceus), Paecilomyces carneus, P. puntoni* and *P. varioti* were isolated at ERH's 55-65% in both grain varieties. Plates 3-4 show some of the fungi isolated from the maize varieties.

TABLE 1

LIST OF SEED-BORNE FUNGI ISOLATED FROM MAIZE VARIETIES ABELEEHI AND OBAATANPA INCUBATED AT 55-95% EQUILIBRIUM RELATIVE HUMIDITY FOR 36 DAYS AT 28-31°C.

ɔergillus candidus Link ex. Fr.[1,2]	*Paecilomyces carneus* (Duche et Heim) A.H. Brown G. Smith 1,2
ɨffusus Tiradoschi[2]	*P.puntonii* (Vuillemin) Nannizzi[1,2]
ɨavus Link ex Fr. [1,2]	*P.varioti* Bainier[1,2]
ɨumigatus Fresenius[1,2]	*Chaetomium globosum* Kunze : Fries[2]
ɨiganteus Wehmer[1]	*Cladosporium herbarum* (Persoon : Fries) Link[1,2]
ɨiger Van Tieghem[1,2]	*Curvularia lunata* Boedji[1,2]
ɔchraceus Wilhelm[1,2]	*Emericella nidulans* (Eidam) Vuill.[1]
	*Eurotium sp.*1,2
ɨulphureus[1] (Fresenius) Thom and Church.	*Fusarium moniliforme* Sheldon[1,2]
amarii Kita[1,2]	*Mucor haemalis* Welmer f.*hiemalis*[1]
erreus Thom[1] Geerlings[1,2]	*Rhizopus oryzae* Went and Pri
ɨstus Bainier Thom and Church[1]	*Scopulariopsis brevicaulis* (Sacc) Bain[2]
ɔersicolor (Vuillemin) Tiraboschi[2]	*Neurospora sitophila* Shear and Dodge[1,2]
ventii Wehmer[1]	
ɔergillus indet[2]	
ɨicillium brevicompactum Dierckx[1,2]	
ɨitrium Thom[1,2]	
ɔerrucosum Dierckx[1,2]	1 - Abeleehi variety
ligitatum Sacc[1,2]	2 - Obaatanpa variety
ɔxpansum Link[1,2]	
ɨuniculosum Thom[2]	
ɨlabrum (Wehmer) Westling[1,2]	
ɨigricans Bainier	
ɨicillium indet[1,2]	

Plate 3. Photograph of 6 days old *Paecilomyces varioti* isolated from 'Abeleehi' and 'Obaatanpa' maize varieties growing on Potato Dextrose Agar at 29^{0}C. (X 3/4)

Plate 4. Photograph of 6 days old *Fusarium moniliforme* isolated from 'Abeleehi' and 'Obaatanpa' maize varieties growing on Potato Dextrose Agar at 29^{0}C for 6 days. (x 3/4)

B. Radial Growth of Three *Paecilomyces* species Isolated from Abeleehi and Obaatanpa Varieties on Five Different Media

Radial growth of Paecilomyces species on agar was influenced by the media and temperature of incubation. Each *Paecilomyces* species behaved differently.

Optimum growth of *P. carneus* on all media tested (Czapek-Dox Agar; Maize meal Agar-Abeleehi; Maize Meal Agar - Obaatanpa; Potato Dextrose Agar) was attained at 30°C ; 35°C and 40°C were clearly unsutable for growth in some instances. Although the fungus grew at 35°C and 40°C, it remianed static after 2-4 days (Fig. 1) except on (Capek-Dox and Maize Meal Agar (prepared from Obaatanpa variety) where growth at 35°C nearly approximated that obtained at30°C. Growth at a temperature of 18°C was intermediate between 30°C and 40°C whereas radial growth was slowest on Potato dextrose agar diameter 60mm at 30°C for 7 days (Fig. 1).

The best radial growth of *P. puntoni* was attained between 30-35°C (Fig. 2). Growth at 18°C initially lagged behind that of cultures incubated at 30-40°C but approximated their radial growth after 6-7 days incubation period. There were no significant statistical differences ($P < 0.05$ student t-test) in the growth of *P. puntoni* incubated in all the media tested at all temperatures ie all the media tested equally supported radial growth of *P. puntoni* (Fig. 2).

Temperature of 35°C and 40°C depressed radial growth of *P. varioti* in all the media tested (Fig. 3). Although the best temperature for growth of *P. varioti* was 30°C, 18°C was almost as suitable as 30°C in supporting vegetative growth of this fungus in most instances (Fig. 3). Radial growth of *P. varioti* was slowest on Potato dextrose agar (Fig. 3).

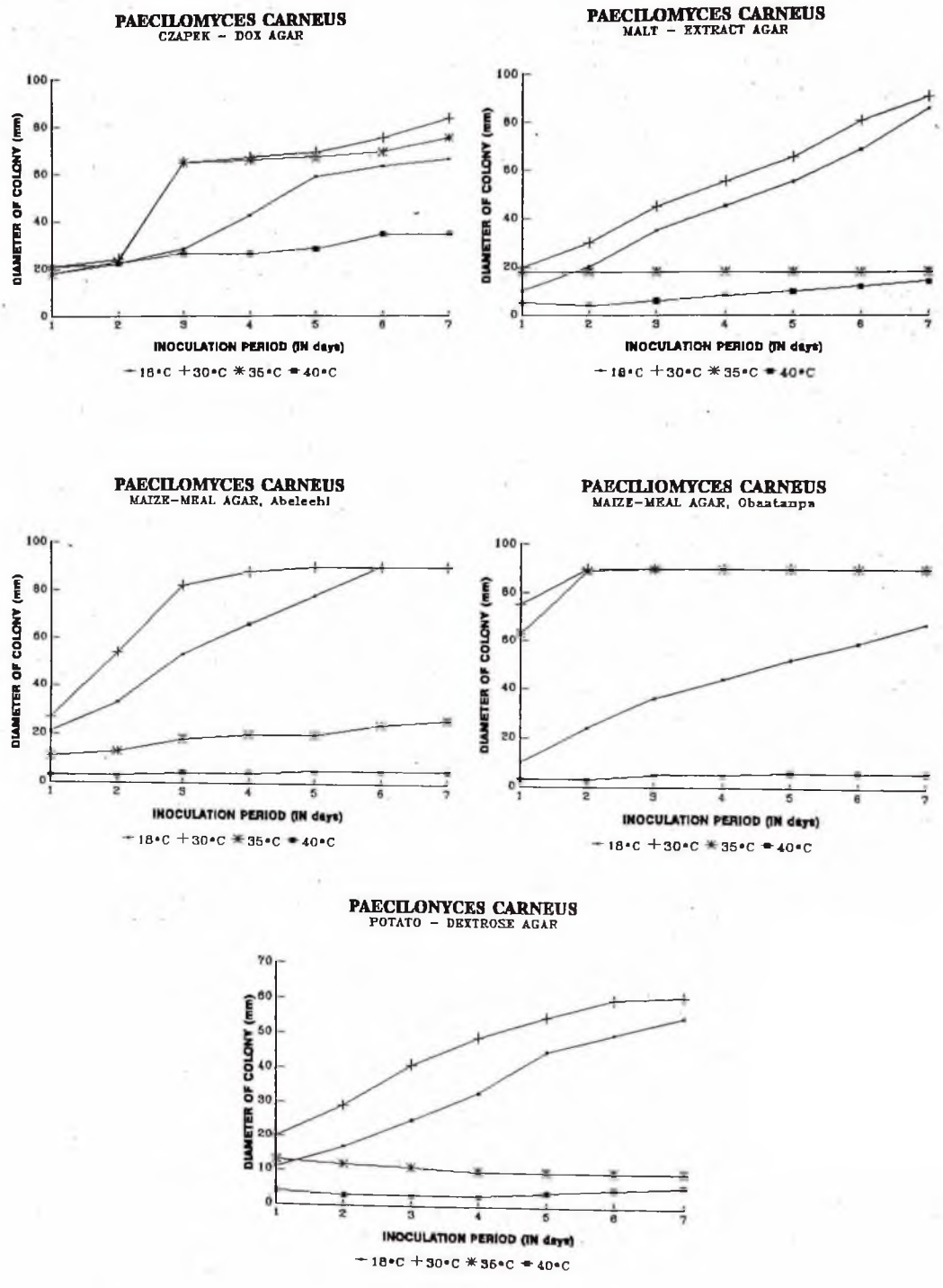

Fig. 1
Radial growth of Paecilomyces. carneus on five different indicated media.

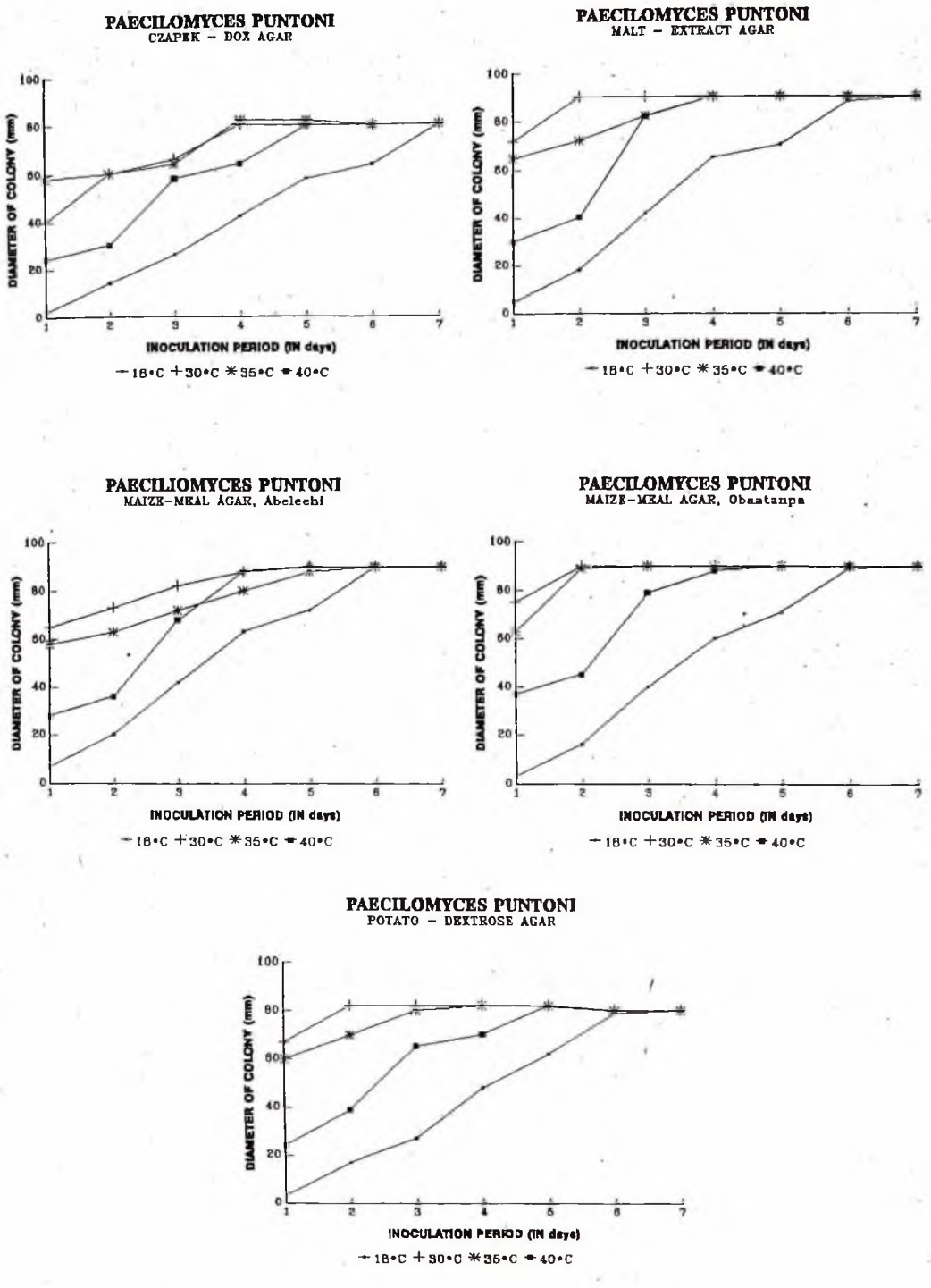

Fig. 2

Radial growth of P. puntoni on five different indicated media. note (The growth at 18°C initially lagging behind the remaining temperatures).

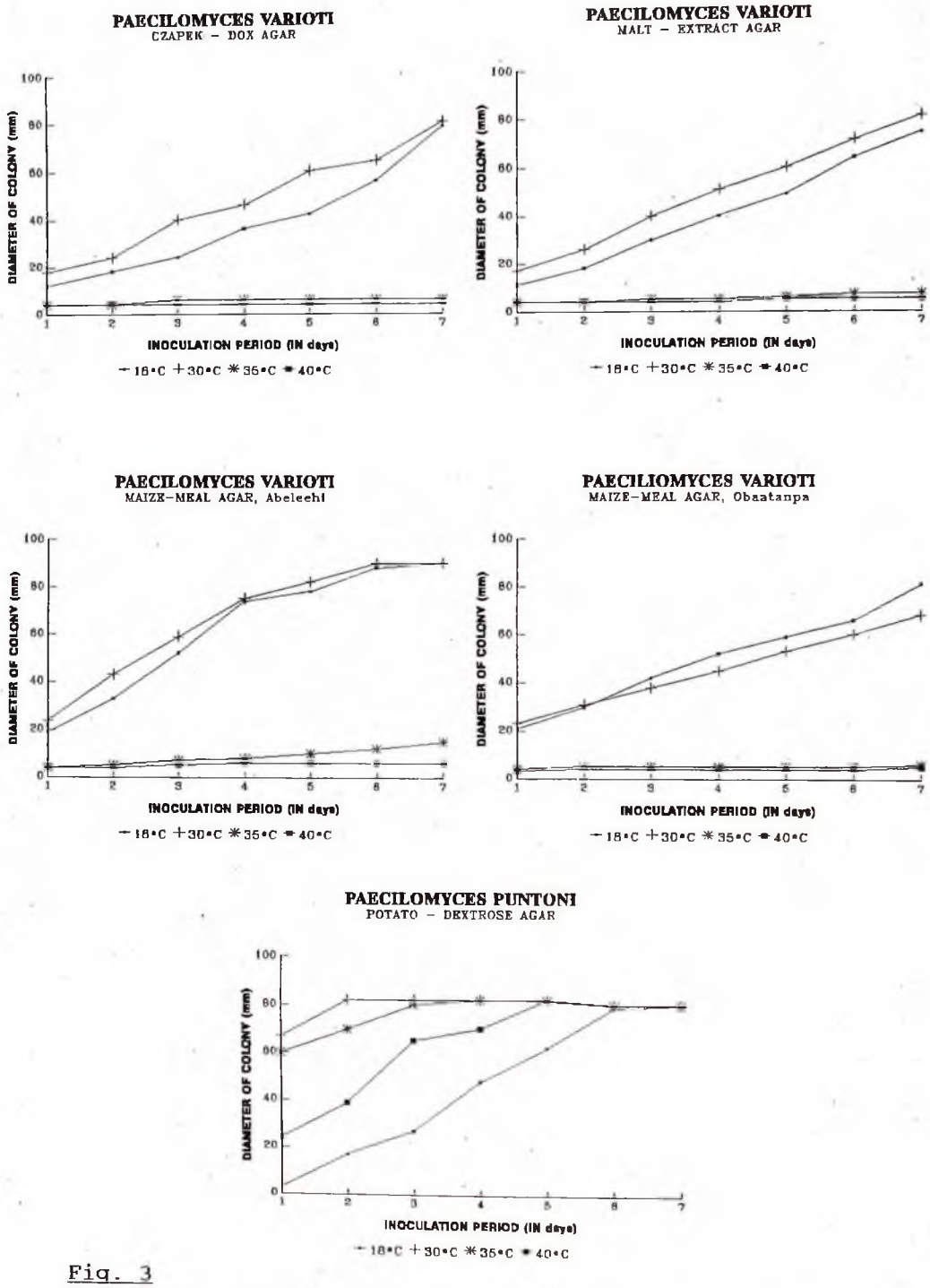

Fig. 3

Radial growth of P. varioti on five different indicated media. (note The relative slow growth of fungus on PDA).

C. Radial Growth of three *Aspergillus* species Isolated from Abeleehi and Obaatanpa on Five Different Media

The mycological media as well as temperature of incubation influenced radial growth of *Aspergillus* species (*A. flavus, A. giganteus* and *A. alutaceus* (= *A. ochraceus*) tested.

Generally, the optimum growth of *A. flavus* was obtained on all media at between 30^{0}C and 35^{0}C (Fig. 4). Growth was depressed at 40^{0}C but not at 18^{0}C (Fig. 4) except on Czapek-Dox Agar. The best medium for growth of *A. flavus* was Maize Meal Agar prepared from Obaatanpa variety. Radial growth was poorest on Potato Dextrose Agar and Czapek-Dox Agar attaining a radius of 50mm after 7 days at 30^{0}C as compared to 85.90mm after 7 days at 30^{0}C on maize meal agar prepared from Obaatanpa variety (Fig. 4).

A. gigianteus grew best at 30^{0}C followed by 18^{0}C on all media. Growth on Czapek-Dox Agar and Malt Extract Agar lagged behind the rest. A temperature of 40^{0}C was unsuitable as radial growth remained nearly static after 2-3 days (Fig. 5).

A. alutaceus (= *A.ochraceus*) grew best at 35°C on Czapek-Dok Agar and Malt extract Agar and at 30°C on Maize Meal Agar. Radial growth of the fungus was considerably depressed at 40°C for all media tested except on Czapek-Dox Agar where at 40°C the fungus attained radius of about 30mm in 7 days as compared with 50mm on Czapek-Dox Agar (Fig 6).

Interestingly, radial growth of *A. alutaceus* at 35°C was nearly the same as at 40°C on Maize Meal Agar prepared from Abeleehi and Obaatanpa varieties.

The optimum growth for this fungus therefore was between 30 and 35°C.

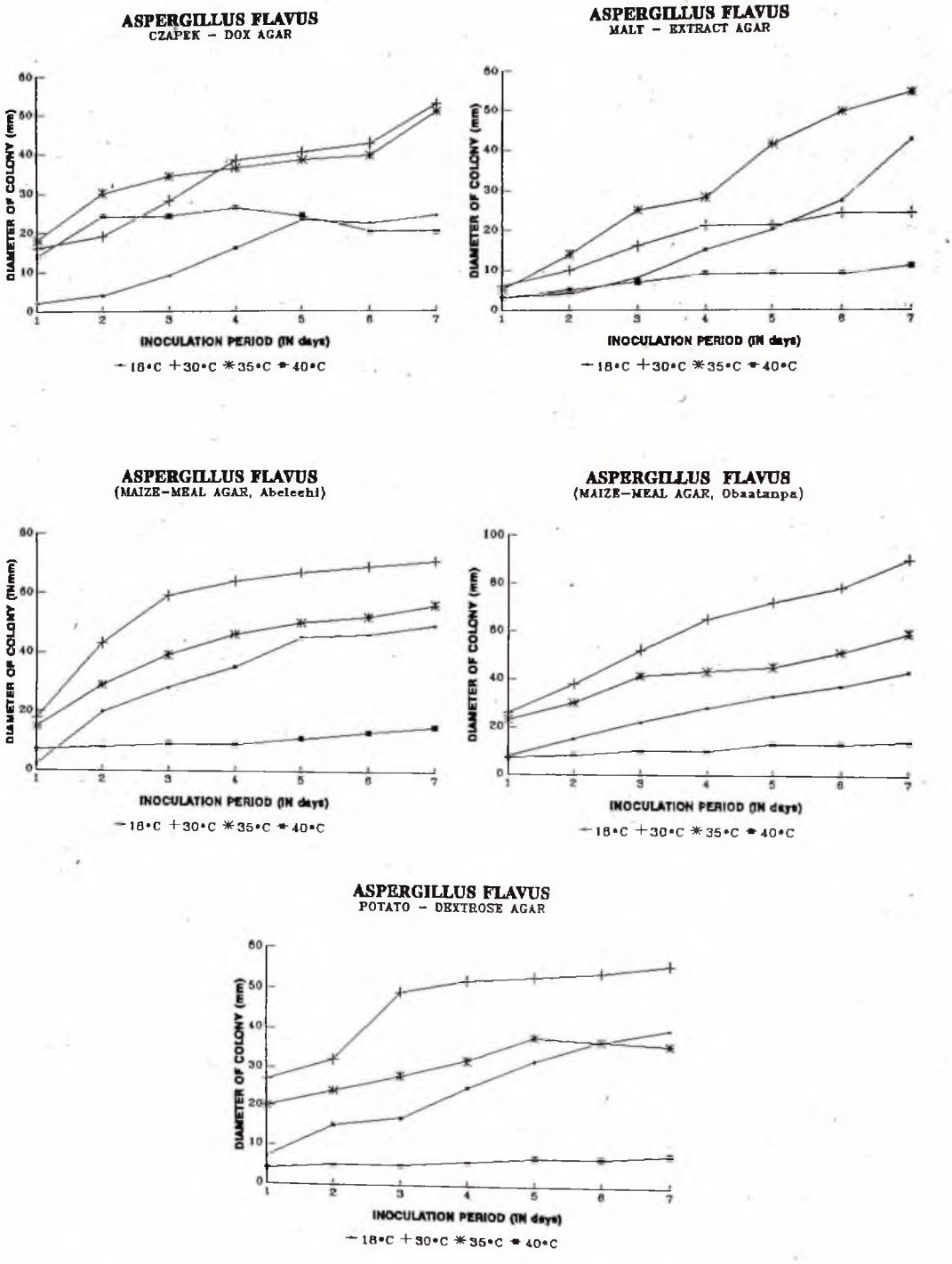

Fig. 4
Radial growth of Aspergillus. flavus on five different indicated media

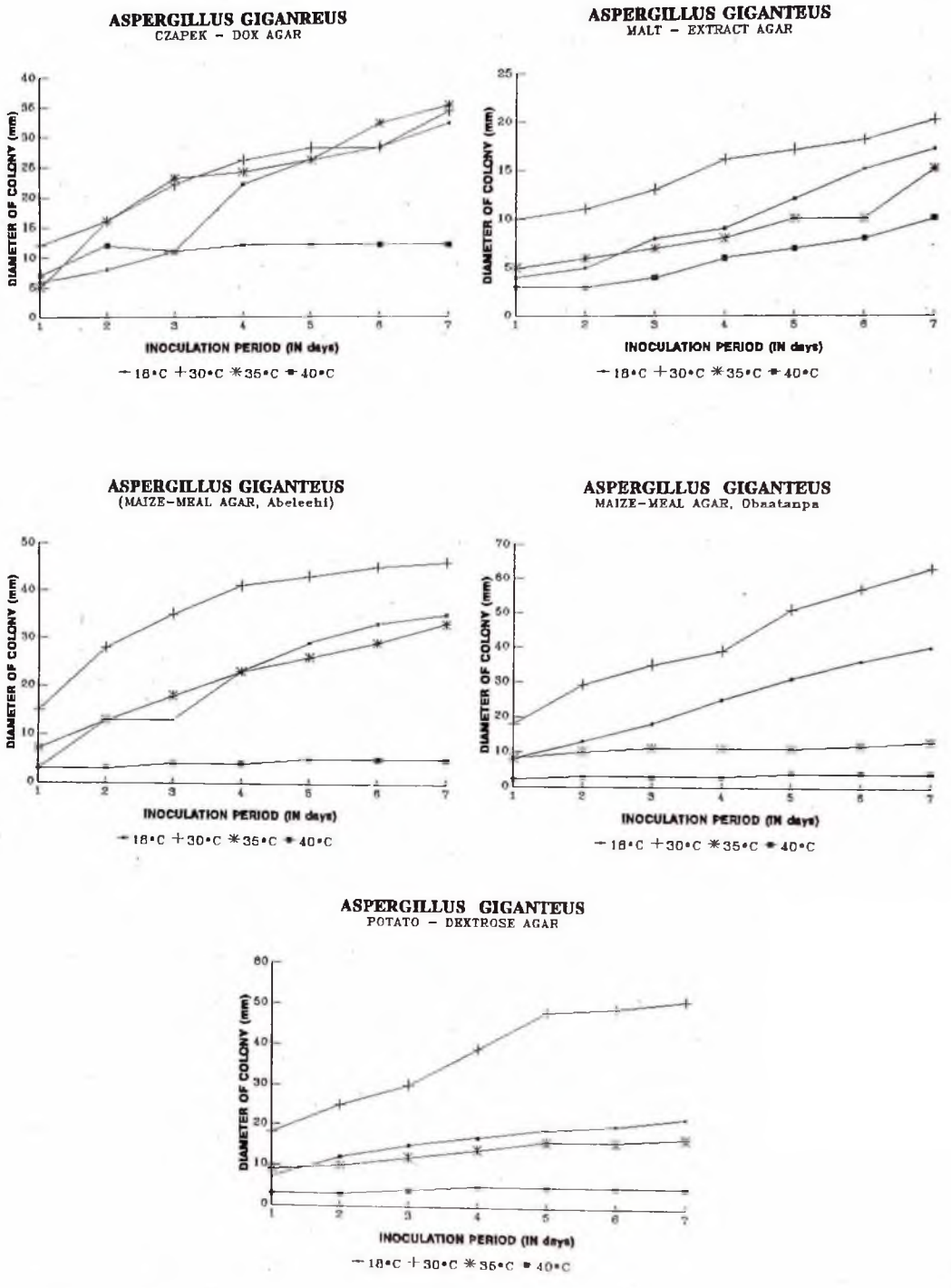

Fig. 5
Radial growth of Aspergillus. giganteus on five different indicated media

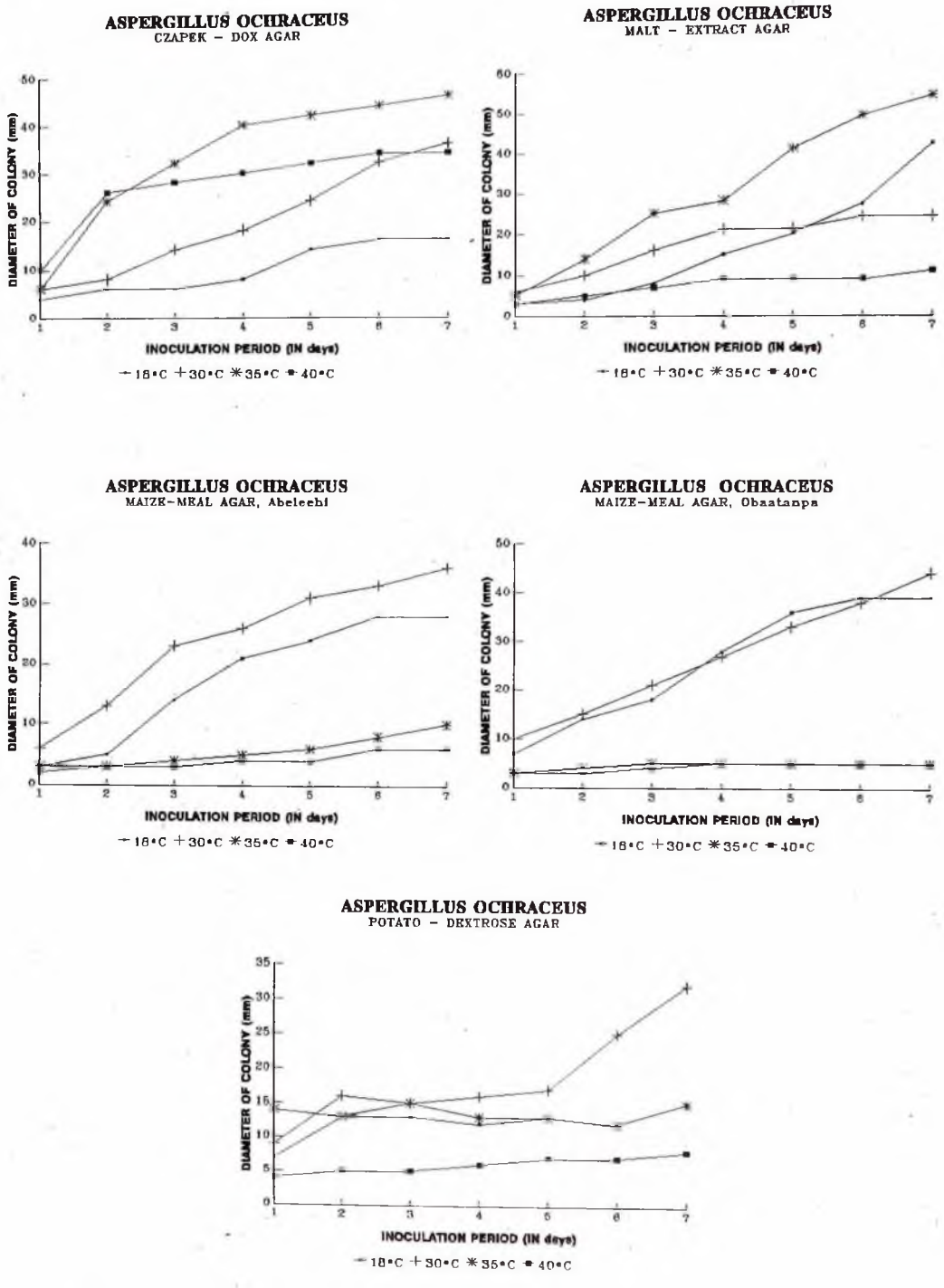

Fig. 6
Radial growth of Aspergillus ochraceus (=A. alutaceus) on five different indicated media.

D. Radial Growth of *Penicillium digitatum* and *Fusarium moniliforme* on Five Different Media

Vegetative growth of *P. digitatum* on all the five media was inferior to what existed for the *Paecilomyces* and *Aspergillus* species growing on the same media (Chapters B and C). The best temperature for optimum growth attained in this experiment was 30^{0}C. Temperatures 35 - 40^{0}C were unsuitable and 18^{0}C was intermediate between the optimum (30^{0}C) and minimum (40^{0}C) Fig. 7).

Radial growth of *F. moniliforme* followed characteristic sigmoid curves (Fig. 8). The best temperature for growth in all media was 30^{0}C. Vegetative growth at 18^{0}C was better than that of 35^{0}C and 40^{0}C. The fungus never grew significantly after 2 days at 40^{0}C such that the diameter of colonies of the fungus growing at 40^{0}C on all media remained nearly the same for up to 7 days (Fig. 8).

The best growth of the fungus was obtained on Maize Meal Agar and Malt Extract Agar for *F. moniliforme* while Czapek-Dox Agar was the best medium for *P. digitatum*.

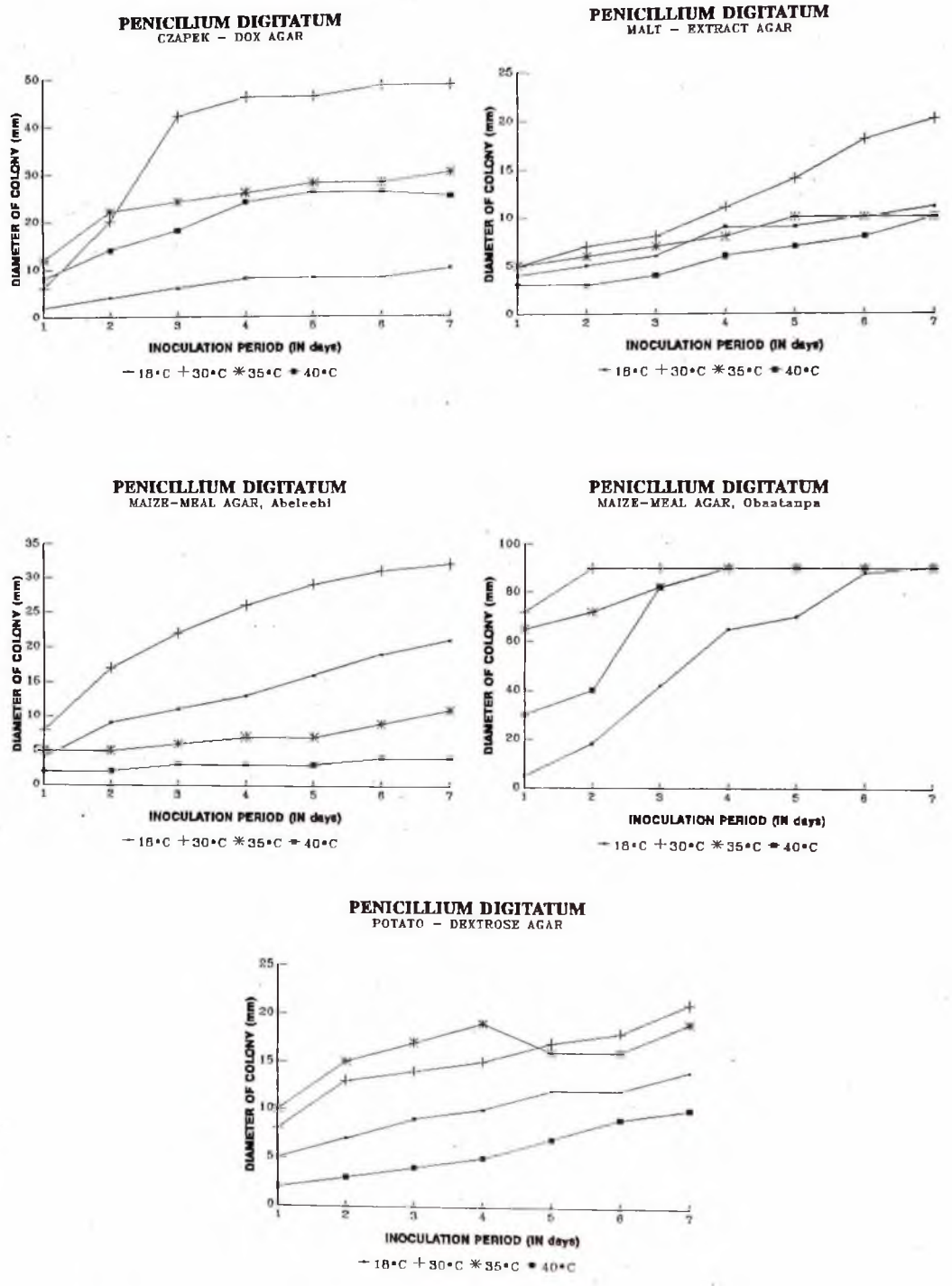

Fig. 7
Radial growth of Penicillium. digitatum on five different indicated media.

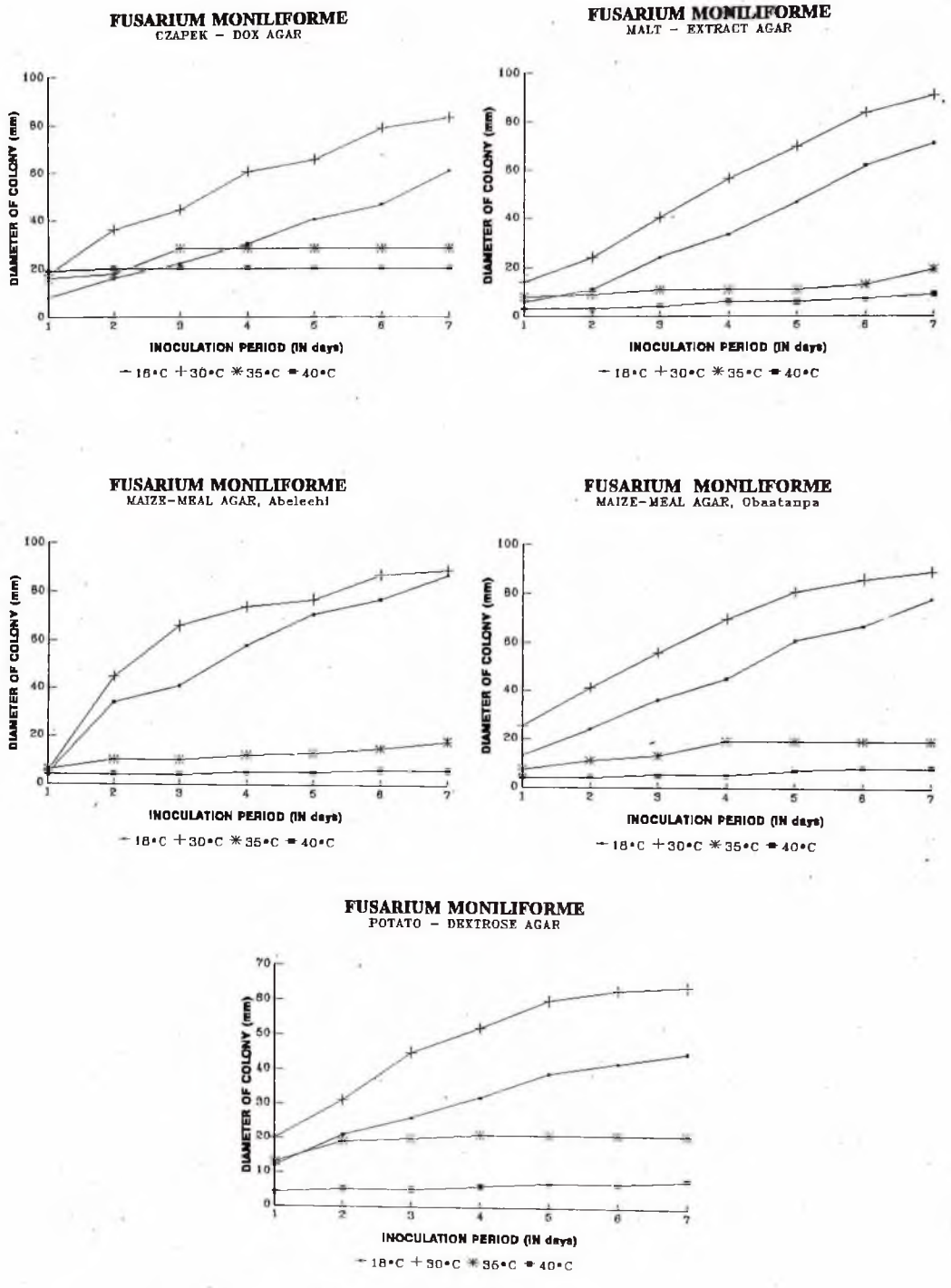

Fig. 8
Radial growth of Fusarium. moniliforme on five different indicated media.

E. In Vitro Studies on the Effects of Metabolites of Three *Paecilomyces* species on Germination and Radicle Development of Maize (Abeleehi and Obaatanpa Vars.)

The three *Paecilomyces* species (*P. carneus, P. puntoni and P. varioti*) produced their inhibitory metabolites in 2 days because inhibition of germination of both Abeleehi and Obaatanpa varieties could be observed when 2 days old culture metabolites produced in maize meal broth and Potato Dextrose Broth were used as germinating media for the grains (Figs 9-16). Percentage germination of maize grains (Abeleehi and Obaatanpa) was depressed by 10-75% by the undiluted 2,4 and 8 days old culture filtrate of the three *Paecilomyces* species (Fig. 9-16). This inhibitory effect was gradually removed with increasing dilution (up to 1:10$^{v}/_{v}$). There were varietal differences in the response of the germinating maize grains to the active ingredients in the culture metablolites of the three *Paecilomyces* spp.

Cultural filtrate of *P. carneus, P. puntoni and P. varioti* severely depressed length of emerging radicles of the two maize varieties by 45-90% at the highest concentration applied (Fig. 17-19). There were marginal differences between the yield of the active ingredients in the various media used (Maize Meal Broth and Potato Dextrose Broth). No significant differences ($P \leq 0.05$) were found in the depression of germination and radicle length obtained in the metabolites obtained from the three media used. As expected, the inhititory effect of the metabolites was gradually removed with dilution such that radicle length of the germinating grains in the presence of 1:10$^{v}/_{v}$ dilution of the filtrates nearly approximated that of the control in most instances (Fig. 17-19). In the case of *P. carneus* and *P. varioti*, the reduction in length of radicle was severer on Abeleehi variety as compared to Obaatanpa whereas the reverse was obtained in culture filtrate of *P. puntoni*. The three *Paecilomyces* species are therefore of pathological importance affecting the development of the seedling stage, at least in vitro. Plates 5 to 10 show the effect of the fungal metabolites on the radicle development in petri plates.

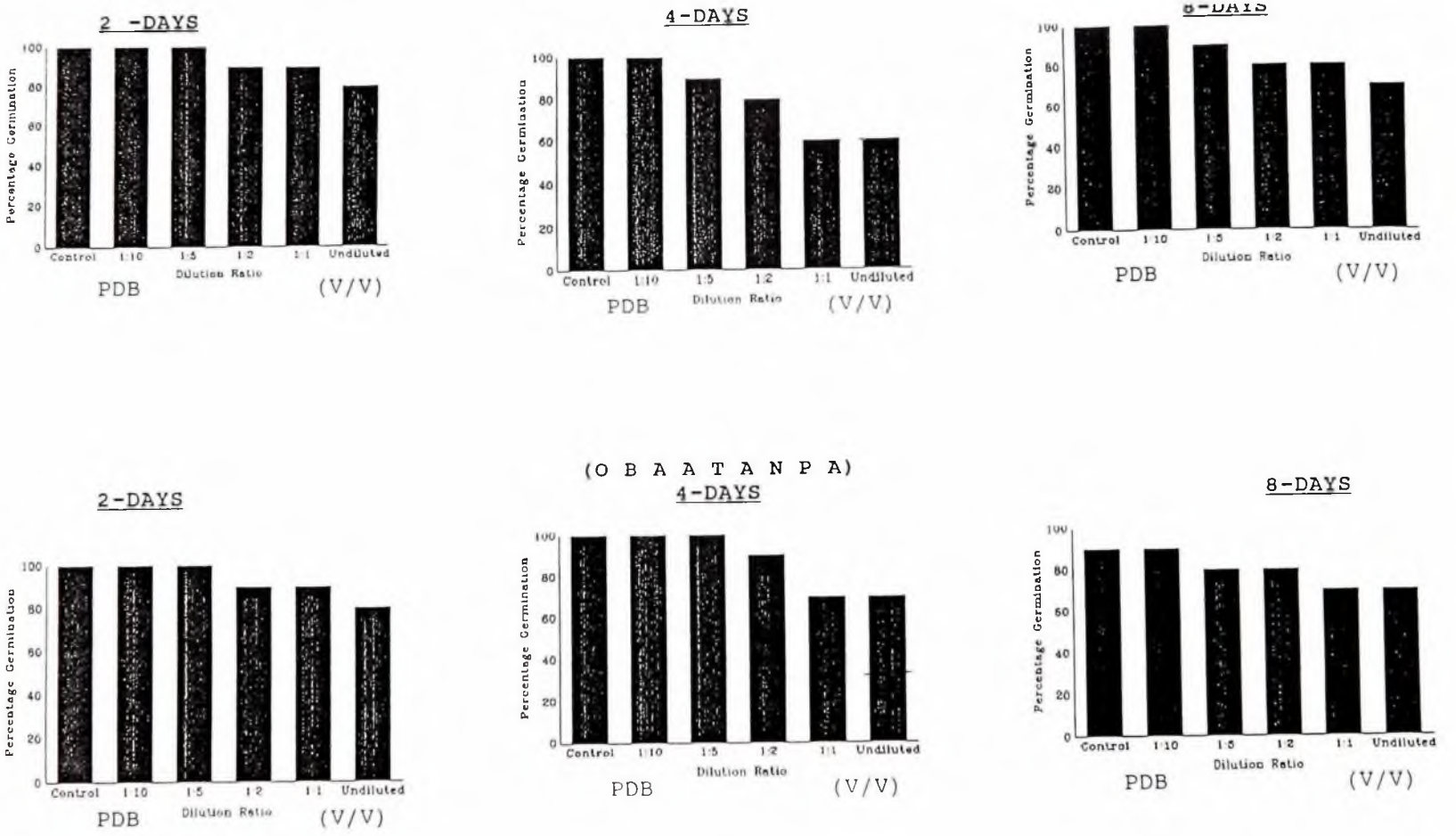

Fig 9.. Influence of the age (days of incubation) of culture and concentration (V/V) of the culture filtrate of P. carneus cultured in Potato Dextrose Broth on the germination capacity of (Top) Abeleehi and (Bottom), Obaatanpa variety-grains.

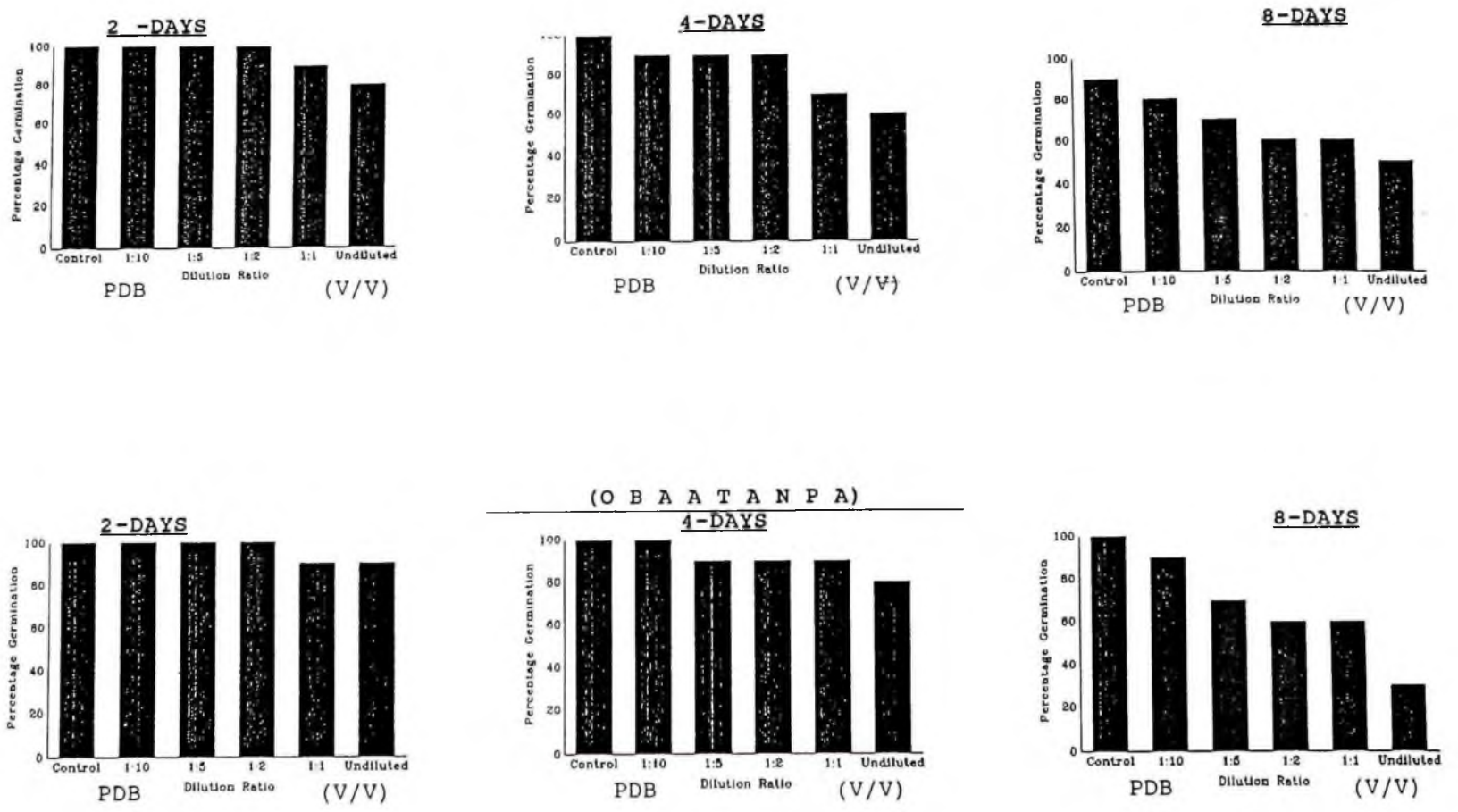

Fig 10. Influence of the age (days of incubation) of culture and concentration (V/V) of the culture filtrate of P. carneus cultured in Maize Meal broth (prepared from Abeleehi variety at 30°C) on the germination capacity of (Top) Abeleehi and (Bottom), Obaatanpa variety-grains.

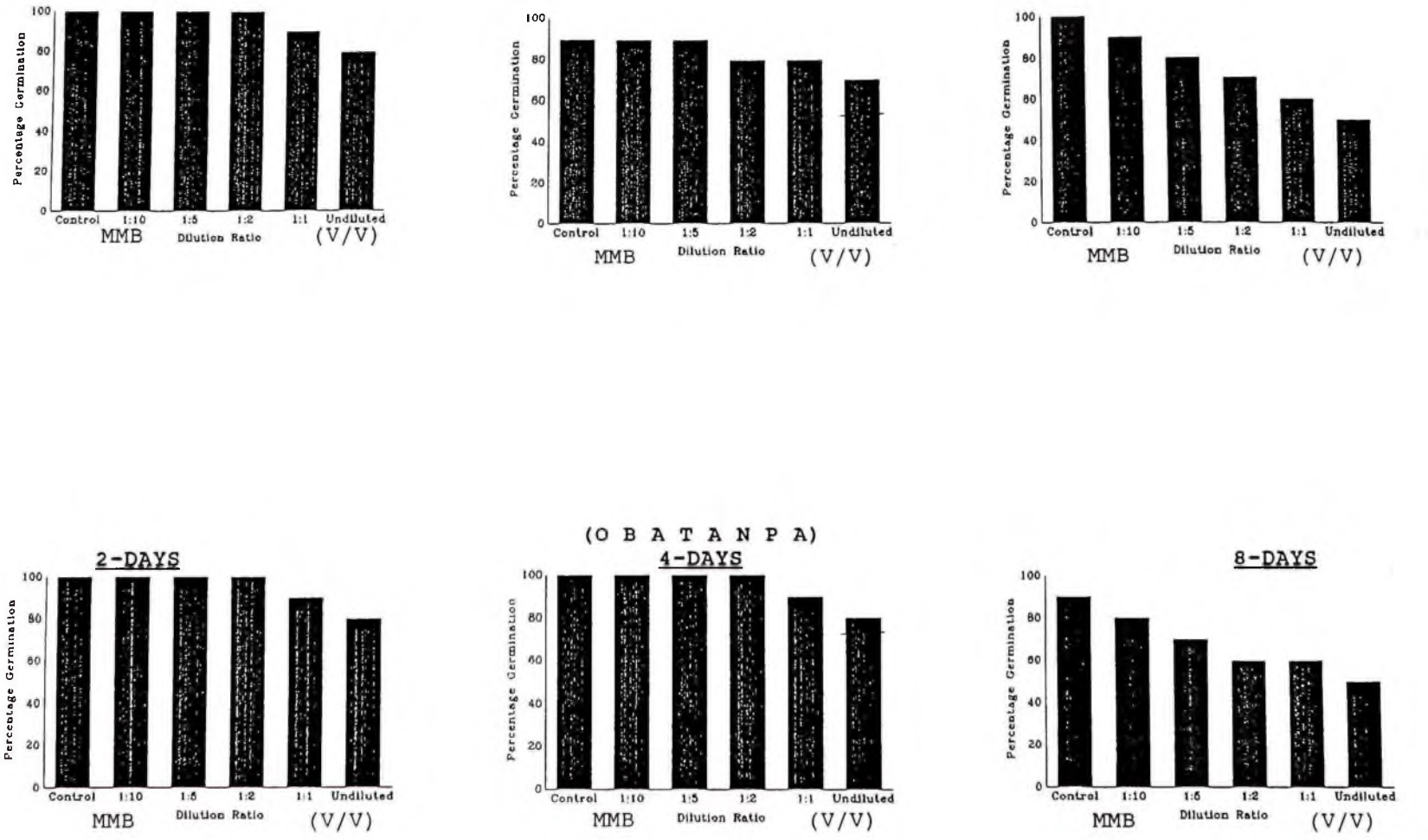

Fig 11. Influence of the age (days of incubation) of culture and concentration (V/V) of the culture filtrate of P. carneus cultured in Maize Meal Broth (prepared from obaatanpa variety at 30^{0}C) on the germination capacity of (Top) Abeleehi and (Bottom), Obaatanpa variety-grains.

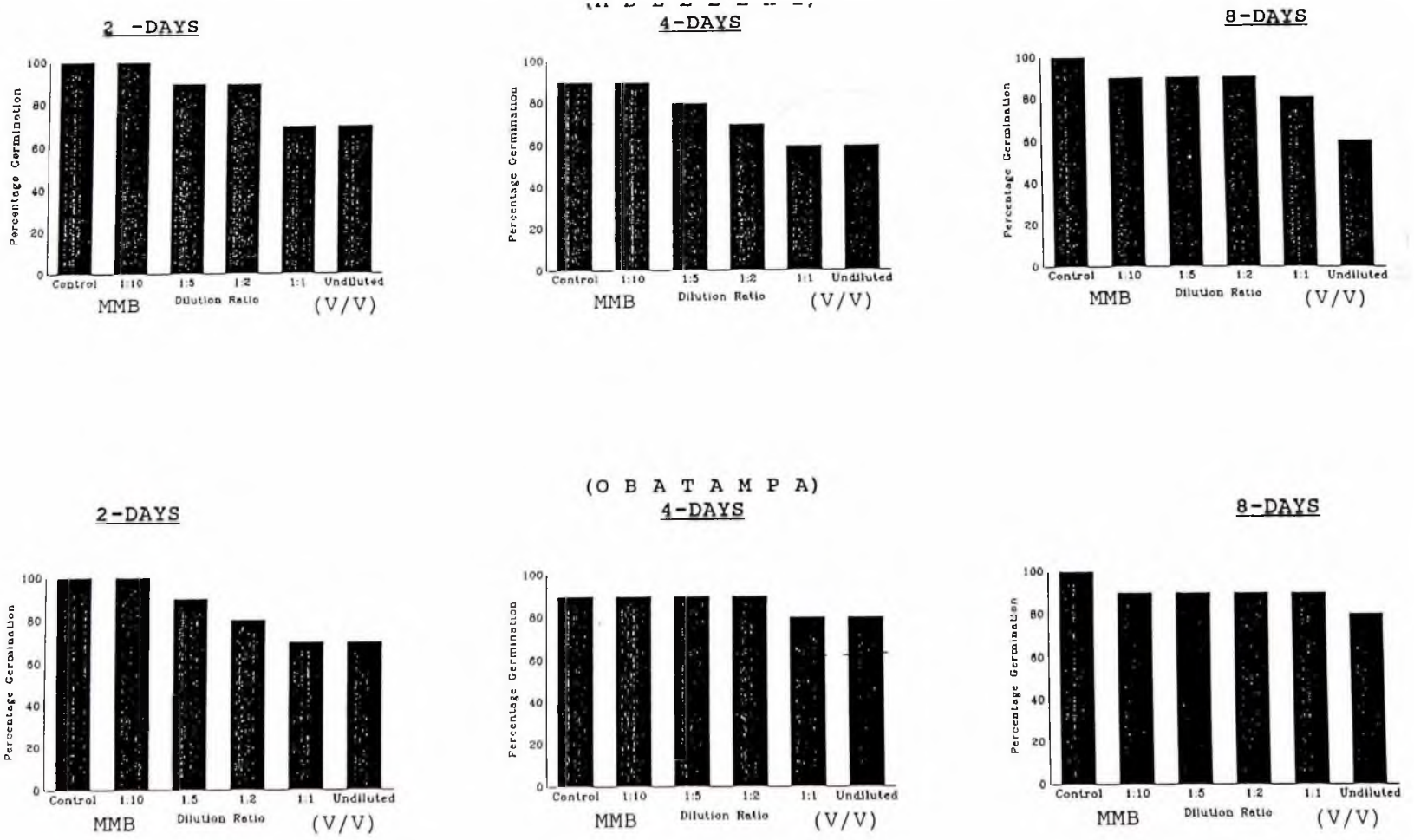

Fig 12. Influence of the age (days of incubation) of culture and concentration (v/v) of the culture filtrate of P.puntoni cultured in Maize Meal Broth(prepared from Abeleehi variety) on the generation capacity of (Top) Abeleehi and (Bottom), Obaatanpa variety.grains.

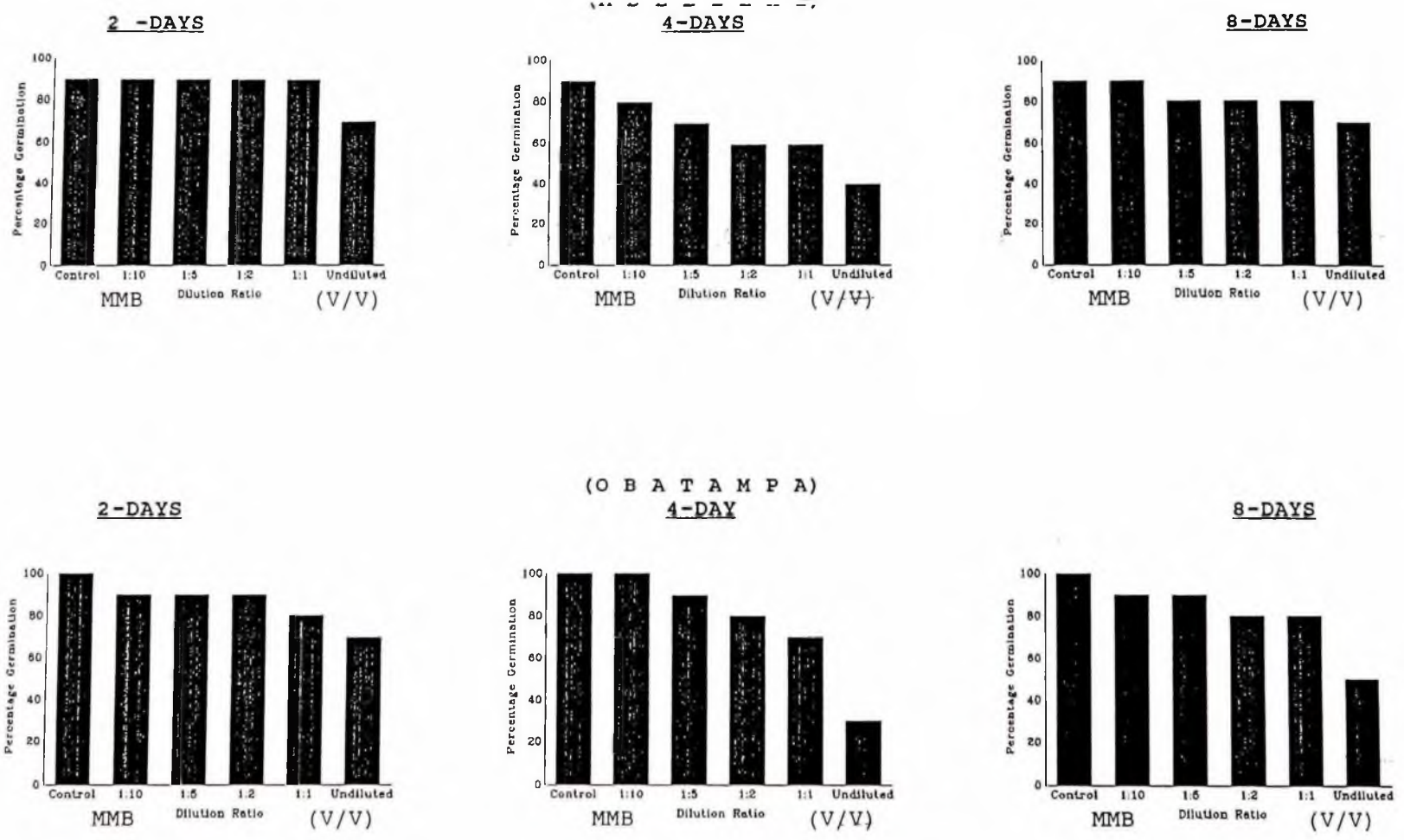

Fig 13. Influence of the age (days of incubation) of culture and concentration (v/v) of the culture filtrate of P.puntoni cultured in Maize Meal Broth(prepared from Obaatanpa variety) on the generation capacity of (Top) Abeleehi and (Bottom), Obaatanpa variety.grains.

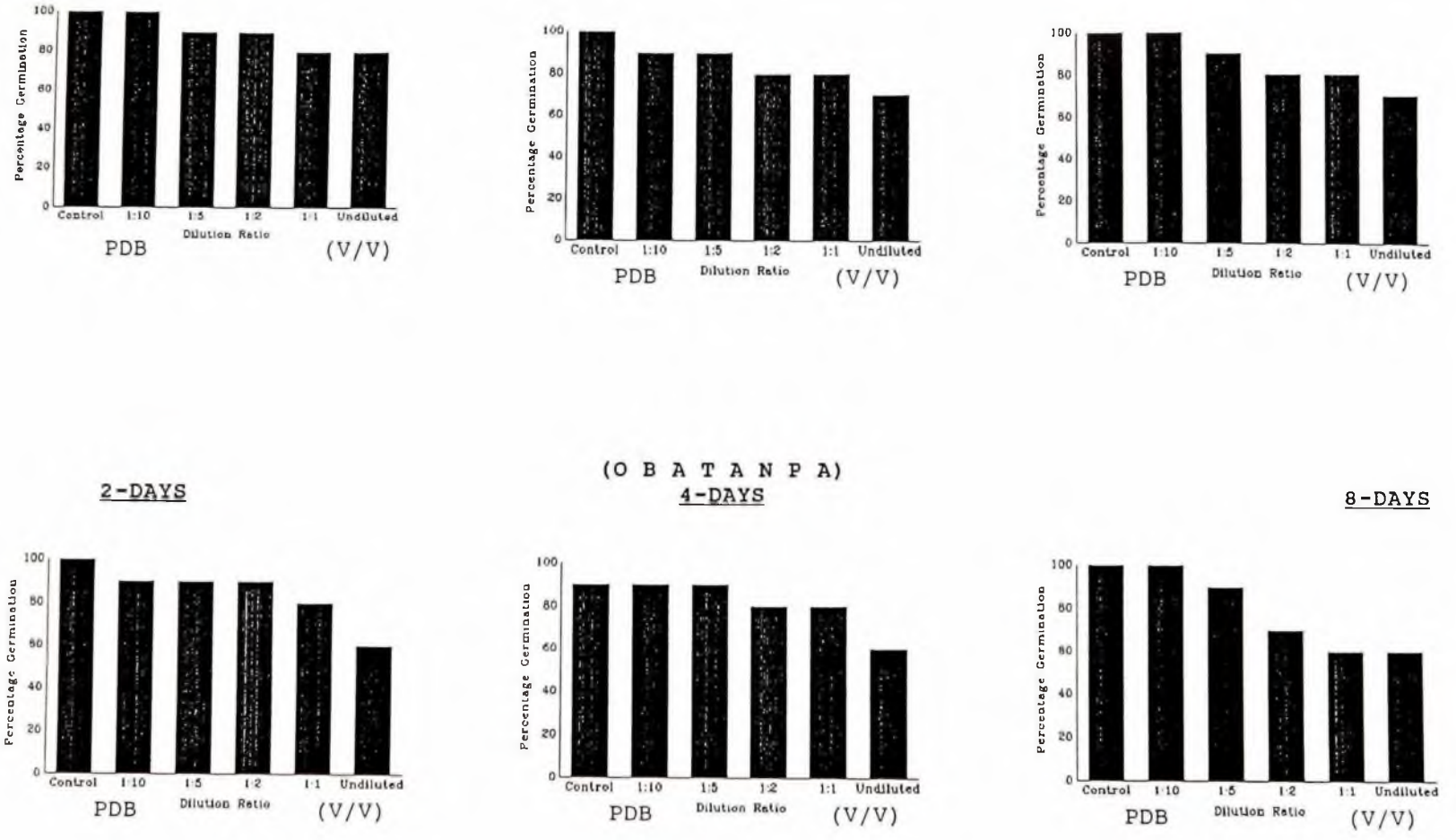

Fig 14. Influence of the age (days of incubation) of culture and concentration (v/v) of the culture filtrate of P.varioti cultured in Potato Dextrose Broth on the germination capacity of (Top) Abeleehi and (Bottom). Obaatanpa variety.grains.

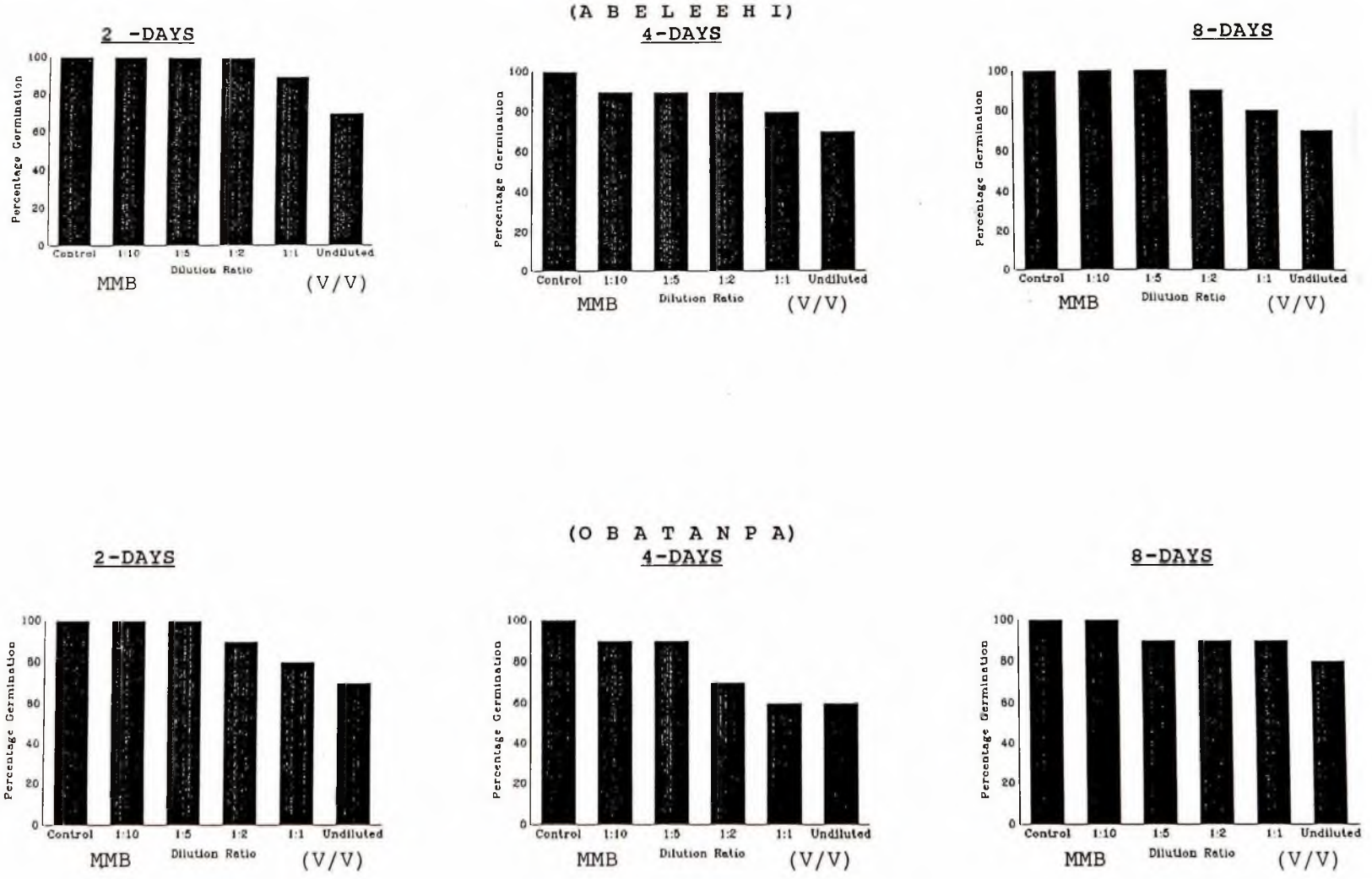

Fig 15. Influence of the age (days of incubation) of culture and concentration (v/v) of the culture filtrate of P.varioti cultured in Maize Meal Broth(prepared from Abeleehi variety) on the germination capacity of (Top) Abeleehi and (Bottom), Obaatanpa variety.grains.

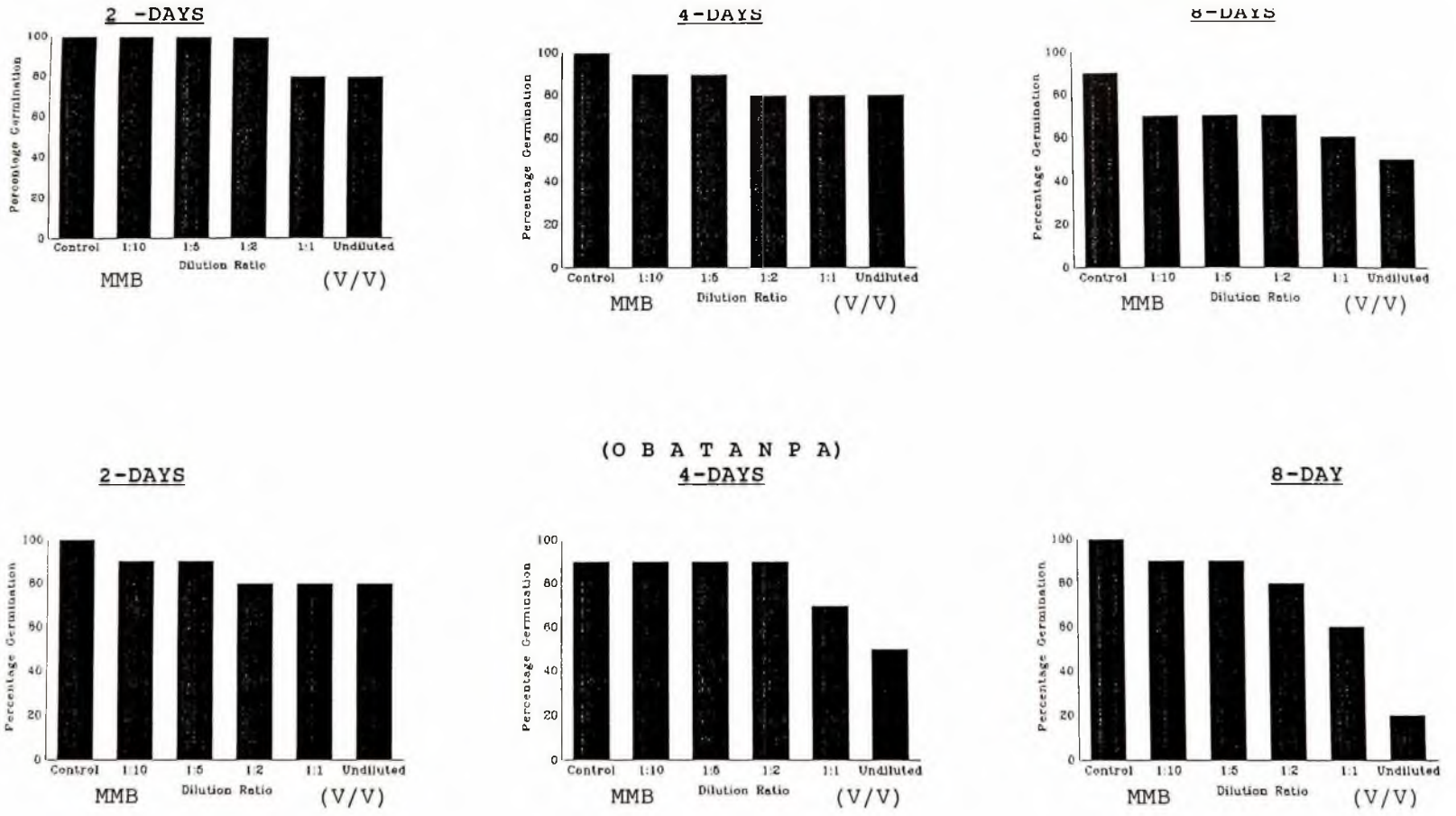

Fig 16. Influence of the age (days of incubation) of culture and concentration (v/v) of the culture filtrate of P.varioti cultured in maize meal Broth(prepared from Obaatanpa variety) on the germination capacity of (Top) Abeleehi and (Bottom), Obaatanpa variety.grains.

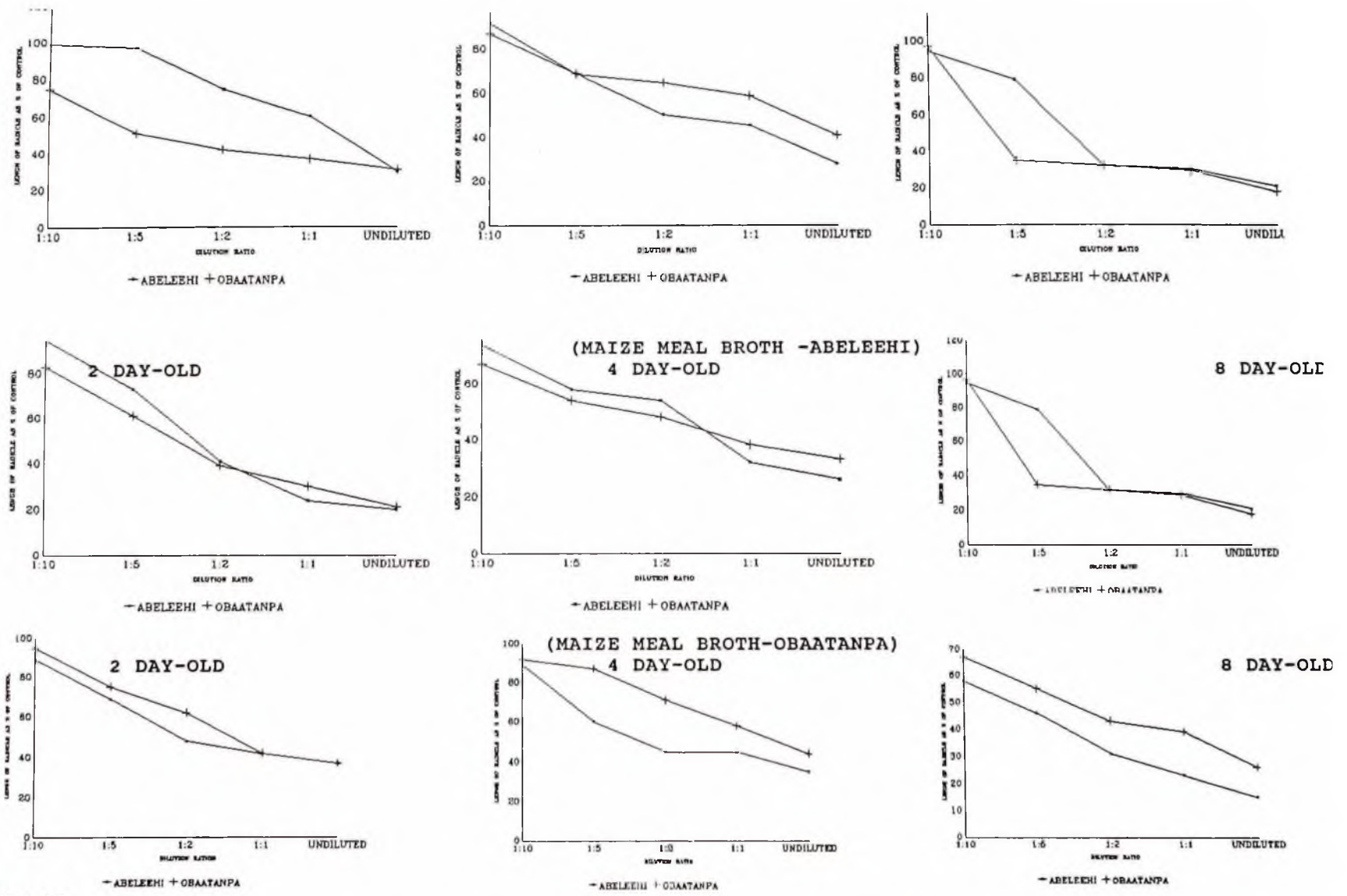

FIG 17

Development of radicle of two maize varieties(Abeleehi and Obataanpa)growing on filter paper moistened with culture filtrate of Paecilomyces carneus

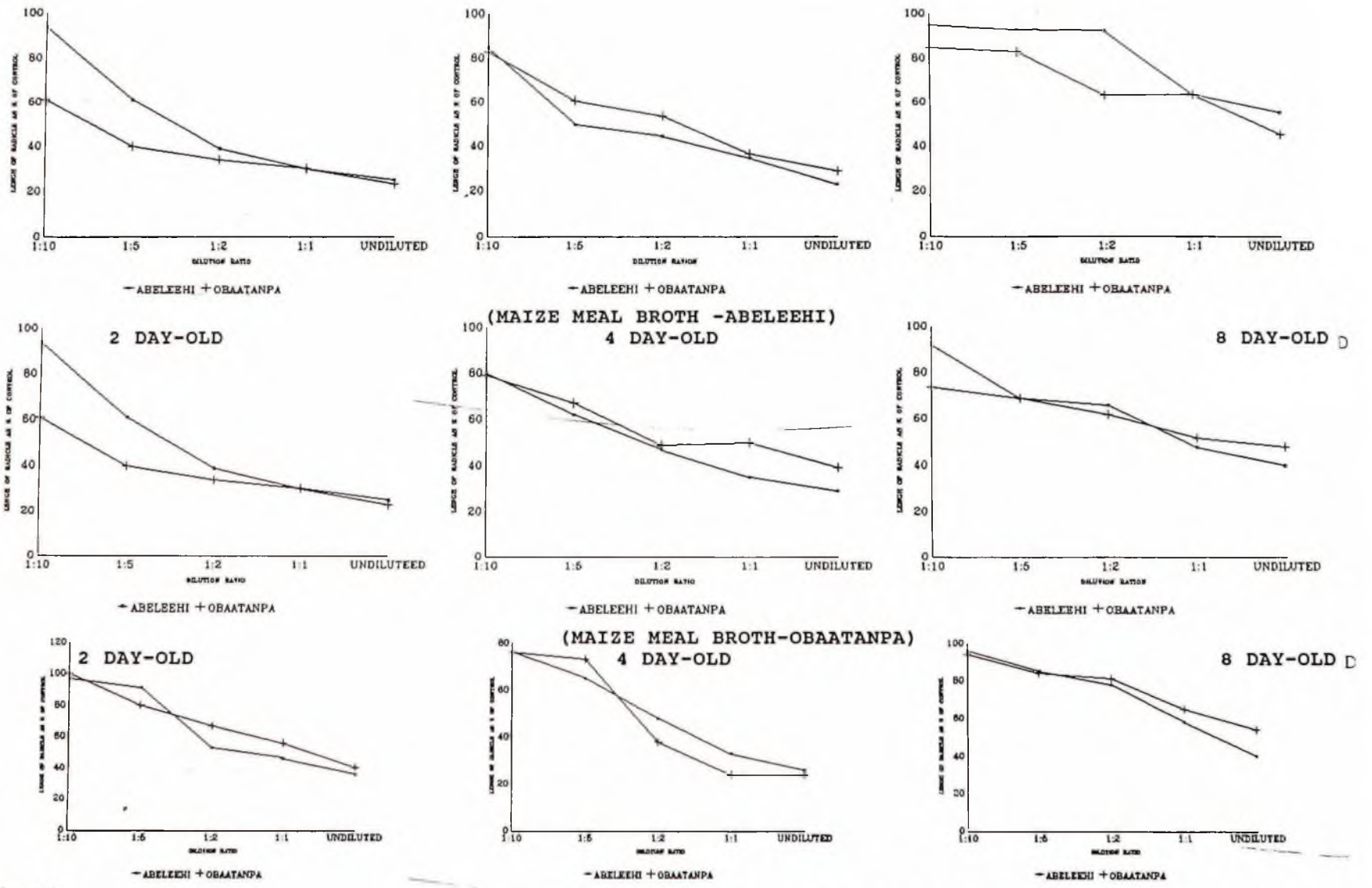

Fig 18.
Development of radicle of two maize varieties Abeleehi and Obataanpa growing on filter paper moistened with culture filtrate of Paecilomyces puntoni

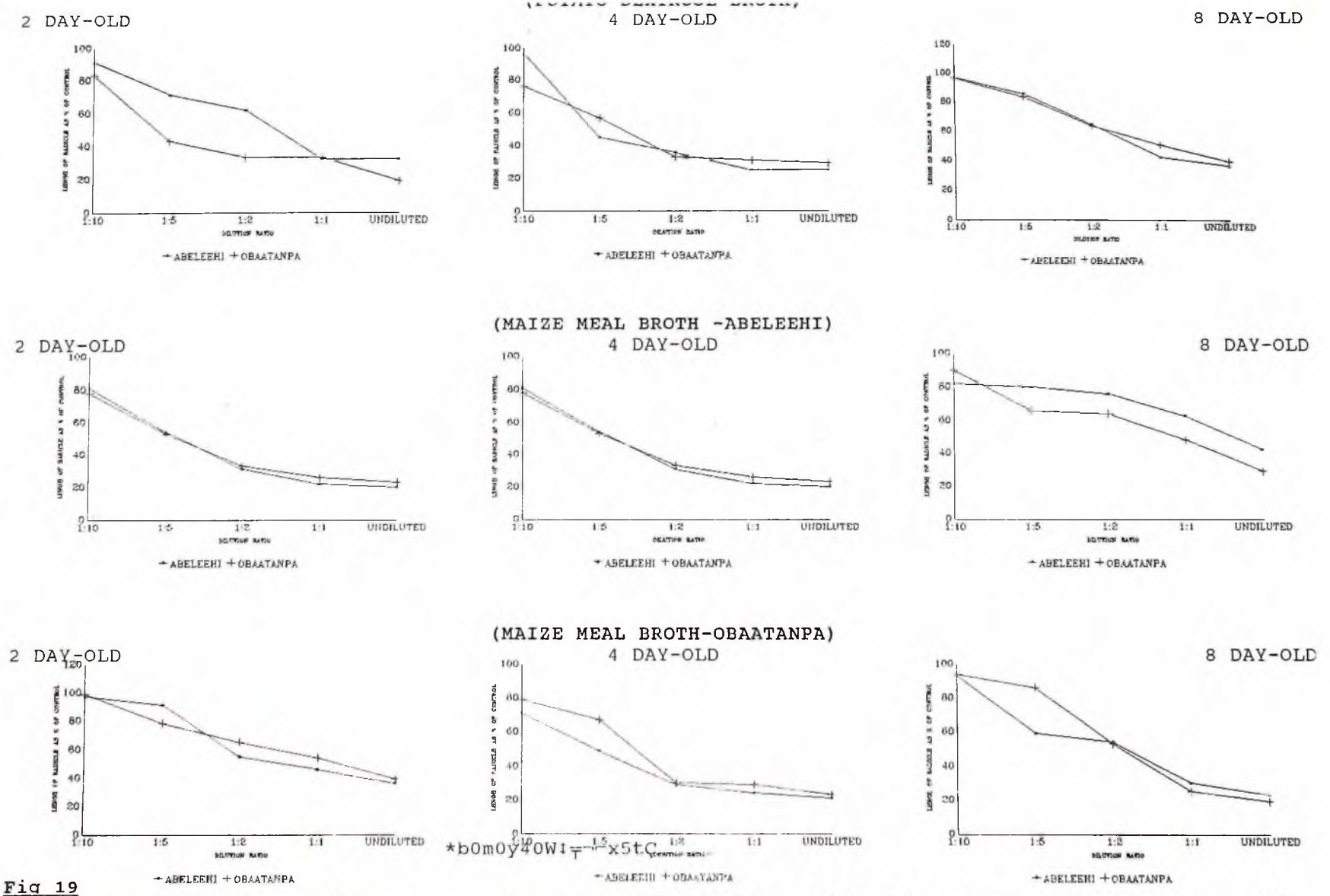

Fig 19
Development of radicle of two maize varieties(Abeleehi and Obaatanpa)growing on filter paper moistened with culture filtrate of Paecilomyces varioti

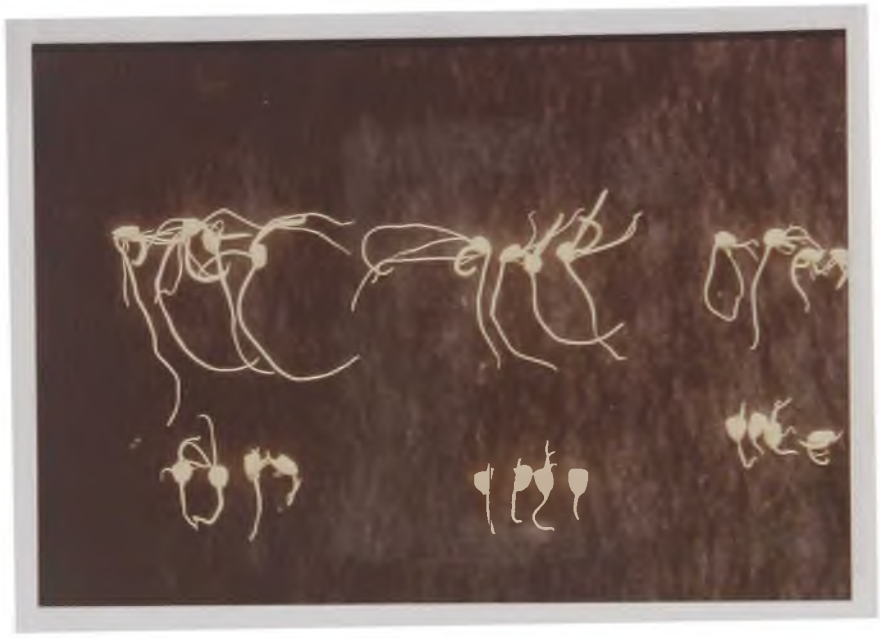

Plate 5. Influence of 4 days old culture metabolites of *P. carneus* on radicle length of germinating seeds of 'Abeleehi'
Top: left (control); Middle (1:10$^{v}/_{v}$); Right ((1:5$^{v}/_{v}$)
Bottom: left ((1:2$^{v}/_{v}$); Middle (1:1$^{v}/_{v}$); Extreme right ((undiluted)
(X 1/8)

Plate 6 Influence of 4 days old culture metabolites of *P. carneus* on radicle length of germinating seeds of 'Obaatanpa'
Top: left (control); Middle (1:10 v/v); Right ((1:5 v/v)
Bottom: left ((1:2 v/v); Middle (1:1 v/v); Extreme right ((undiluted)
(X 1/8)

Plate 7 Influence of 4 days old culture metabolites of *P. puntoni* on radicle length of germinating seeds of 'Abeleehi'
Top: left (control); Middle (1:10 v/v); Right ((1:5 v/v)
Bottom: left ((1:2 v/v); Middle (1:1 v/v); Extreme right ((undiluted)
(X 1/8)

Plate 8. Influence of 4 days old culture metabolites of *P. puntoni* on radicle length of germinating seeds of 'Obaatanpa'
Top: left (control); Middle (1:10$^{v}/_{v}$); Right ((1:5$^{v}/_{v}$)
Bottom: left ((1:2$^{v}/_{v}$); Middle (1:1$^{v}/_{v}$); Extreme right ((undiluted)
(X 1/8)

Plate 9. Influence of 4 days old culture metabolites of *P. varioti* on radicle length of germinating seeds of 'Abeleehi'
Top: left (control); Middle (1:10$^{v}/_{v}$); Right ((1:5$^{v}/_{v}$)
Bottom: left ((1:2$^{v}/_{v}$); Middle (1:1$^{v}/_{v}$); Extreme right ((undiluted)
(X 1/8)

Plate 10. Influence of 4 days old culture metabolites of *P. varioti* on radicle length of germinating seeds of 'Obaatanpa'
Top: left (control); Middle (1:10$^{v}/_{v}$); Right ((1:5$^{v}/_{v}$)
Bottom: left ((1:2$^{v}/_{v}$); Middle (1:1$^{v}/_{v}$); Extreme right ((undiluted)
(X 1/8)

F. In Vitro Studies on the Effect of Metabolites of Aspergillus (*A. alutaceus* = *A. ochraceus*) on Germination and Radicle Development of Maize (Abeleehi and Obaatanpa Vars.)

The culture filtrate of *A. alutaceus* (= *A. ochraceus*) depressed germination at the highest concentration by 50 to 70% (Table 2 and 3). The inhibitory effect was produced even 2 days after culturing the fungus. The severity of the inhibition of germination was gradually removed with increasing dilution of the culture filtrate (Table 2-3) such that germination in plates containing 1:10$^{v}/_{v}$ dilution of the culture filtrate of *A. alutaceus* (= *A. ochraceus*) approximated that of the control.

The same culture filtrate of *A. alutaceus* (*A. ochraceus*) adversely affected radicle development of germinating maize grains. There were varietal difference on the response of the grains to the active ingredients in the culture metabolites of *A. alutaceus* (= *A. ochraceus*). Culture filtrate of *A. alutaceus (= A. ochraceus)* severely depressed (60-90%) radicle development of both test maize varieties at the highest concentration applied (undiluted) but the severity was reduced by increasing dilution such that at 1:10$^{v}/_{v}$ dilution radicle length was depressed by 10-20% or even approximated that of the control in some instances (Fig. 20). The fungus therefore had significant adverse effect on the germination and radicle development of both maize varieties.

TABLE 2

INFLUENCE OF THE CULTURE FILTRATES OF INDICATED FUNGI RAISED IN THREE DIFFERENT MEDIA ON THE GERMINATION CAPACITY OF ABELEEHI MAIZE VARIETY.

Maize variety (Type of medium providing filtrate used as germination medium)	Dilution ratio of culture filtrate (v/v)	% Germination in culture filtrate of indicated fungus after (days)								
		2 days			4 days			8 days		
		Ao	Fm	Pd	Ao	Fm	Pd	Ao	Fm	Pd
ABELEEHI (Maize meal broth prepared from Abeleehi Var.)	Undiluted	60	50	60	50	50	60	60	40	50
	1:1	70	60	70	80	50	60	70	50	60
	1:2	90	60	80	90	60	70	80	60	70
	1:5	90	70	80	100	70	80	90	60	90
	1:10	100	90	100	100	100	100	100	80	100
	Control (Distilled water)	100	100	100	100	100	100	100	90	100
ABELEEHI (Maize meal broth prepared from Obaatanpa var.)	Undiluted	40	60	60	50	50	60	60	60	50
	1:1	60	70	70	60	60	60	70	60	60
	1:2	70	80	80	60	70	70	80	70	70
	1:5	80	80	80	90	80	80	90	80	90
	1:10	100	90	100	100	100	100	90	90	100
	Control (Distlled water)	100	100	100	100	100	100	100	100	100
ABELEEHI (Potato dextrose Broth)	Undiluted	60	60	50	50	50	40	60	40	40
	1:1	70	60	50	60	60	50	80	60	50
	1:2	80	70	60	80	70	60	80	80	60
	1:5	80	80	70	90	90	80	100	80	60
	1:10	100	100	90	90	100	100	100	100	80
	Control (Distilled water)	100	100	100	100	100	100	100	100	90

Ao - *Aspergillus ochraceus*

Fm - *Fusarium moniliforme*

Pd - *Penicillium digitatum*

* - Figures corrected to the nearest whole number.

TABLE 3

INFLUENCE OF THE CULTURE FILTRATES OF INDICATED FUNGI RAISED IN THREE DIFFERENT MEDIA ON THE GERMINATION CAPACITY OF OBAATANPA MAIZE VARIETY.

Maize variety (Type of medium providing filtrate used as germination medium)	Dilution ratio of culture filtrate (v/v)	% Germination in culture filtrate of indicated fungus after (days)								
		2 days			4 days			8 days		
		Ao	Fm	Pd	Ao	Fm	Pd	Ao	Fm	Pd
OBAATANPA (Maize meal broth prepared from Abeleehi Var.)	Undiluted	60 *	50	50	50	50	50	50	40	40
	1:1	70	60	50	60	50	60	70	50	50
	1:2	70	60	60	80	60	70	80	70	60
	1:5	80	70	60	90	70	70	90	70	70
	1:10	100	90	70	100	80	80	100	80	80
	Control (Distilled water)	100	100	90	100	100	100	100	90	100
OBAATANPA (Maize meal broth prepared from Obaatanpa var.)	Undiluted	50	60	50	30	50	40	40	40	30
	1:1	60	60	60	50	50	70	50	50	40
	1:2	70	70	60	60	60	80	60	60	60
	1:5	80	80	70	80	60	90	70	90	70
	1:10	100	100	100	90	100	100	90	100	90
	Control (Distilled water)	100	100	100	100	100	100	100	100	100
OBAATANPA (Potato dextrose Broth)	Undiluted	50	50	50	40	40	40	50	30	30
	1:1	60	60	60	50	50	50	60	50	40
	1:2	70	60	60	70	60	50	80	60	50
	1:5	90	70	70	90	70	70	80	70	60
	1:10	100	90	80	100	90	100	100	90	80
	Control (Distilled water)	100	100	100	100	100	100	100	90	90

Ao - *Aspergillus ochraceus*

Fm - *Fusarium moniliforme*

Pd - *Penicillium digitatum*

* - Figures corrected to the nearest whole number.

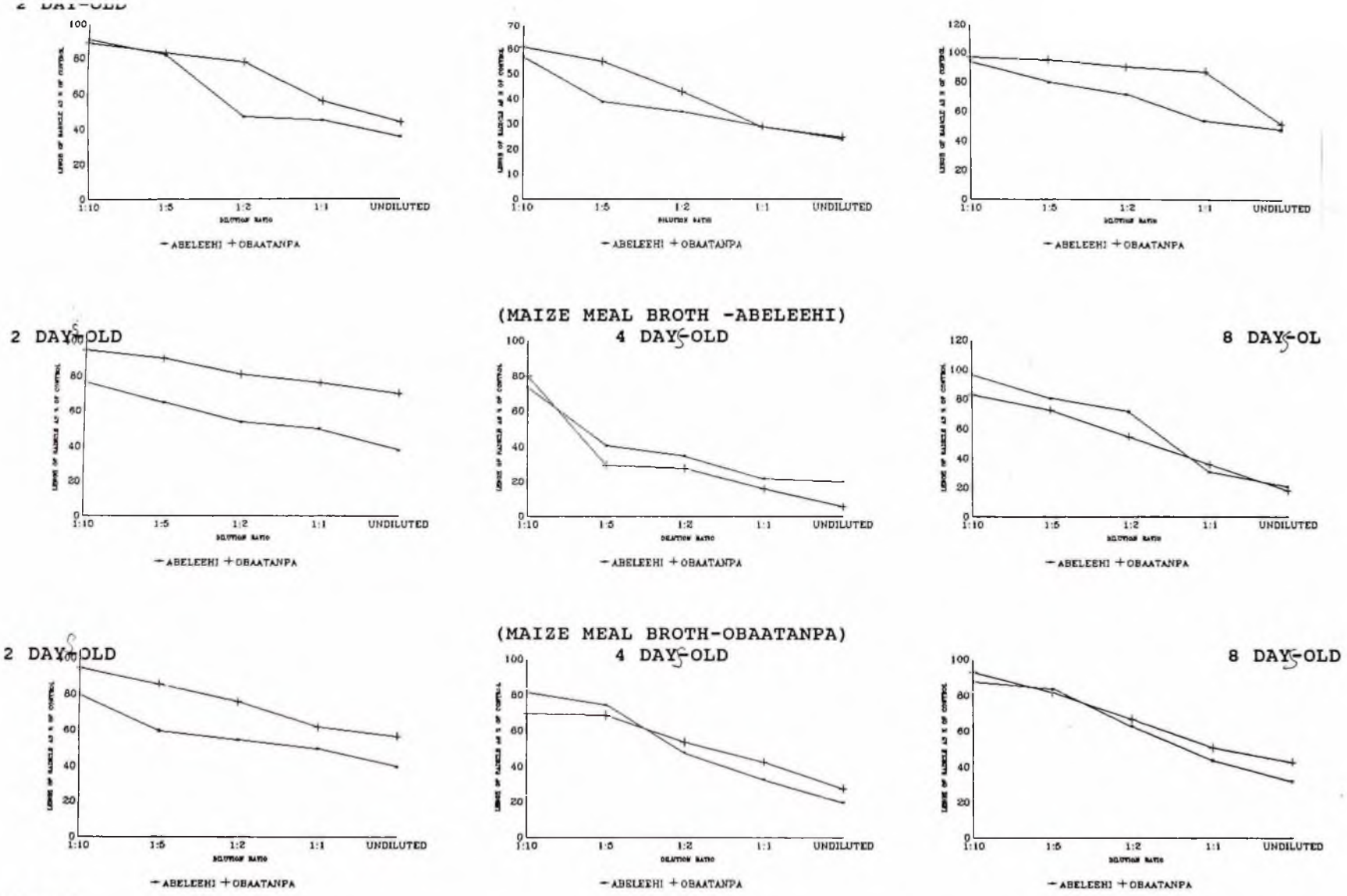

FIG 20

Development of radicle of two maize varieties Abeleehi and Obataanpa growing on filter paper moistened with culture filtrate of Aspergillus ochraceus (A. alutaceus)

G. In Vitro Studies on the Effect of the Metabolites of *Fusarium moniliforme* and *Penicillium digitatum* on Germination and Radicle Development of Maize (Abeleehi and Obaatanpa Varieties

The metabolites of *F. moniliforme* and *P. digitatum* had similar deleterious effect on germination and radicle development of the two maize varieties as in Chapter E and F (Fig. 9-20).

Seed germination was depressed by 50 to 70% at the higher concentration of the culture filtrate of *F. moniliforme* and *P. digitatum* (Table 2 and 3).

The inhibitory effect of the metabolites of the two fungi on seed germination was gradually removed with increasing dilution of the culture filtrate. 2-4 days old culture metabolites of *F. moniliforme* severely depressed (by 40-90%) radicle development of both Abeleehi and Obaatanpa at the highest concentration applied. In most instances the effect was severer on Abeleehi than on Obaatanpa (Fig. 21) except in the case of 4 days culture of *F. moniliforme* raise in maize meal broth prepared from Obaatanpa. In all instances the inhibitory effect was gradually reduced with increasing dilution of the culture filtrate such that the 1:10$^{v}/_{v}$ dilution nearly approximately that of the control (untreated).

The metabolites of *P. digitatum* generally exerted severer depressive effect on the development of the radicles of Obaatanpa than that of Abeleehi variety (Fig. 22). Again the inhibitory principle was gradually removed by increasing dilution of the filtrate used as germinating medium for seed. The general conclusion is that culture metabolites of both *F. moniliforme* and *P. digitatum* have adverse effect on the germination and radicle development of Abeleehi and Obaatanpa varieties.

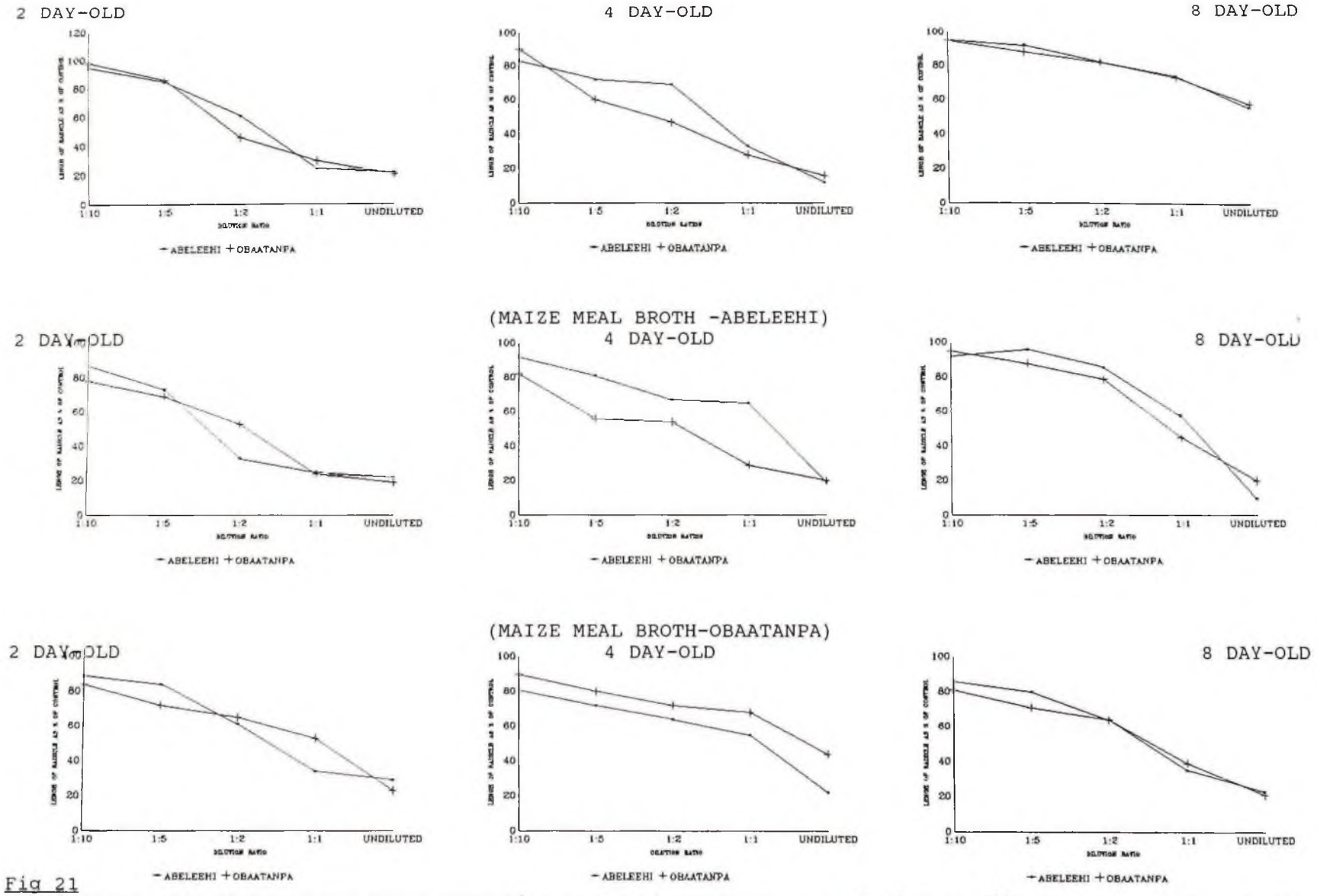

Fig 21

Development of radicle of two maize varieties Abeleehi and Obataanpa growing on filter paper moistened with culture filtrate of Fusarium moniliforme

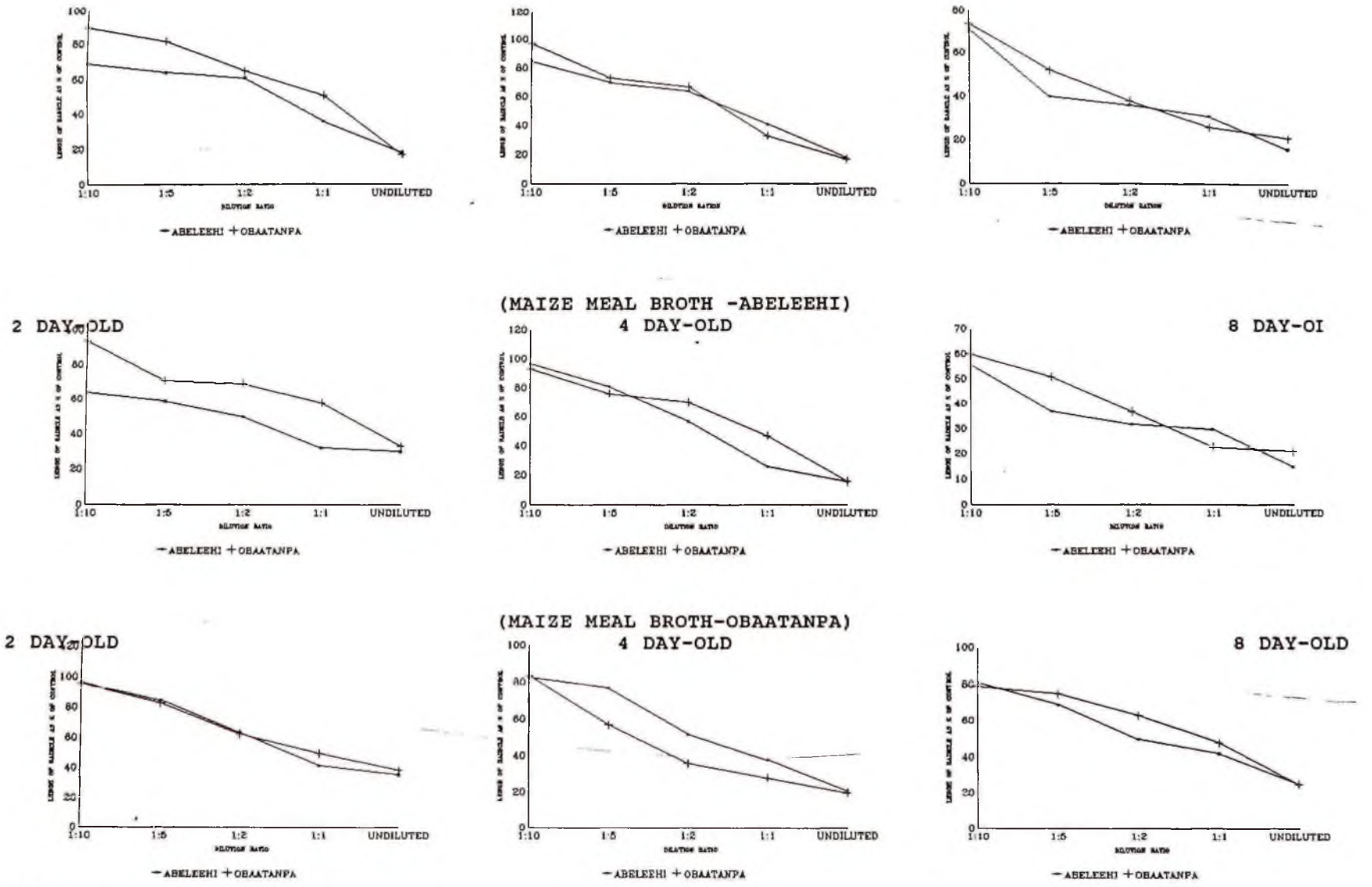

Fig 22
Development of radicle of two maize varieties Abeleehi and Obaatanpa growing on filter paper moistened with culture filtrate of Penicillium digitatum

H. Influence of Metabolites of Three *Paecilomyces* species on Germination and Radicle Development of Pepper (*Capsicum annuuml*) and tomato (*Lycopersicon esculentum* Mill)

The inhibitory effect of the metabolites of *Paecilomyces carneus, P. puntoni* and *P. varioti* on germination and radicle development cannot be confined to maize grains only. These same metabolites in the culture filtrates of the respective *Paecilomyces* species significantly ($P \leq 0.05$) depressed seed germination and radicle development of two tomato varieties (CV's Owusu-Bio and Wosowoso) and hot pepper (Var, Legon 18.).

Each culture filtrate from the test fungi was unique in its effect on the germination and radicle development of the seedling of tomato and pepper. There were also varietal differences in the response of the tomato and pepper seed to the same metabolites (Table 4). The inhibitory effect of the metabolites was highest on var. Owusu-Bio than var. Wosowoso. The inhibitory principle was still potent even at $1:10^{v}/_{v}$ dilution level. Clearly, tomato and pepper seeds are also adversely affected by the culture metabolites of the *Paecilomyces* species.

TABLE 4

INFLUENCE OF THE METABOLITES OF INDICATED *PAECILOMYCES* SPECIES ON GERMINATION AND RADICLE DEVELOPMENT OF TOMATO (*LYCOPERSICON ESCULENTUM*) AND PEPPER (*CAPSICUM ANNUUM*, LEGON 18) AT 28-31°C FOR 5 DAYS

Seed Variety	Dilution ratio of filtrate (v/v)	Germination (%) in filtrate of Pc	Pp	Pv	Radicle length (mm) in filtrate of Pc	Pp	Pv
	Undiluted	30	15	17	4.0±1.9	1.0±0.0	1.0±0.1
Lycopersicon esculentum var Owusu-Bio	1:1	40	30	34	5.0±0.9	1.0±0.6	2.0±0.9
	1:2	45	50	38	7.0±2.0	1.0±0.3	3.0±1.8
	1:5	50	55	42	7.0±2.3	4.0±1.7	8.0±1.5
	1:10	70	67	53	13.0±1.8	10.0±1.3	11.0±1.2
	Control (Distilled water)		85			25.1 ± 3.1	
	Undiluted	70	65	55	3.0±0.8	3.0±0.8	2.0±0.3
Lycopersicon esculentum var Wosowoso	1:1	75	78	68	9.0±1.9	4.0±2.0	4.0±1.6
	1:2	80	88	85	12.0±2.1	4.0±1.5	6.0±1.5
	1:5	94	90	95	19.0±2.8	6.0±1.5	15.0±2.0
	1:10	97	93	95	26.0±2.7	9.0±1.6	18.0±2.1
	Control (Distilled water)		100			40.4 ± 4.0	
	Undiluted	0	10	0	-	1.0±0.0	-
Capsicum annuum var Legon 18	1:1	13	17	3	2.0±1.1	1.0±0.7	1.0±0.8
	1:2	10	40	17	3.0±0.8	1.0±0.0	2.0±0.9
	1:5	33	48	37	3.0±0.9	3.0±1.0	2.0±1.2
	1:10	47	52	50	4.0±0.9	4.0±0.7	4.0±1.1
	Control (Distilled water)		78			5.6 ± 1.8	

Pc - *Paecilomyces carneus*; Pp - *P. puntoni* ; Pv - *P.varioti*

I. Influence of Metabolites of *Paecilomyces* on Vegetative Growth and Dry Matter Accumulation and Chlorophyll Content of Maize (Var Abeleehi and Obaatanpa)

Field Studies

The height, leaf length and leaf width of Abeleehi and Obaatanpa varieties plants whose seeds were inoculated with the mycelium/conidia of the three *Paecilomyces* species prior to sowing were significantly (student's t test; $P \leq 0.05$) depressed by the metabolites of the growing *Paecilomyces* species (Fig. 23). There were differences between the efficacy of three *Paecilomyces* species in depressing plant development in the field and each plant part responded differently to the inhibitory effect of the culture metabolities. Photographs of the seedlings growing in the field are shown in the plates 11 and 12. The resulting cobs on the treated plants were also diminutive and carried fewer grains as compared to the control (Plate 13 and 14).

Greenhouse Studies

Reduction in plant height, leaf length and leaf width of Abeleehi and Obaatanpa in pots in the greenhouse by the culture filtrate of *P. carneus, P. puntoni* and *P. varioti* can be described as marginal and did not differ significantly ($P \leq 0.05$) from the control seedlings (Fig. 24) except in the case of Obaatanpa seedlings where the leaves were narrower than the untreated (control). Furthermore, *P. carneus* metabolites exerted greater inhibitory effect on leaf width than that of *P. puntoni* and *P. varioti* (in decreasing order) (Fig. 24). Each plant part of the respective maize variety behaved differently in its response to the inhibitory principle in the metabolites of the test *Paecilomyces* species. Fig. 25 shows result of the dry matter accumulation by leaves, stem and root systems of maize (Abeleehi and Obaatanpa) in pots moistened with culture metabolites of *Paecilomyces* species in the greenhouse. There were varietal differences in the response of the maize grains to dry matter accumulation by shoot and root systems in the presence of the metabolites of the three *Peacilomyces* species. Each plant part behaved differently. For example, whilst there was no statistical differences between the

control and the dry weight of leaves of Abeleehi treated with metabolites of the three *Peacilomyces* species, there were clear statistical ($P \leq 0.05$) differences between the dry weight obtained in Obaatanpa plants treated with *P. carneus*, *P. puntoni* and *P. varioti* (Fig. 25). The severity of the depression can be ranked as following in decreasing order: *P. varioti* > *P. carneus* > *P. puntoni*.

The effect of the *Paecilomyces* metabolites on the dry matter accumulation by stem and roots of Abeleehi and Obaatanpa seedlings were different and can be ranked as follows.

P. puntoni > *P. varioti* > *P. carneus*.

Data which was used in plotting Figures 23-25 are presented in the Appendices 2a - 2c

Chlorophyll Content

Interestingly, the metabolites of *P. carneus*, *P. puntoni* and *P. varioti* affected the chlorophyll content of the leaves of the growing seedlings of Abeleehi and Obaatanpa varieties both in the field and in the greenhouse.

Chlorophyll a and b contents were lowest in Abeleehi and Obaatanpa plants growing in the field whose seeds were inoculated with *P. carneus* followed by seeds treated with *P. puntoni* (Table 5). Duncian's Multiple Range Test showed that the data recorded were significantly ($P \leq 0.05$) different from the untreated (control). Total chlorophyll content of Abeleehi seedlings was also significantly ($P \leq 0.05$) lower in seedlings whose seeds were inoculated with *P. carneus* and *P. puntoni* but not with *P. varioti*.

Seedlings of Abeleehi and Obaatanpa in the greenhouse which were treated with metabolites of the three *Paecilomyces* species behaved differently. Metabolites of *P. carneus*, *P. puntoni* and *P. varioti* severely reduced chlorophyll a and b contents of both Abeleehi and Obaatanpa. *P. puntoni* metabolite was more potent. Total chlorophyll contents of the leaves of both maize varieties treated with the metabolites of the three *Paecilomyces* species were also lower (Table 5). Therefore the metabolites of *Paecilomyces* species also affected the photosynthetic apparatus of the maize varieties tested.

TABLE 5

CHLOROPHYLL CONTENT OF SEEDLINGS OF INDICATED MAIZE VARIETIES GROWING IN THE FIELD OR IN POTS UNDER NORMAL DAY/NIGHT REGIME AT 28 - 32°C 56 DAYS.

Maize Variety	Fungus inoculated	Chlorophyll content (mg/1)					
		Chl. a		Chl. b		Total Chlorophyll	
		Field	Pot	Field	Pot	Field	Pot
Abeleehi	Untreated (Control)	11.28	15.59	19.23	24.51	31.27	41.49
	P.carneus	8.44	13.81	15.15	18.73	24.79	40.13
	P.puntoni	10.41	9.85	17.88	15.11	29.34	29.06
	P.varioti	11.06	11.09	18.61	16.89	30.88	31.95
Obaatanpa	Untreated (Control)	16.43	16.01	29.83	20.82	41.42	33.12
	P.carneus	9.69	9.07	17.81	15.19	27.46	26.66
	P.puntoni	13.43	8.67	22.51	14.40	35.99	25.74
	P.varioti	15.92	8.84	26.98	14.69	41.01	26.11

ANALYSIS OF VARIANCE

ABELEEHI

Multiple Range Tests: Duncan test with significance level .05

Indicates significant differences which are shown in the lower triangle

G G G G
r r r r
p p p p
3 2 4 1

Mean	ABPCARN
12.0800	Grp 3
20.2033	Grp 2
28.9417	Grp 4
47.8417	Grp 1 * *

Homogeneous Subsets (highest and lowest means are not significantly different)

Subset 1

Group	Grp 3	Grp 2	Grp 4
Mean	12.0800	20.2033	28.9417

Subset 2

Group	Grp 4	Grp 1
Mean	28.9417	47.8417

OBAATANPA

Indicates significant differences which are shown in the lower triangle

G G G G
r r r r
p p p p

3 1 4 2

Mean	OBCODE	
19.0517	Grp 3	
26.1050	Grp 1	
70.8200	Grp 4	* *
81.3333	Grp 2	* *

Homogeneous Subsets (highest and lowest means are not significantly different)

Subset 1

Group	Grp 3	Grp 1
Mean	19.0517	26.1050

Subset 2

Group	Grp 4	Grp 2
Mean	70.8200	81.3333

Plate 11. Photograph of 'Obaatanpa' variety growing untreated (Control) in the field after 90 days at 29°C (X 1/4)

Plate 12. Photograph showing the devastating effect of the three *Paecilomyces* species on the development of the maize plant in the field (Note the moribund plants at the centre of the field) (X 1/8)

Plate 13. Photograph showing cobs form on the Abeleehi maize plant after 3 months (90 days) exposure to the indicated *Paecilomyces* in the field (X ¼)
(Top) From left Control; *P. varioti*, *P. carneus*, *P. puntoni*

Plate 14. Photograph of plate 13 showing cobs with husks removed (X ¼)

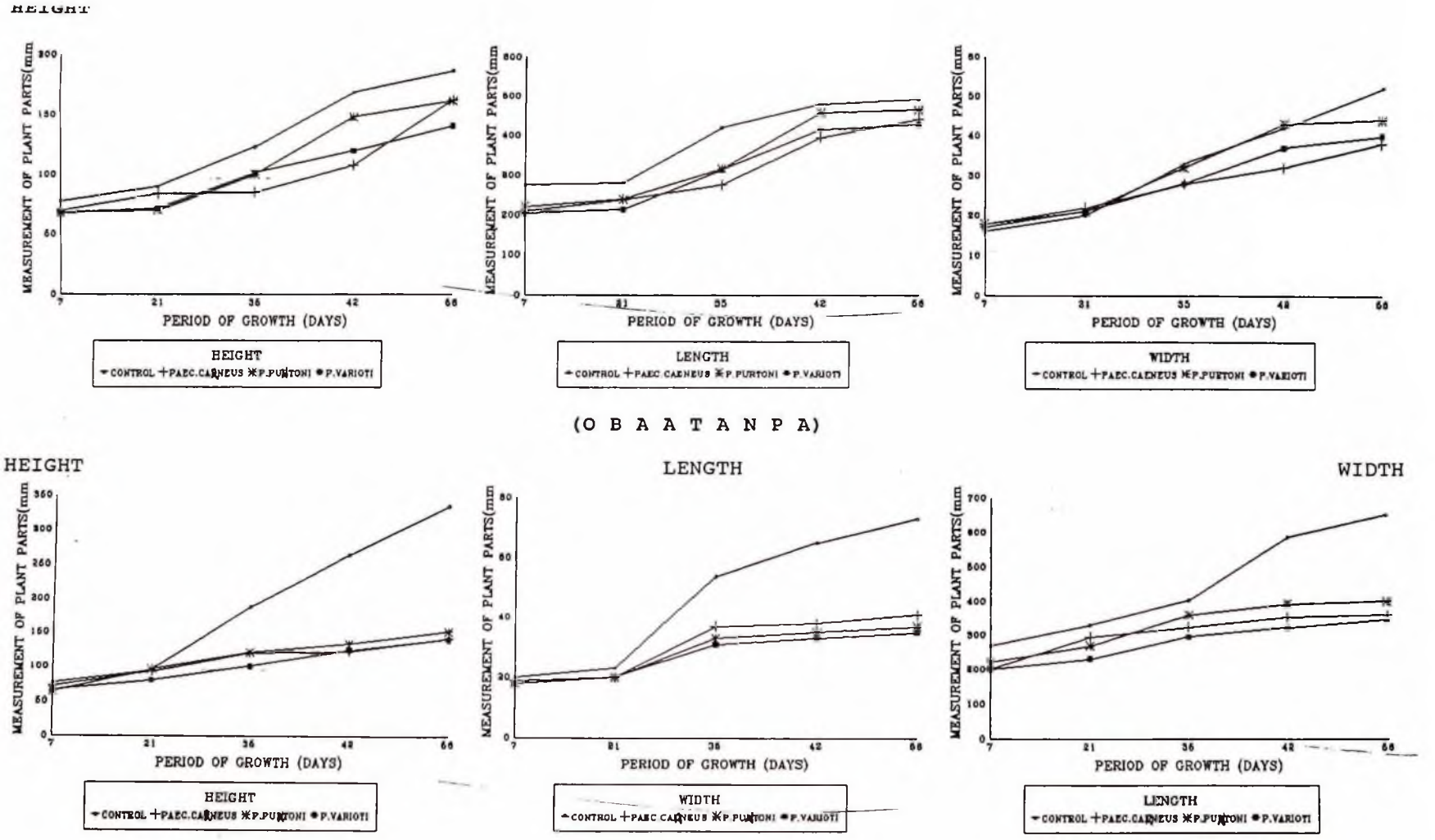

Fig 23
Influence of metabolites of the indicated Paecilomyces Species on height, length and width of leaf of maize varities in the field at 28° - 31°

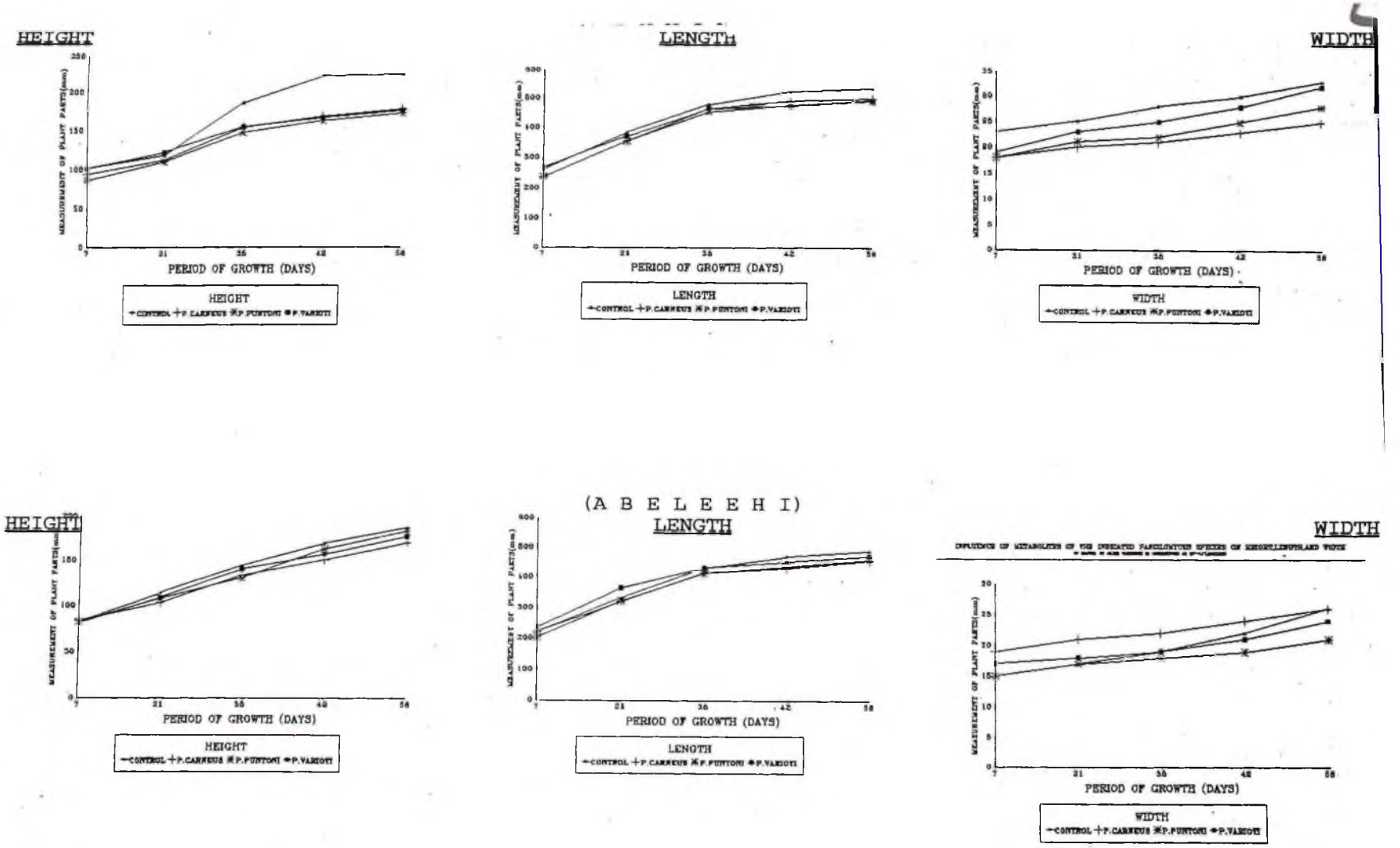

Fig 24
Influence of metabolites of the indicated Paecilomyces species on height, length and width of leaf maize varieties in the Greenhouse at 28° - 31°

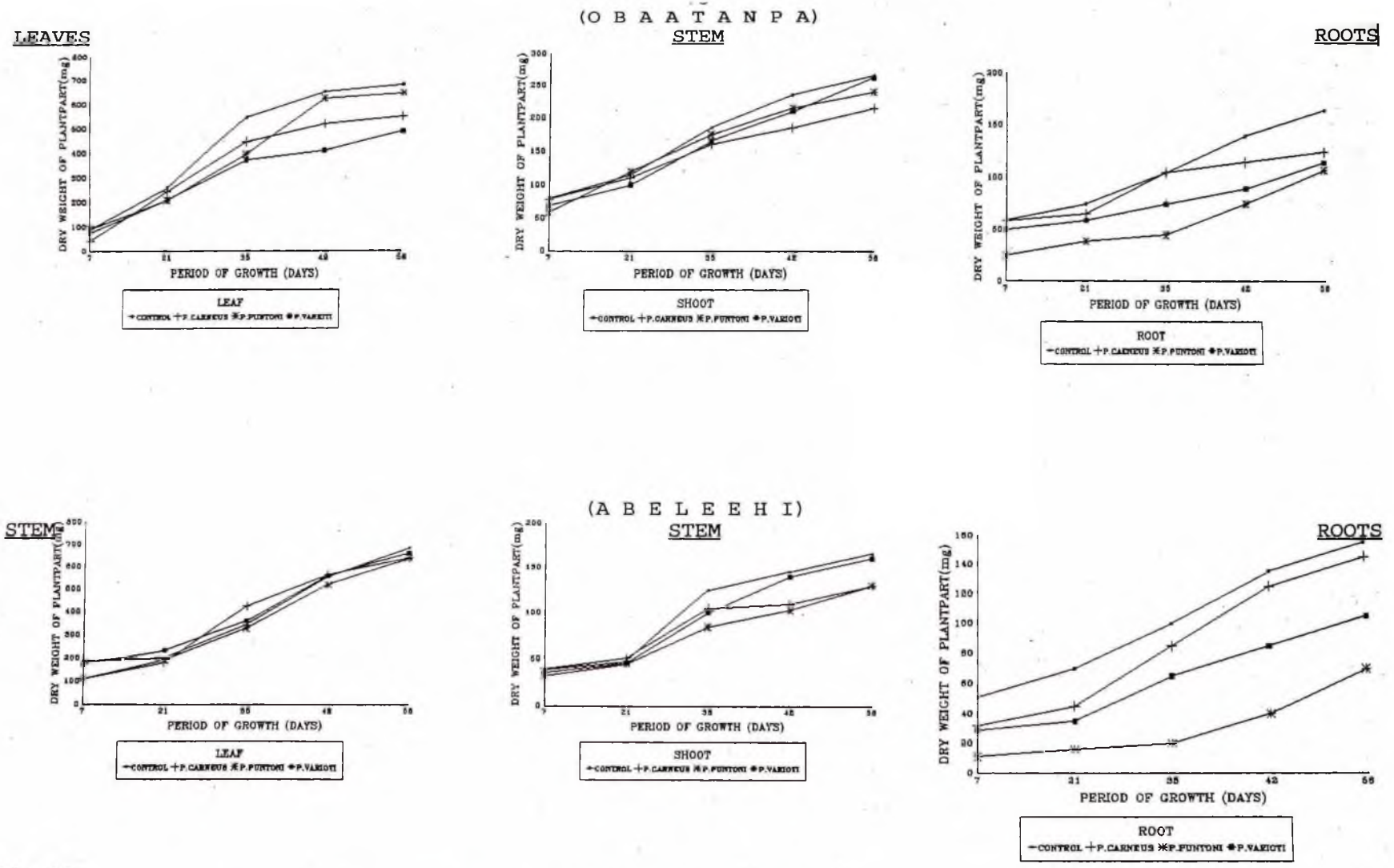

Fig 25

Influence of metabolites of the indicated Paecilomyces species on dry matter accumulation by leaves, shoots and roots of maize varieties in the Green house at 28° - 31°

J. Rhizosphere and Non-Rhizosphere Fungi Associated with Seedlings of Abeleehi and Obaatanpa Varieties Treated with Mycelium/Metabolites of *Paecilomyces species*

The presence of *P. carneus*, *P. puntoni* and *P. varioti* influenced the rhizosphere mycobiota profile (Tables 6 to 11) as follows:

***Aspergillus species* (Abeleehi variety)**

A. ustus although present in the initial control soil (26.0%) could not be detected again in both rhizosphere and non-rhizosphere soil after 7 days growth of Abeleehi variety in the field under the influence of the three *Paecilomyces* species; *A. fumigatus* was also completely eliminated in rhizosphere and non rhizosphere soil under the influence of *Paecilomyces* species except 28 days after growth where it was detected in low quantities (1.2 - 2.2%). *A. tamarii* initially constituted 43.4% of the soil mycoflora but was eliminated by *P. carneus* and *P. puntoni* metabolites except soils seeded with seeds inoculated with *P. varioti* which contained depressed (1.5 - 2.9%) population of *A. tamarii*. Only *A. flavus*, *A. niger*, *A. alutaceus* (= *A. ochraceus*) and *A. versicolor* could somehow withstand to some extent the competitive antagonism from the *Paecilomyces* species to varying extent (Table 6).

Aspergillus species (Obaatanpa variety)

Survival of *A. ustus*, *A. fumigatus*, *A. suphureus* was depressed by the *Paecilomyces* species (Table 9) *A. versicolor* although present in the control soil initially could not be detected until after 4 days when its presence was higher in the treated soils than in the control and thereafter declined. Only *A. flavus*, *A. niger* and *A. alutaceus* (= *A. ochraceus*) remained viable in the soil inspite of the presence inhibitory principle exuded by the *Paecilomyces* species.

Penicillium species (Abeleehi variety)

P. citrinum remained depressed in rhizosphere soil containing seeds inoculated with *Paecilomyces* spp. as compared with non - rhizosphere soil.

On the other hand *P. digitatum* could not be detected in rhizosphere soil containing seed inoculated with *P. puntoni and P. varioti* while it was thriving in soil containing seeds inoculated with *P. carneus*. In any case, *P. digitatum* phased out competely in the rhizosphere and non-rihizosphere of both control and treated soil after 28 days of growth of the seedlings (Table 7).

Penicillium species (Obaatanpa variety)

P. brevi-compactum, P. digitatum and *P. expansum* did not grow very well in the control (untreated soil). However, the presence of especially *P. puntoni* and *P. varioti* aggravated the situation aftet 14 days *P. citrinum* could invariably tolerate the metabolites of the three *Paecilomyces* species in both rhizosphere and non-rhizosphere soil but showed depressed occurrence (Table 10).

Fungi belonging to other genera (Abeleehi variety)

Occurrence of all the fungi belonging to other genera (*Cladosporium, Fusarium, Mucor, Rhizopus, Rhodotorula, Scopulariopsis, Trichoderma* and Yeast) declined with time up to 56 days in control soil (Table 8). However, only *C. herbarium, F. moniliforme Rhodotorula* sp and *T. viride* survived in the treated soil in competition with the metabolites of the *Paecilomyces* species. *T. viride* and *Rhodotorula* were initially almost completely depressed but recovered showing appreciable viability after 28 days. All three *Paecilomyces* species varied in their

individual ability to depress/compete with the members of the other genera encountered *Pullularia pullulans* and *Scopulariopsis brevicaulis* were poor competitors even in control soils (Table 8).

Fungi belonging to other genera (Obaatanpa variety)

Occurence of all the fungi belonging to other genera (*Cladosporium, Mucor, Rhizopus, Rhodotorula, Scopulariopsis, Trichoderma* and Yeast) declined with time. (*Cladosporium, herbarium, F. moniliforme, T. viride and Rhodoturula,* other Yeast and *Mucor* survived to varying extent in the treated soil containing mycelia of the three *Paecilomyces* species. Occurrence of *Pullularia pullulans* was low and poor even in the untreated soil and this fungus could not be detected 7 days after emergence of the seedlings of Obaatanpa (Table 11).

Green house Experiment (IN POTS)

The seed inoculation with the mycelium/conidia of *Paecilomyces* influenced the rhizosphere mycobiota profile as follows (Table12-17).

Aspergillus species (Abeleehi variety)

Very low population of *A. ustus* was detected in cotnrol soil and the presence of the metabolites of the three *Paecilomyces* species eliminated this fungus such that it could not be isolated 7 days after emergency of the seedlings (Table 12). *A. fumigatus* could not also survive in the soil after 14 days. The rhizosphere and non-rhizosphere region of the seedling of Abeleehi was predominated by *A. flavus, A. niger, A. tamarii, A. alutaceus* (= *A. ochraceus*)

and *A. versicolor* in decreasing order and were thus able to withstand to varying extent the inhibitory effects of the metabolites of the *Paecilomyces* species (Table 12).

Aspergillus species (Obaatanpa variety)

A. flavus, A. niger, A. alutaceus (= *A. ochraceus*) *A. tamarii*, remained viable in the soil inspite of the presence of the inhibitory effect exerted by the metabolites of the three *Paecilomyces* species. *A. fumigatus, A. ustus* and *A. versicolor* were depressed to variable extent by the *Paecilomyces* species (Table 15). Although *A. versicolor* was present initially in the soil, it could not be detected 7-14 days in the control and soils containing *P. carneus* and *P. varioti*. However, after 28 days it reappeared in higher proportion than in the control and thus was only temporarily depressed (Table 15).

Penicillium species (Abeleehi variety)

Penicillium brevicompactum could not be isolated from the control untreated soil but appears in non-rhizosphere soil containing *Paecilomyces puntoni* and *P varioti* up to 28 days and thereafter could not be detected *P. digitatum* and *P. expansum* were encountered in non-rhizosphere soil only with sporadic appearance in rhizosphere soil containing *Paecilomyces puntoni*. *Penicillium citrinum* thrived in competition with the *Paecilomyces* species and could be isolated in comparable proportion in the treated and untreated soil (Table 13).

Penicillium species (Obaatanpa variety)

The profile of occurrence obtained for *Penicillium* species associated with the rhizosphere of Obaatanpa was akin to what existed for Abeleehi (table 16) except for variations in percentage occurrence. Again *P. citrinum* could withstand the inhibitory antagonistic principles from the *Paecilomyces* species in most instances (Table 16).

Fungus belonging to other genera (Abeleehi)

C. herbarium, F. moniliforme, Rhodotorula and *T. viride* survived in the treated soil in competition with the three *Paecilomyces* species. *Pullularia pullulans* appeared only momentarily at the onset of the experiment and was phased out of the soil after 14 days. However, *S. brevicaulis* did not survive in the control and treated soil after 28 days inspite of its 5.8 - 7.8% occurrence in soil treated with *P. varioti* and 2.4% occurrence in soil treated with *P. carneus* after 14 days (Table 14).

Fungus belonging to othe genera (Obaatanpa varieties)

F. moniliforme, Mucor, Rhizopus oryzae, Rhodotorula and other yeasts survived the antagonism of *Paecilomyces* in a similar manner as above except for variation in percentage occurrence. *T. viride* survived in the rhizosphere for at least 28 days in the presence of all but one of the *Paecilomyces* species. *P. varioti* could not completely depress the competitive ability of *T. viride* (Table 17). Tables 18 to 21 show the mycoflora associated with the rhizosphere and non-rhizosphere regions of Abeleehi and Obaatanpa maize variety growing either in the pots (Table 18 and 19) or in the field pots (Tables 20 and 21) in the green house. Generally there were more fungal species isolated from the field soils than the same region in the pots (Table 18-21). More fungal species were isolated from the rhizosphere than the non-rhizosphere control soil. *Aspergillus* species predominated in both the rhizosphere and non-rhizosphere soil followed by *Penicillium* species.

TABLE 6

ASPERGILLUS SPECIES ENCOUNTERED IN THE RHIZOSPHERE (R) AND NON - RHIZOSPHERE (NR) DURING GROWTH OF MAIZE SEEDLING (ABELEEHI) IN THE FIELD AT 31°C + 2 FOR DAYS 56 DAYS.

Fungal species	Treatment	% Occurrence in rhizosphere (R) and non-rhizosphere after (day)									
		7		14		28		42		56	
		R	NR	R	NR	R	NR	R	NR	N	R
Asperillus flavus	Control	23.1	5.8	1.0	-	33.7	0.9	4.4	3.6	-	0.4
	P. carneus	14.7	-	3.0	-	70.3	4.7	-	-	-	-
	P. puntoni	16.9	0.8	-	-	-	2.9	1.0	-	-	8.6
	P. varioti	18.2	2.1	4.5	-	4.6	2.2	-	0.6	-	1.9
A.fumigatus	Control	-	-	-	-	2.2	-	-	-		
	P. carneus	-	-	-	-	-	-	-	-	-	-
	P. puntoni	-	-	-	-	-	1.9	-	-	-	-
	P. varioti	-	-	-	-	-	1.0	-	-	-	-
A.niger	Control	31.6	25.7	2.0	-	-	8.7	16.9	8.0	-	3.1
	P. carneus	27.3	26.3	31.4	-	0.3	9.4	-	3.4	-	4.2
	P. puntoni	26.7	18.2	1.1	1.6	0.9	14.6	0.8	0.6	5.2	2.8
	P. varioti	28.1	11.6	7.5	32.1	1.4	3.2	3.2	9.7	4.1	0.5
A.alutaceus	Control	-	2.7	-	10.3	6.7	6.0	5.0	4.0	-	7.1
	P. carneus	-	3.8	-	31.0	-	8.7	-	3.1	9.4	-
	P. puntoni	0.6	5.1	2.3	36.5	1.8	12.6	1.0	1.7	0.6	54.1
	P. varioti	1.7	0.9	14.9	25.0	4.1	1.9	0.4	1.6	8.3	87.7
A.sulphureus	Control	2.1	-	-	-	1.1	-	1.3	2.0	-	-
	P. carneus	-	-	-	-	-	-	-	-	-	-
	P. puntoni	-	-	-	-	-	1.0	0.2	0.7	-	-
	P. varioti	2.7	-	-	-	0.5	0.3	19.2	0.3	-	-
A.tamarii	Control	-	-	-	-	-	-	-	-	-	-
	P. carneus	-	-	-	-	-	-	-	-	-	-
	P. puntoni	-	-	-	-	-	-	-	-	-	-
	P. varioti	-	-	1.5	-	1.3	2.9	-	-	-	-
A.ustus	Control	-	-	-	-	-	-	-	-	-	-
	P. carneus	-	-	-	-	-	-	-	-	-	-
	P. puntoni	-	-	-	-	-	-	-	-	-	-
	P. varioti	-	-	-	-	-	-	-	-	-	-
A. versicolor	Control	-	-	-	-	7.9	4.6	1.3	3.6	-	0.9
	P. carneus	-	-	-	33.8	-	-	-	4.0	0.8	2.5
	P. puntoni	-	-	-	-	-	-	1.0	1.0	-	-
	P. varioti	2.8	-	11.9	21.4	3.7	5.1	-	-	2.5	-

PENICILLIUM SPECIES ENCOUNTERED IN THE RHIZOSPHERE (R) AND NON - RHIZOSPHERE (NR) DURING GROWTH OF MAIZE SEDDLING (ABELEEHI) IN THE FIELD AT 31°C + 2 FOR DAYS 56 DAYS.

Fungal Species	Treatment	% Occurrence in rhizosphere (R) and Non-rhizosphere after days									
		7		14		28		42		56	
		R	NR	R	NR	R	NR	R	NR		
Penicillium	Control	-	-	-	1.5	1.1	5.5	-	-	-	4.0
brevi-	P. carneus	-	-	-	-	-	-	10.1	-	24.9	10.2
compactum	P. puntoni	-	-	-	-	14.0	-	-	-	-	-
	P. varioti	-	-	-	-	6.0	7.4	0.9	-	-	-
P.citrium	Control	52.2	48.2	3.0	2.9	6.7	2.3	11.3	5.6	4.5	0.9
	P. carneus	2.7	31.4	-	1.3	4.0	6.0	-	0.8	16.0	0.8
	P. puntoni	6.7	15.2	-	69.8	-	8.7	1.3	1.9	0.6	-
	P. varioti	3.1	11.1	-	17.9	9.6	6.1	2.8	1.6	1.5	-
P.digitatum	Control	6.8	2.8	50.3	3.8	-	-	-	-	-	-
	P. carneus	2.6	4.9	62.7	28.8	-	-	-	-	-	-
	P. puntoni	-	16.5	-	-	-	-	-	-	-	-
	P. varioti	-	19.1	-	-	-	-	-	-	-	-
P.expansum	Control	-	2.8	-	13.2	-	0.6	0.8	-	-	-
	P. carneus	-	0.8	-	13.8	-	-	4.2	-	-	
	P. puntoni	-	16.5	-	-	-	-	-	1.6	-	-
	P. varioti	-	-	6.0	-	-	-	1.8	2.8	-	-

TABLE 8

OTHER FUNGAL SPECIES ENCOUNTERED IN THE RHIZOSPHERE (R) AND NON - RHIZOSPHERE (NR) DURING GROWTH OF MAIZE SEEDLING (ABELEEHI) IN THE FIELD AT 31°C + 2 FOR 56 DAYS.

FUNGAL SPECIES	TREATMENT	% OCCURENCE IN RHIZOSPHERE (R) AND NON-RHIZOSPHERE AFTER DAYS									
		7		14		28		42		56	
		R	NR	R	NR	R	NR	R	NR	R	NR
Cladosporium herbarum	Control	5.7	3.4	4.0	17.6	-	11.5	-	2.8	-	-
	P.carneus	-	4.2	-	3.8	-	6.0	-	0.4	2.8	5.9
	P.puntoni	3.4	0.6	12.6	11.1	25.4	50.5	-	3.8	5.8	0.8
	P.varioti	6.3	-	76.1	8.9	17.9	4.8	11.3	14.9	73.5	0.6
Fusarium moniliforme	Control	8.5	2.1	-	7.4	9.0	14.2	3.1	3.6	3.7	6.7
	P.carneus	3.2	0.9	-	-	-	-	-	13.8	-	1.9
	P.puntoni	-	5.2	-	25.4	1.8	7.8	0.3	0.5	5.8	3.0
	P.varioti	11.2	11.0	13.4	48.2	1.8	1.0	4.4	7.3	10.3	0.6
Mucor sp	Control	2.1	-	1.0	-	1.1	-	-	-	93.3	2.7
	P.carneus	1.1	0.3	-	9.0	7.5	-	-	0.4	89.2	0.8
	P.puntoni	6.1	-	8.0	-	4.4	1.0	-	-	1.9	-
	P.varioti	5.1	2.1	6.0	8.9	-	0.6	-	0.3	2.5	0.6
Pullularia pullulans	Control	-	-	-	-	-	-	0.6	-	-	-
	P.carneus	-	-	-	-	-	-	-	-	-	-
	P.puntoni	-	-	-	-	-	-	-	-	-	-
	P.varioti	-	-	-	-	-	-	-	0.3	-	-
Rhizopus oryzae	Control	-	-	-	-	16.9	14.2	5.6	3.2	-	-
	P.carneus	-	-	-	-	-	9.4	1.5	3.8	-	-
	P.puntoni	-	-	-	-	1.8	19.4	1.0	2.2	2.6	-
	P.varioti	-	-	-	-	-	-	4.0	2.5	-	-
Rhodotorula SP	Control	-	-	-	-	40.4	-	36.9	17.3	13.4	95.5
	P.carneus	-	-	-	-	15.5	14.8	10.6	1.9	94.8	90.5
	P.puntoni	-	-	-	-	17.5	76.7	72.7	67.1	61.2	65.2
	P.varioti	-	-	-	-	26.1	-	19.5	13.6	96.1	60.4
Scopulariopsis brevicaulis	Control	-	-	5.0	14.7	-	-	-	-	-	-
	P.carneus	-	-	-	12.5	-	-	-	-	-	-
	P.puntoni	-	-	-	-	-	-	-	-	-	-
	P.varioti	-	-	-	-	-	-	-	-	-	-
Trichderma viride	Control	-	2.1	-	-	3.4	1.0	14.4	15.3	-	-
	P.carneus	-	0.6	-	-	-	17.4	90.4	8.0	-	-
	P.puntoni	-	-	-	-	2.6	3.9	2.6	2.0	10.7	-
	P.varioti	-	2.5	-	-	-	-	0.8	5.1	8.3	86.2
Yeast	Control	-	2.1	-	-	-	-	-	0.8	-	8.0
	P.carneus	-	6.4	-	-	-	-	16.2	11.9	-	-
	P.puntoni	-	2.5	-	-	-	-	-	10.6	28.5	7.9
	P.varioti	-	0.9	-	-	-	-	1.1	-	1.8	1.3

ASPERGILLUS SPECIES ENCOUNTERED IN THE RHIZOSPHERE (R) AND NON - RHIZOSPHERE (NR) DURING GROWTH OF MAIZE SEEDLING (OBAATANPA) IN THE FIELD AT 31°C + 2 FOR 56 DAYS.

Fungal Species	Treatment	% Occurrence in rhizosphere and non-rhizosphere after (days)									
		7		14		28		42		56	
	R NR	R	NR	R	NR	R	NR	R	NR		
Aspergillus flavus	Control	58.1	21.2	42.1	11.3	13.3	1.3	12.7	10.0	10.1	7.9
	P.carneus	29.1	14.2	15.6	9.4	1.7	1.6	7.2	5.9	2.0	-
	P.puntoni	32.4	6.8	17.2	4.2	0.8	25.6	6.2	4.1	0.7	1.9
	P.varioti	11.7	2.8	8.6	-	5.1	0.7	1.7	4.5	0.4	1.7
A fumigatus	Control	2.1	-	-	-	-	-	-	-	-	-
	P.carneus	-	-	-	-	-	-	-	-	-	-
	P.puntoni	0.7	-	0.2	-	-	-	-	-	-	-
	P.varioti	1.1	-	0.8	-	-	-	-	-	-	-
A.niger	Control	61.2	48.1	59.2	53.2	73.4	88.0	17.8	3.2	15.1	17.0
	P.carneus	43.7	15.2	24.6	23.2	4.9	23.5	2.9	6.1	18.1	66.2
	P.puntoni	28.3	10.1	32.1	9.1	11.5	13.9	0.9	6.3	37.1	2.7
	P.varioti	15.1	12.3	17.8	29.3	6.8	31.9	8.5	2.3	15.1	7.3
A.alutaceus (A. ochraceus)	Control	2.2	-	-	1.1	-	0.4	3.4	3.2	8.2	15.1
	P.carneus	0.1	1.2	-	2.1	0.3	3.2	-	0.9	0.8	1.5
	P.puntoni	-	0.1	-	-	-	2.2	3.5	4.8	13.3	6.8
	P.varioti	3.2	0.6	0.8	-	1.1	2.2	0.4	3.2	1.7	2.8
A.sulphureus	Control	2.1	1.2	-	0.9	-	-	-	-	-	-
	P.carneus	-	2.1	-	0.6	-	0.3	-	-	-	-
	P.puntoni	0.8	3.2	-	-	-	-	-	-	-	0.7
	P.varioti	0.2	2.4	-	-	-	-	-	-	-	-
A.tamari	Control	-	-	0.2	-	0.6	-	1.7	0.3	2.6	3.0
	P.carneus	-	-	-	-	0.3	-	0.5	-	-	-
	P.puntoni	-	-	-	-	-	3.3	1.2	1.8	5.7	1.4
	P.varioti	-	-	-	-	-	3.7	0.6	-	-	1.6
A.ustus	Control	2.1	-	3.4	-	-	-	-	-	-	-
	P.carneus	0.8	-	-	-	-	-	-	-	-	-
	P.puntoni	-	-	-	-	-	-	-	-	-	-
	P.varioti	0.6	-	0.4	-	-	-	-	-	-	-
A.versicolor	Control	-	-	-	-	-	-	3.4	-	3.3	6.1
	P.carneus	-	-	-	-	-	-	86.3	88.0	3.8	0.9
	P.puntoni	-	-	-	-	-	-	1.5	4.4	3.8	-
	P.varioti	-	-	-	-	-	-	0.6	4.5	-	1.2

PENICILLIUM SPECIES ENCOUNTERED IN THE RHIZOSPHERE (R) AND NON - RHIZOSPHERE (NR) DURING GROWTH OF MAIZE SEEDLINGS (OBAATANPA) IN THE FIELD AT 31°C + 2 FOR 56 DAYS.

Fungal Species	Treatment	% Occurrence in rhizosphere (R) and Non-rhizosphere after days									
		7		14		28		42		56	
		R	NR	R	NR	R	NR	R	NR	R	NR
Penicillium	Control	-	-	-	-	-	-	-	-	-	-
brevi-	P. carneus	-	-	-	-	-	-	-	-	-	-
compactum	P. puntoni	-	-	-	-	-	-	-	-	-	
	P. varioti	-	-	-	-	-	-	-	-	-	-
P.citrium	Control	15.1	2.1	0.8	-	15.6	-	34.7	67.4	2.0	3.0
	P. carneus	13.2	1.1	2.1	1.8	0.3	3.2	0.2	-	-	5.3
	P. puntoni	11.7	0.8	-	2.1	-	3.9	48.0	64.6	6.8	-
	P. varioti	13.7	0.7	0.9	-	1.7	3.7	91.5	61.7	0.8	2.2
P.digitatum	Control	-	-	-	-	-	-	-	-	-	-
	P. carneus	-	-	-	-	-	-	-	-	-	-
	P. puntoni	-	-	-	-	-	-	-	-	-	-
	P. varioti	-	-	-	-	-	-	-	-	-	-
P.expansum	Control	-	-	-	-	-	-	-	-	-	-
	P. carneus	-	-	-	-	-	-	-	-	-	-
	P. puntoni	-	-	-	-	0.8	-	-	-	-	-
	P. varioti	2.1	-	-	-	-	-	-	-	-	-

OTHER FUNGAL SPECIES ENCOUNTERED IN THE RHIZOSPHERE (R) AND NON - RHIZOSPHERE (NR) DURING GROWTH OF MAIZE SEEDLING (OBAATANPA) IN THE FIELD AT 31°C + 2 FOR . . 56 DAYS.

Fungal Species	Treatment	% Occurrence in rhizosphere (R) and non-rhizosphere after (days)									
		7		14		28		42		56	
	R NR	R	NR	R	NR	R	NR	R	NR		
Cladosporium herbarum	Control	6.3	1.8	2.1	-	3.5	0.9	-	0.3	-	0.7
	P.carneus	1.4	2.1	-	0.7	0.3	0.8	-	-	-	3.4
	P.puntoni	2.1	0.7	1.3	17.9	5.3	47.8	-	-	8.1	23.8
	P.varioti	0.9	-	2.1	-	-	-	-	1.4	-	5.6
Fusarium moniliforme	Control	4.7	-	2.1	1.1	-	1.3	0.8	-	7.1	0.7
	P.carneus	2.3	-	-	0.7	0.6	1.4	-	-	11.3	3.0
	P.puntoni	6.2	-	2.1	5.2	3.1	6.1	-	-	9.5	6.7
	P.varioti	5.8	1.2	27.8	8.1	36.7	11.1	-	-	13.8	25.7
Mucor Sp	Control	1.1	1.2	0.9	1.1	1.2	-	-	-	-	1.3
	P.carneus	2.3	-	-	0.9	-	-	0.5	-	1.5	-
	P.puntoni	0.7	1.2	-	-	-	-	-	-	12.2	3.8
	P.varioti	0.9	0.7	0.7	0.6	-	-	-	-	3.2	1.1
Pullaria pullulans	Control	0.1	-	-	-	-	-	-	-	-	-
	P.carneus	1.2	-	-	-	-	-	-	-	-	-
	P.puntoni	-	-	-	-	-	-	-	-	-	-
	P.varioti	-	-	-	-	-	-	-	-	-	-
Rhizopus oryzae	Control	2.3	5.7	-	0.7	-	-	7.6	1.5	-	-
	P.carneus	1.2	6.2	2.1	8.1	-	-	-	-	-	-
	P.puntoni	1.7	1.6	-	3.2	-	-	-	-	-	-
	P.varioti	2.6	0.7	-	0.1	-	-	-	-	-	-
Rhodotorula Sp	Cnotrol	5.7	0.7	0.7	-	-	-	6.8	1.5	34.8	-
	P.carneus	-	6.2	15.2	8.1	30.5	-	-	-	48.3	-
	P.puntoni	-	1.6	28.4	3.2	63.7	-	59.1	-	-	-
	P.varioti	-	0.7	16.7	0.1	26.0	-	-	4.1	61.5	-
Scopulariopsis brevicaulis	Control	-	-	0.9	-	-	-	-	-	-	-
	P.carneus	-	-	2.1	11.6	-	28.1	-	-	-	-
	P.puntoni	-	-	-	28.1	-	71.1	-	57.1	-	-
	P.varioti	-	-	5.8	37.8	-	76.3	-	15.8	-	-
Trichoderma viride	Control	7.8	-	2.7	-	-	-	6.8	3.2	1.5	2.3
	P.carneus	6.1	-	0.1	0.1	0.3	0.3	0.5	1.4	3.5	2.3
	P.puntoni	2.7	-	-	-	-	3.3	0.9	3.0	8.1	8.6
	P.varioti	5.2	0.7	0.9	0.6	0.6	0.7	0.8	-	2.8	10.1
Yeast	Control	-	-	-	0.2	7.0	-	-	-	3.5	2.0
	P.carneus	-	-	0.9	0.4	-	-	-	-	69.5	6.5
	P.puntoni	1.2	-	0.7	-	-	-	-	-	60.8	48.6
	P.varioti	0.9	-	-	-	-		-	-	54.3	73.7

ASPERGILLUS SPECIES ENCOUNTERED IN THE RHIZOSPHERE (R) AND NON - RHIZOSPHERE (NR) DURING GROWTH OF MAIZE SEEDLING (ABELEEHI) IN THE POTS AT 28°C + 2 FOR 56 DAYS IN THE GREENHOUSE

Fungal Species	Treatment	% Occurrence in rhizosphere and non-rhizosphere after (days)									
		7		14		28		42		56	
		R	NR	R	NR	R	NR	R	NR	R	NR
Aspergillus flavus	Control	58.1	17.1	42.1	10.2	13.3	11.3	12.7	7.9	10.1	9.8
	P.carneus	29.1	15.2	15.6	8.6	1.7	2.5	7.2	6.4	2.0	5.3
	P.puntoni	32.4	7.3	17.2	5.2	0.9	18.7	6.2	6.2	0.7	2.9
	P.varioti	11.7	3.2	8.6	-	5.1	1.1	1.7	3.5	0.4	2.7
A fumigatus	Control	2.1	-	-	-	-	-	-	-	-	-
	P.carneus	-	-	-	-	-	-	-	-	-	-
	P.puntoni	0.7	-	0.4	-	-	-	-	-	-	-
	P.varioti	2.0	-	0.9	-	-	-	-	-	-	-
A.niger	Control	61.2	38.1	59.2	53.2	73.4	64.1	17.8	2.2	15.1	16.0
	P.carneus	43.7	1682	24.6	24.2	9.4	23.4	8.2	5.1	18.1	36.0
	P.puntoni	28.3	10.7	32.1	9.8	11.6	14.5	0.9	6.2	37.2	4.8
	P.varioti	16.1	12.3	17.8	21.4	6.8	31.9	8.5	3.2	15.6	6.8
A.alutaceus (=*A.ochraceus*)	Control	2.2	6.3	-	2.8	-	-	3.4	5.1	8.2	9.8
	P.carneus	0.1	2.6	-	3.2	0.3	2.7	-	-	0.8	0.9
	P.puntoni	-	-	-	-	-	-	3.5	3.6	14.3	12.3
	P.varioti	-	4.2	0.8	0.8	1.1	3.1	0.4	2.1	2.7	2.2
A.sulphureus	Control	2.1	5.6	-	-	-	1.8	-	0.9	-	-
	P.carneus	-	-	-	1.8	-	-	-	0.8	-	2.1
	P.puntoni	0.8	2.8	-	-	-	0.6	-	-	-	
	P.varioti	0.2	1.8	-	2.1	-	-	-	-	-	-
A.tamari	Control	-	2.3	0.3	0.8	0.6	2.1	1.7	3.8	-	4.2
	P.carneus	-	5.1	-	-	0.3	0.8	0.8	1.1	2.6	2.3
	P.puntoni	-	3.4	-	-	-	3.1	1.2	2.8	5.7	0.8
	P.varioti	-	2.1	0.4	-	4.5	2.2	0.6	2.4	-	0.7
A.ustus	Control	-	1.8	-	2.0	-	0.8	-	-	-	-
	P.carneus	-	-	-	-	-	-	-	-	-	-
	P.puntoni	-	-	-	-	-	-	-	-	-	-
	P.varioti	-	-	-	-	-	-	-	-	-	-
A.versicolor	Control	-	-	-	-	-	-	3.6	-	3.1	-
	P.carneus	-	-	-	-	21.2	-	86.3	-	76.2	-
	P.puntoni	-	-	7.0	2.5	1.5	-	2.2	-	3.8	-
	P.varioti	-	7.0	-	6.1	1.8	5.2	0.6	4.8	-	2.8

TABLE 13

PENICILLIUM SPECIES ENCOUNTERED IN THE RHIZOSPHERE (R) AND NON - RHIZOSPHERE (NR) DURING GROWTH OF MAIZE SEEDLINGS (ABELEEHI) IN THE POTS AT 28°C + 2 FOR 56 DAYS IN THE GREENHOUSE.

Fungal Species	Treatment	% Occurrence in rhizosphere (R) and Non-rhizosphere after days									
		7		14		28		42		56	
		R	NR	R	NR	R	NR	R	NR	R	NR
Penicillium	Control	-	-	-	-	-	-	-	-	-	-
brevi-	P. carneus	-	0.8	-	2.0	-	1.1	-	-	-	-
compactum	P. puntoni	-	0.2	0.9	-	-	-	-	-	-	-
	P. varioti	-	-	-	-	-	-	-	-	-	-
P.citrium	Control	15.1	17.1	0.8	0.8	15.6	13.2	34.7	40.2	2.0	2.3
	P. carneus	13.2	14.6	2.1	3.1	0.8	0.3	0.2	0.8	-	-
	P. puntoni	11.7	11.6	-	-	-	-	48.0	38.7	6.8	5.8
	P. varioti	13.7	13.6	0.9	2.5	1.7	1.9	91.5	86.1	1.8	0.8
P.digitatum	Control	-	1.2	-	1.4	-	7.8	-	1.9	-	-
	P. carneus	-	3.1	-	18.1	-	3.4	-	0.8	-	-
	P. puntoni	-	3.1	-	-	-	2.1	-	1.2	-	1.7
	P. varioti	-	12.1	-	-	-	3.4	-	-	-	-
P.expansum	Control	-	5.3	-	2.1	-	-	-	-	-	-
	P. carneus	-	2.8	-	0.7	-	-	-	-	-	-
	P. puntoni	-	1.8	-	1.2	1.8	-	0.8	-	-	-
	P. varioti	2.1	2.7	-	1.4	-	-	-	-	-	-

OTHER FUNGAL SPECIES ENCOUNTERED IN THE RHIZOSPHERE(R) AND NON - RHIZOSPHERE (NR) DURING GROWTH OF MAIZE SEEDLING (ABELEEHI) IN POTS AT 28°C ± 2 FOR 56 DAYS IN THE GREENHOUSE.

Fungal Species	Treatment	% Occurrence in rhizosphere (R) and non-rhizosphere after (days)									
		7		14		28		42		56	
		R	NR	R	NR	R	NR	R	NR	R	NR
Cladosporium herbarum	Control	6.3	2.8	2.1	–	3.5	0.9	–	0.3	–	0.7
	P.carneus	1.4	2.1	–	0.7	0.3	0.8	–	–	–	3.4
	P.puntoni	2.1	0.7	1.3	0.9	5.3	47.6	–	–	–	23.8
	P.varioti	0.9	–	2.1	–	0.8	–	–	1.4	–	5.6
Fusarium moniliforme	Control	4.7	–	2.1	1.1	–	1.4	–	1.7	7.1	0.1
	P.carneus	2.3	–	–	0.7	0.6	1.6	–	–	11.3	3.0
	P.puntoni	6.2	–	2.1	5.2	3.1	5.6	–	–	9.5	6.7
	P.varioti	5.8	–	27.8	8.1	36.7	10.6	–	–	13.8	25.1
Mucor SP	Control	1.1	1.2	0.9	1.0	1.2	–	–	–	–	1.3
	P.carneus	2.3	–	–	0.9	–	–	0.5	–	1.5	–
	P.puntoni	0.7	1.4	–	–	–	–	–	–	12.2	3.8
	P.varioti	0.9	0.7	0.7	0.7	–	–	–	–	3.2	2.1
Pullaria pullulans	Control	0.1	–	–	–	–	–	–	–	–	–
	P.carneus	1.2	–	–	–	–	–	–	–	–	–
	P.puntoni	–	–	–	–	–	–	–	–	–	–
	P.varioti	–	–	–	–	–	–	–	–	–	–
Rhizopus oryzae	Control	2.3	5.7	–	0.8	–	–	7.6	1.5	–	–
	P.carneus	1.2	6.2	2.1	8.4	–	–	–	–	–	–
	P.puntoni	1.7	1.6	–	3.2	–	–	–	–	–	–
	P.varioti	2.6	0.7	0.1	0.1	–	–	1.4	4.1	–	–
Rhodoturula SP	Control	–	–	0.7	–	–	–	6.8	–	–	16.1
	P.carneus	–	–	15.2	11.6	30.5	28.1	–	–	48.3	66.5
	P.puntoni	–	–	28.6	28.1	63.7	71.1	59.1	57.1	–	61.5
	P.varioti	–	–	16.7	37.8	26.0	76.3	–	15.8	61.5	60.9
Scopulariopsis	Control	–	–	1.1	–	–	–	–	–	–	–
	P.carneus	–	–	2.4	–	–	–	–	–	–	–
	P.puntoni	–	–	–	–	–	–	–	–	–	–
	P.varioti	–	–	7.8	7.8	–	5.8	6.8	3.2	1.5	2.3
Trichoderma viride	Control	7.8	–	2.7	–	–	–	0.5	1.4	3.5	3.2
	P.carneus	6.1	–	0.1	0.1	0.3	0.7	0.9	3.0	8.1	8.6
	P.puntoni	2.7	–	–	–	–	3.3	0.8	–	2.8	10.1
	P.varioti	5.2	0.7	0.9	0.6	0.6	0.7	–	–	3.5	2.0
Yeast	Control	–	–	–	0.2	7.0	–	–	–	69.5	6.7
	P.carneus	–	–	0.9	0.4	–	–	–	–	60.8	48.6
	P.puntoni	1.2	–	0.7	–	–	–	–	–	54.7	73.7
	P.varioti	0.9	–	–	–	–	–				

ASPERGILLUS SPECIES ENCOUNTERED IN THE RHIZOSPHERE (R) AND NON - RHIZOSPHERE (NR) DURING GROWTH OF MAIZE SEEDLING (OBAATANPA) IN THE POTS AT 28°C + 2 FOR 56 DAYS IN THE GREENHOUSE

Fungal Species	Treatment	% Occurrence in rhizosphere and non-rhizosphere after (days)									
		7		14		28		42		56	
		R	NR	R	NR	R	NR	R	NR	R	NR
Aspergillus flavus	Control	47.2	34.1	34.2	43.1	16.7	15.3	13.2	18.8	17.2	17.1
	P.carneus	32.1	21.1	18.2	6.5	10.2	2.7	7.8	7.4	4.0	3.0
	P.puntoni	23.8	23.6	17.5	17.8	2.8	1.8	7.2	7.6	0.9	1.8
	P.varioti	21.7	10.7	9.2	9.2	6.5	6.3	2.7	2.3	1.4	1.2
A fumigatus	Control	5.1	3.1	2.1	-	0.8	-	-	-	-	-
	P.carneus	0.8	-	-	-	-	-	-	-	-	-
	P.puntoni	1.7	2.1	1.2	0.8	0.8	-	-	-	-	-
	P.varioti	1.8	1.8	0.9	1.2	0.8	-	-	-	-	-
A.niger	Control	58.2	61.2	42.1	59.2	48.1	73.4	18.2	17.8	16.1	18.1
	P.carneus	48.2	43.7	34.2	24.6	10.2	4.9	1.8	3.1	19.1	18.0
	P.puntoni	32.1	28.3	23.1	34.1	11.6	11.8	0.9	0.9	43.2	32.1
	P.varioti	13.2	15.2	13.8	17.8	7.2	6.4	9.0	8.5	13.1	15.1
A.alutaceus	Control	-	3.6	1.8	2.1	-	-	4.1	4.6	7.3	10.2
(=*A.ochraceus*	P.carneus	-	0.8	2.1	-	0.7	0.7	-	-	1.8	0.8
	P.puntoni	-	-	-	3.2	0.9	-	-	3.5	14.3	16.3
	P.varioti	-	3.2	1.7	0.8	2.1	2.1	0.1	0.8	2.7	2.2
A.sulphureus	Control	3.2	4.2	2.1	-	0.8	-	-	-	-	-
	P.carneus	0.7	-	-	-	-	-	-	-	-	-
	P.puntoni	-	0.8	0.8	-	-	-	-	-	-	-
	P.varioti	0.2	1.8	-	0.4	-	-	-	-	-	-
A.tamari	Control	1.7	-	2.6	0.2	2.8	0.8	1.2	2.8	-	2.6
	P.carneus	0.3	-	1.4	-	-	0.3	-	0.5	-	-
	P.puntoni	-	-	-	-	3.1	-	2.1	1.2	-	0.7
	P.varioti	-	-	-	0.4	2.8	4.5	1.7	0.6	-	-
A.ustus	Control	-	-	-	-	0.8	-	1.7	-	-	-
	P.carneus	-	-	-	-	1.2	-	2.1	-	2.6	-
	P.puntoni	-	-	0.8	-	0.2	-	-	-	-	-
	P.varioti	-	-	-	-	-	-	-	-	-	-
A.versicolor	Control	-	-	-	-	-	-	3.7	2.4	3.4	3.9
	P.carneus	-	-	-	-	11.2	-	46.2	7.2	15.2	3.3
	P.puntoni	0.9	-	1.1	-	4.6	-	3.8	1.5	5.2	3.8
	P.varioti	-	-	-	-	6.1	-	7.1	0.6	-	-

PENICILLIUM SPECIES ENCOUNTERED IN THE RHIZOSPHERE (R) AND NON - RHIZOSPHERE (NR) DURING GROWTH OF MAIZE SEEDLINGS (OBAATANPA) IN THE POTS AT 28°C + 2 FOR 56 DAYS IN THE GREENHOUSE.

Fungal Species	Treatment	% Occurrence in rhizosphere (R) and Non-rhizosphere after days									
		7		14		28		42		56	
		R	NR	R	NR	R	NR	R	NR	R	NR
Penicillium	Control	1.2	-	0.8	-	-	-	-	-	-	-
brevi-	P. carneus	-	1.8	-	1.1	-	-	-	-	-	-
compactum	P. puntoni	-	0.4	-	0.9	-	-		-	-	0.4
	P. varioti	-	-	-	-	-	-	-	-	-	-
P.citrium	Control	11.4	48.2	2.8	2.9	16.5	2.3	24.6	6.8	12.1	0.9
	P. carneus	14.8	31.4	4.1	1.3	1.8	6.0	1.2	1.8	-	1.8
	P. puntoni	18.7	15.2	12.1	69.3	2.8	7.8	38.4	1.9	16.7	-
	P. varioti	12.8	12.3	1.1	17.4	2.7	6.3	81.2	1.6	2.1	-
P.digitatum	Control	1.8	3.2	0.9	23.8	0.7	-	-	-	-	-
	P. carneus	1.1	5.0	-	23.8	-	-	-	-	-	-
	P. puntoni	-	15.6	2.1	-	-	-	-	-	-	-
	P. varioti	-	21.0	-	-	-	-	-	-	-	-
P.expansum	Control	-	3.2	-	13.2	-	-	-	2.1	-	0.8
	P. carneus	-	1.8	-	14.8	-	-	-	0.2	-	-
	P. puntoni	-	1.8	-	1.2	1.8	-	-	1.6	-	-
	P. varioti	2.1	2.7	-	1.4	-	-	-	-	-	-

OTHER FUNGAL SPECIES ENCOUNTERED IN THE RHIZOSPHERE (R) AND NON - RHIZOSPHERE (NR) DURING GROWTH OF MAIZE SEEDLING (OBAATANPA) IN THE POTS AT 28°C + 2 FOR 56 DAYS IN THE GREENHOUSE.

Fungal Species	Treatment	% Occurrence in rhizosphere (R) and non-rhizosphere after (days)									
		7		14		28		42		56	
		R	NR	R	NR	R	NR	R	NR	R	NR
Cladosporium herbarum	Control	7.4	4.8	3.2	5.8	3.5	2.1	2.1	2.3	0.8	3.2
	P.carneus	2.2	3.1	0.8	2.7	-	1.8	-	1.3	-	5.4
	P.puntoni	3.2	2.1	0.3	1.2	4.2	21.1	-	15.1	-	23.8
	P.varioti	-	0.8	-	1.9	0.8	1.1	-	1.7	-	6.5
Fusarium moniliforme	Control	5.2	2.6	3.2	2.4	0.8	2.8	-	8.1	-	3.2
	P.carneus	3.2	-	2.1	0.8	0.7	3.4	-	-	11.3	5.1
	P.puntoni	2.6	-	4.2	4.2	4.8	6.4	3.2	-	8.4	23.8
	P.varioti	4.8	-	7.8	9.8	27.8	10.2	-	2.8	31.8	1.5
Mucor SP	Control	2.4	2.1	1.1	4.1	1.4	7.8	-	8.9	-	12.4
	P.carneus	6.4	5.6	-	3.9	0.8	-	1.5	-	2.1	-
	P.puntoni	1.7	1.8	-	-	-	-	8.2	-	6.4	-
	P.varioti	1.8	3.1	0.8	0.7	-	0.9	-	-	4.2	-
Pullularia pullulans	Control	0.8	1.8	2.1	1.2	-	-	-	-	-	-
	P.carneus	2.1	0.4	0.8	-	-	-	-	-	-	-
	P.puntoni	-	-	-	0.6	-	-	-	-	-	-
	P.varioti	-	0.8	-	1.1	-	-	-	-	-	-
Rhizopus oryzae	Control	5.2	7.5	3.2	1.4	6.3	0.6	2.1	-	0.8	-
	P.carneus	1.4	6.2	3.1	4.8	0.8	-	0.9	-	-	-
	P.puntoni	1.6	1.6	-	2.3	0.6	-	-	-	-	-
	P.varioti	2.1	0.8	0.9	0.2	-	5.1	-	-	-	-
Rhodoturula SP	Control	6.0	-	1.7	-	2.2	-	27.1	-	28.9	21.2
	P.carneus	-	-	14.3	10.7	23.8	27.1	15.1	15.2	32.4	48.2
	P.puntoni	-	-	32.6	15.1	36.7	52.1	53.2	63.2	-	71.1
	P.varioti	-	-	17.8	28.4	32.1	76.1	21.1	28.5	67.2	69.1
Scopulariopsis	Control	3.2	0.8	1.2	1.8	1.0	1.1	-	-	-	-
	P.carneus	1.8	-	3.2	2.2	0.8	1.8	-	-	-	-
	P.puntoni	-	-	0.9	-	1.1	-	-	-	-	-
	P.varioti	-	-	6.8	-	5.1	-	-	-	-	-
Trichoderma viride	Control	6.7	7.1	3.1	-	2.1	-	-	2.3	-	1.8
	P.carneus	5.1	-	0.9	2.1	0.3	4.2	-	1.3	-	0.7
	P.puntoni	3.4	-	-	0.9	1.2	-	-	1.1	-	-
	P.varioti	6.2	0.8	0.8	-	2.2	7.1	-	0.9	-	-
Yeast	Control	-	-	-	-	0.8	9.0	-	1.1	3.7	-
	P.carneus	-	-	1.2	5.1	-	-	0.7	-	52.4	7.6
	P.puntoni	1.2	2.1	0.7	-	-	-	-	-	50.1	63.1
	P.varioti	1.9	-	-	1.2	-	2.8	-	15.8	62.1	58.2

TABLE 18

FUNGAL SPECIES ISOLATED FROM THE RHIZOSPHERE AND NON-RHIZOSPHERE REGIONS OF MAIZE SEEDLINGS (ABELEEHI) GROWING IN POTS AT 28°C ± 2 FOR 56 DAYS IN THE GREENHOUSE

FUNGAL SPECIES	REGIONS	
	RHZOSPHERE	NON-RHIZOSPHERE
Aspergillus flavus	+	+
Aspergillus fumigatus	+	-
Aspergillus niger	+	+
Aspergillus alutaceus(A. ochraceus)	+	+
Aspergillus sulphureus	+	-
Aspergillus tamarii	+	+
Aspergillus ustus	+	+
Aspergillus versicolor	+	+
Cladosporium herbarum	+	+
Fusarium moniliforme	+	+
Mucor Sp	+	+
Penicillium brevi-compactum	-	-
Penicillium citrinum	+	+
Penicillium digitatum	+	+
Penicillium expansum	+	-
Pullularia pullulans	-	-
Rhizopus oryzae	+	-
Rhodoturula Sp	+	+
Scorpulariopsis	+	+
Sterile mycelium	+	-
Trichoderma Viride	+	-
Yeast	+	+
		+
TOTAL	20	15

+ = PRESENT
- = ABSENT

TABLE 19

FUNGAL SPECIES ISOLATED FROM THE RHIZOSPHERE AND NON-RHIZOSPHERE REGIONS OF MAIZE SEEDLINGS (OBAATANPA) GROWING IN POTS AT 28°C + 2 FOR 56 DAYS IN THE GREENHOUSE

FUNGAL SPECIES	REGIONS	
	RHZOSPHERE	NON-RHIZOSPHERE
Aspergillus flavus	+	
Aspergillus fumigatus	+	+
Aspergillus niger	+	-
Aspergillus alutaceus(A. ochraceus)	+	+
Aspergillus sulphureus	+	-
Aspergillus tamarii	+	-
Aspergillus ustus	+	-
Aspergillus versicolor	-	+
Cladosporium herbarum	+	+
Fusarium moniliforme	+	+
Mucor Sp	+	+
Penicillium brevi-copactum	-	+
Penicillium citrinum	+	-
Penicillium digitatum	+	+
Penicillium expansum	+	+
Pullularia pullulans	-	+
Rhizopus oryzae	+	+
Rhodoturula Sp	+	+
Scorpulariopsis	+	+
Sterile mycelium	+	-
Trichoderma Viride	+	-
Yeast	+	+
		+
		+
TOTAL	19	16

+ = PRESENT

- = ABSENT

TABLE 20

FUNGAL SPECIES ISOLATED FROM THE RHIZOSPHERE AND NON-RHIZOSPHERE REGIONS OF MAIZE SEEDLINGS (OBAATANPA) GROWING IN THE FIELD AT 31°C + 2 FOR 56 DAYS

FUNGAL SPECIES	REGIONS	
	RHZOSPHERE	NON-RHIZOSPHERE
Aspergillus flavus	+	+
Aspergillus fumigatus	+	+
Aspergillus niger	+	+
Aspergillus alutaceus(A. ochraceus)	+	+
Aspergillus sulphureus	+	-
Aspergillus tamarii	+	+
Aspergillus ustus	+	-
Aspergillus versicolor	+	+
Cladosporium herbarum	+	+
Fusarium moniliforme	+	+
Mucor Sp	+	+
Penicillium brevi-compactum	+	-
Penicillium citrinum	+	+
Penicillium digitatum	+	+
Penicillium expansum	+	+
Pullularia pullulans	-	-
Rhizopus oryzae	+	+
Rhodoturula Sp	+	+
Scorpulariopsis	+	-
Sterile mycelium	+	+
Trichoderma viride	+	+
Yeast	+	+
		-
TOTAL	21	17

+ = PRESENT

- = ABSENT

TABLE 21

FUNGAL SPECIES ISOLATED FROM THE RHIZOSPHERE AND NON-RHIZOSPHERE REGIONS OF MAIZE SEEDLINGS
(ABELEEHI) GROWING IN THE FIELD AT 31°C + 2 FOR 56 DAYS IN THE GREENHOUSE

FUNGAL SPECIES	REGIONS	
	RHZOSPHERE	NON-RHIZOSPHERE
Aspergillus flavus	+	+
Aspergillus fumigatus	+	+
Aspergillus niger	+	+
Aspergillus alutaceus(A. ochraceus)	+	+
Aspergillus sulphureus	+	+
Aspergillus tamarii	+	+
Aspergillus ustus	-	-
Aspergillus versicolor	+	+
Cladosporium herbarum	+	+
Fusarium moniliforme	+	+
Mucor SP	+	+
Penicillium brevi-copactum	-	+
Penicillium citrinum	+	+
Penicillium digitatum	+	+
Penicillium expansum	+	+
Pullularia pullulans	+	+
Rhizopus oryzae	+	-
Rhodoturula SP	+	-
Scorpulariopsis	+	+
Sterile mycelium	+	-
Trichoderma Viride	+	+
Yeast	+	+
		+
TOTAL	20	18

+ = PRESENT

- = ABSENT

K. Preliminary Studies on the Root Anatomy of Maize Seedling (Abeleehi and Obaatanpa Varieties) Growing under the Influence of *Paecilomyces* species

Plates 15 a, b, and 16a, b show the effect of the metabolites on the anatomy of maize seedlings. The root of the untreated seedlings (control) was 2-3 times wider in diameter than those seedlings exposed to the metabolites of *P. carneus, P. puntoni* and *P. varioti*. However, the endodermis and pericycle were clearly formed and demarcated in both the treated and the untreated (control) samples. The pith parenchyma was sclerified and 2-3 times narrower in diameter in the treated plants exposed to the metabolites of the *Paecilomyces* spp; the proto- and metaxylem vessels were about 2 times wider in the control plants. The phloem and xylem regions of the root were thus reduced in number and size.

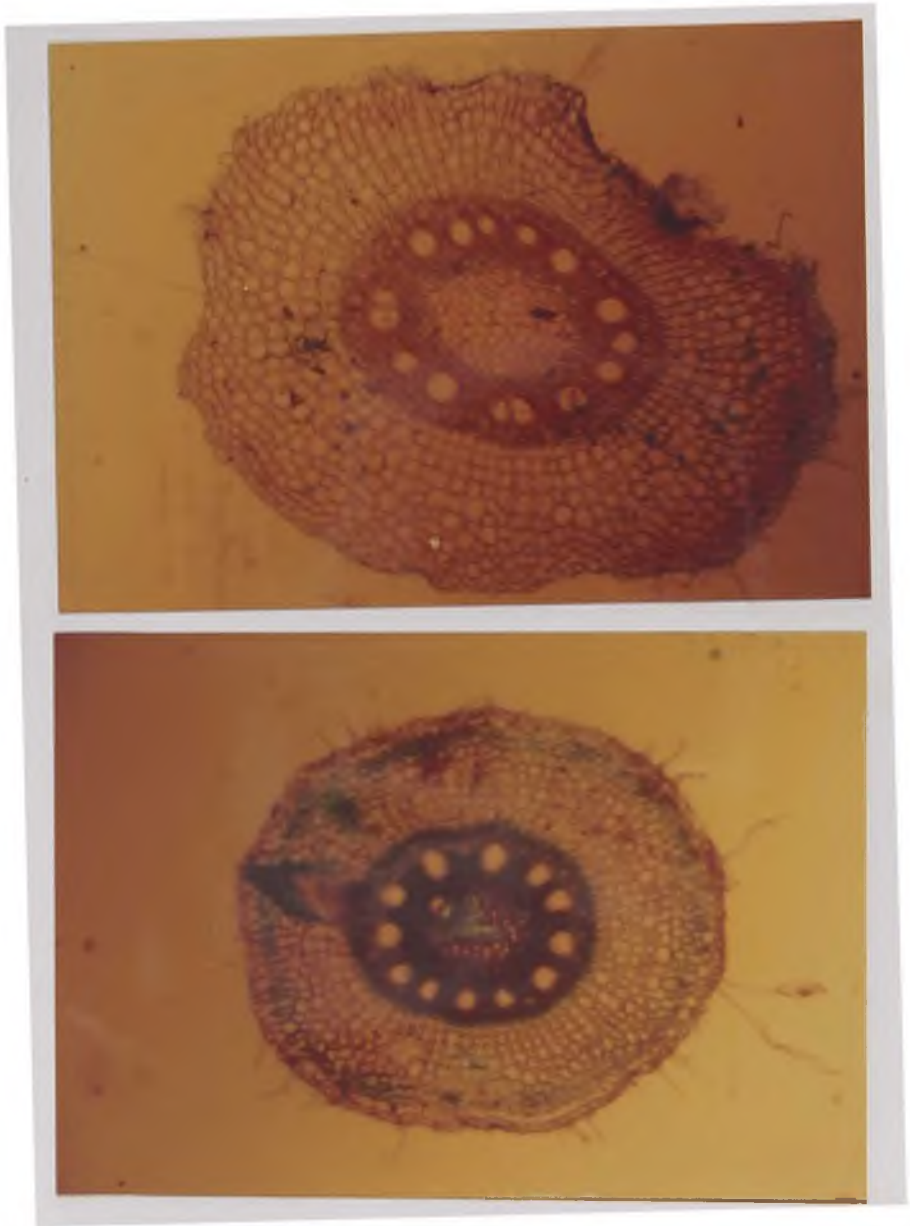

Plate 15a&b Transverse section of roots of 'Abeleehi' seedlings
Top: Untreated (Control)
Bottom: Treated with 4 days old culture metabolites of *P. varioti* growing in pots in the greenhouse. (X 400)

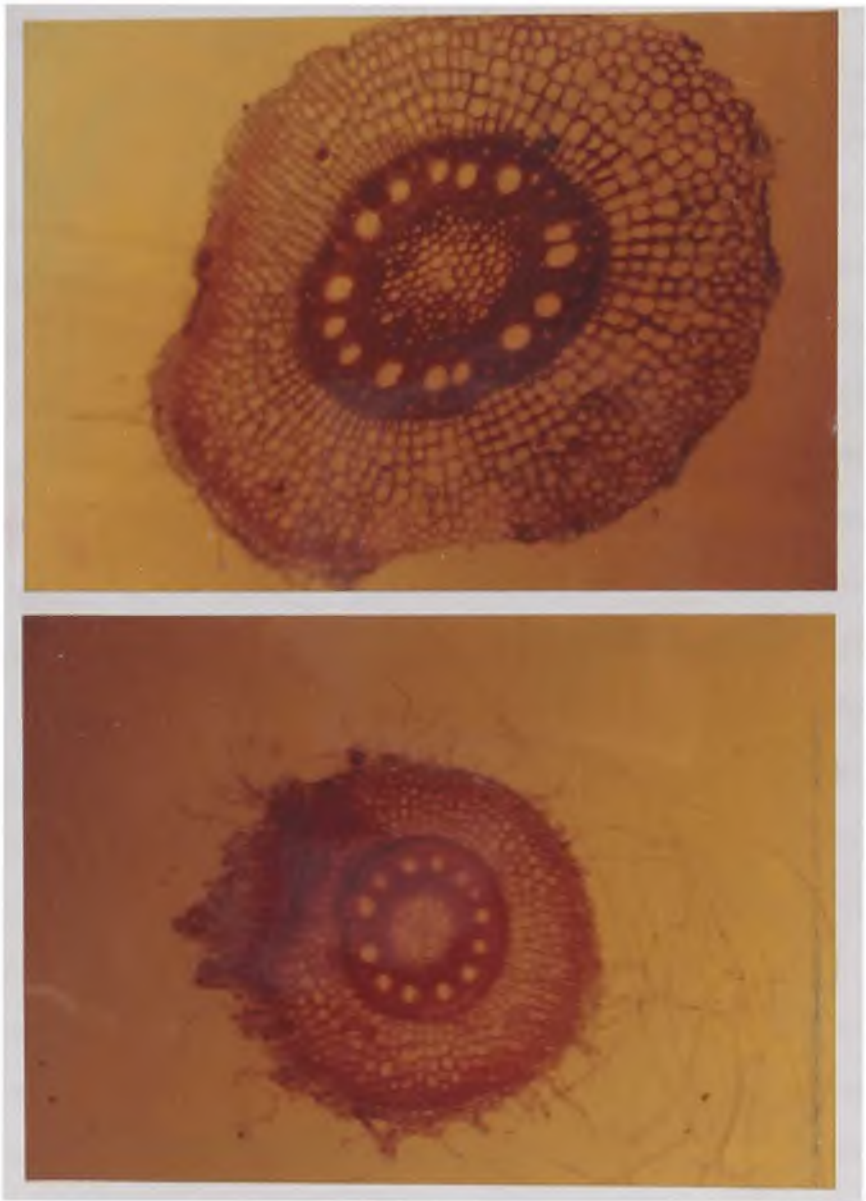

Plate 16a&b Transverse section of roots of 'Obaatanpa' seedlings
Top: Untreated (Control)
Bottom: Treated with 4 days old culture metabolites of *P. carneus* growing in pots in the greenhouse. (X 400)

GENERAL DISCUSSION

It is two hundred and forty years ago when Tillet (1755) followed by other workers established that *Tilletia caries*, the fungus responsible for causing bunt or covered smut of wheat is seed-borne. For more than one hundred years the smuts remained as the sole demonstrable example of seed-borne fungal pathogens. Since then and particularly during the first half of twentieth century, knowledge of seed-borne diseases of crops has greatly increased and there is hardly any cultivated crop where at least one seed-borne fungal pathogen is not known (Malone and Musket, 1964). The extent of their occurrence and some idea of the damage they cause have been compiled by Orton (1931) Noble, De Tempe and Neergaard (1958) and Neergaard (1983). The reasons for this increased interest in seed-borne disease is due not only to technological advances which have made more detailed investigational work possible but also the increased attempt by man to cultivate new species and varieties of crops more suited to his needs. Man has to introduce new species and varieties into territories where they are not indigenious, to grow the same crop over wide areas to facilitate its hauling and harvesting of the produce and to produce maximum yields by intensive crop husbandry. All these factors have contributed to the incidence and spread of seed-borne disease and the growing need for the further investigation and control of seed-borne pathogens.

The Crops Research Institute of the Council for Scientific and Industrial Research, CSIR has through the Grains and Legumes Improvement Programme, developed high lysine content maize grains including Abeleehi, Obaatanpa, Okomasa, Dobidi, to mention but a few which are being sold to the local farmers. However, there is hardly any information on the mycoflora

associated with these grains which have to be stored for prolonged periods as seeds grains for the next planting seasons, This thesis is an attempt to document the mycoflora associated with Abeleehi and Obaatanpa and show their pathological effect on the crop under greenhouse and field conditions. Many forms of fungi, bacteria, viruses and insects may be carried on or in seeds and of these, fungal species are perhaps predominant.

To survive in seed/grain, most fungi must be able to survive dehydration, yet there are two ecologically distinct groups of fungi forming a contrast regarding survival and longevity in seed: hydrophilic fungi - those unable to produce resting spores, oospores or those doing so sparsely thus being dependent on a constant humid environment ($\geq$ 85% ERH) and xerophilic fungi - those fungi which are characteristically capable of producing xerotolerant propagules, often abundant, such as chlamydospores, drought - resistant conidia or other dormant structures, including dormant mycelium, sclerotia and microsclerotia (Neergaard, 1983). Most xerotolerant conidia become quiescent if the Environmental Relative Humidity remains too low for germination usually below 80% ERH.

Seed-borne fungi isolated from Abeleehi and Obaatanpa maize varieties are being recorded for the first time in these varieties in Ghana (Table 1). *Aspergillus* species (12) predominated over the other species encountered followed by *Penicillium* (9). The species diversity was influenced by grain variety and the ERH at which the grains were incubated. Xerotolerant species like *A. flavus, A. giganteus, A. alutaceus, (= A. ochraceus) and A. fumigatus* were isolated. *A. flavus* was ubiquitous and was encountered in both Abeleehi and Obaatanpa stored at ERH's 55-95%. *Aspergillus* species are common contaminants of various

substrates in subtropical and tropical regions where their occurrence is more common than the Penicillia (Neergaard, 1983; Samson and van Reenen - Hoekstra 1988). *Fusarium moniliforme* was isolated from the grains at 65-95% ERH. It behaves both like a hydrophilic and xerophilic fungus occurring in tropics and subtropics (rarely in temperate zones in Europe except for the green house) in maize, rice, sugarcane, banana, asparagus and cotton (Samson and Van Reenen - Hoekstra, 1988). Xerophilic species of *Paecilomyces* (*P. carneus, P. puntoni, P. varioti*) were isolated at ERH's 55-65% in both maize grains varieties. *Paecilomyces* species are dominant in cereals stored in airtight condition at low ERH's. *P. varioti* is a common contaminant in substrates from higher temperatures. The species is thermophilic growing even at 50^{0}C (Samson and Van Reenen Hoekstra, 1988). The local isolates of *P. varioti* grew best at 30-35^{0}C (Fig. 2) but could still thrive at 40^{0}C. The optimum growth for *P. puntoni* was between 35-40^{0}C (Fig. 2), *P. carneus* grew at 30 - 35^{0}C (Fig. 1).

The striking feature of the local isolation of *Paecilomyces* species is that they continue to thrive even at 40^{0}C. The optimum temperature for growth of *Paecilomyces* species isolated elsewhere is close to what obtained for the Ghanaian species. For instance *P. niveus* Stock and Samson has an optimum temperature 30-35^{0}C, minimum about 10^{0}C, maximum 40^{0}C. *P. fulvus* Stolk and Samson optimum 30-35^{0}C, minimum about 10^{0}C, maximum 45^{0}C (Samson, 1974; Samson and Van Reenen - Hoekstra, 1988).

The *Aspergillus* species (*A. flavus, A. giganteus, A. alutaceus (A. ochraceus*) studied in chapter C grew best at 30-35^{0}C (Figs. 4-6). In heated grains such as obtained in Stackburned grains, *Paecilomyces* species and other thermophilic species encountered are likely to thrive and play a role in deterioration even under quiescent conditions in heated grains. Stackburn is the

term used to describe maize grains stored in woven polypropylene sacks stacked in the warehouse which experience heated conditions of about 40^0C for up to 5 months and consequently become discoloured turning from white to varying shades of brown in the testa and the germ region. These grains are subsequently downgraded and disposed of cheaply - this constitutes a loss to the farmer and the Warehousing agent. The interactions between fungi, insects and the physiological state of the grain during the heating in woven polypropylene bags storage is the subject of investigation reported elsewhere (ECDXII Maize Stackburn Project Report, 1994; 1995).

However, findings in this thesis (Chapt E-K) point to another important role *Paecilomyces* species, *F. moniliforme, A alutaceus* (= *A. ochraceus*) and *Penicillium digitatum* may play as seed-borne pathogen during storage of the newly developed maize varieties Abeleehi and Obaatanpa earmarked as seed maize for the next growing season.

The inhibitory active ingredients in the metabolites of the three *Paecilomyces* species, *A. alutaceus* (= *A. ochraceus*), *F. moniliforme* and *Pencillium digitatum* were formed in 2 days on the various media used. The difference in shift of pH during vegetative growth of these fungal species in culture may reflect the varying chemical composition of metabolites of the fungal species. These metabolites when undiluted depressed seed germination of Abeleehi and Obaatanpa by 10-80% and drastically reduced by ($\geq$ 45-85%) length of the emerging radicles (Figs. 17-19) Tables 2&3). The maize varietal differences in response to germination and radicle development in the presence of the metabolites 'in vitro' could be attributed to the intrinsic genotypic differences in the seeds and also the possible variation in the composition of the metabolites from the three *Paecilomyces* species as well as that from *A. alutaceus* (= *A.*

ochraceus), *F. moniliforme* and *Penicillium digitatum*. Genotypic difference in plants accounted for the quantitative differences in the rhizosphere microflora of maize and cowpea (Dua - Yentumi and Ahiabor, 1992).

Paecilomyces varioti produces patulin (Frisvad, 1988) but the nature of the mycotoxins from *P. carneus, P. puntoni* have not been clearly elucidated to date. *Fusarium moniliforme* is one of the most prevalent fungi associated with maize, a basic human and animal dietary staple (Marasas et al, 1984). Experimental studies in South Africa (Marasas et al, 1984) and in China (Li and Cheng, 1984; Lin and Tang, 1980, Yang, 1980) have shown that cultures of *F. moniliforme* on maize and maize products can cause cancer in rats; the hepatocarcinogen(s) produce by one strain can survive drying of the maize at 45-50^{0}C for 24h (Marasas et al, 1984). Furthermore, at least two classes of mutagens are formed by *F. moniliforme* namely Fusarin C (Wiebe and Bjeldanes, 1981; Gelderblom et al, 1983) and Moniliformin (Cole et al 1973; Rabie et al, 1982; Scott et al. 1986). Fusaric acid is a phytoxic compound (Marasas et al, 1984 a,b) and Fusariocins A and C (Arai and Ito, 1970) have also been isolated from the metabolites *F. moniliforme*. These compounds if present in the metabolites might have acted in concert to depress seed germination and radicle development of maize seedlings.

The toxicity of *F. moniliforme* to animals and human acting as a hepatocarcinogen has been known for sometime now. Thus the danger to human and animal health of *F. moniliforme*-infected maize is self evident (Marasas, 1986). Furthermore, it is well established that *F. moniliforme* can be internally seed-borne in symptomless apparently healthy maize kernels, (Foley, 1962; Marasas et al, 1979; Thomas and Buddenhagen, 1980). *Aspergillus ochraceus* (= *A. alutaceus*) forms ochratoxin A in maize (Frisvad, 1988) as well as other mycotoxins such

as emodin, kojic acid, neospergillic acids, penicillic acid secalonic acid *A. Viomellenin* and *Xanthomegnin* (Frisvad, 1988). *Penicillium digitatum* forms patulin in culture. These metabolites might have played a role in the depression of germination and development of maize seedlings. Apart from the pathological implication of the effect of the metabolites on maize plant growth and development, many other fungal flora encountered in Abeleehi and Obaatanpa produce mycotoxins in foods (Table 22) and may have serious public health implication if ingested by the consumers.

Although detailed analyses of mycotoxins production in the two maize varieties studied fall outside the scope of this thesis, it is imperative that future investigations are carried out to quantify production of potent mycotoxins such as aflatoxins (*A. flavus*), cyclopiazonic acid (*A. tamari*) *ochratoxin* and *Penicillic* acid (*A. alutaceus* = *A. ochraceus*), patulin (*Paecilomyces* species) to mention but a few in maize stored for prolonged period for human and animal consumption.

The culture filtrates of the three *Paecilomyces* species similarly depressed germination and radicle development of two tomato varieties (vars. Owusu-Bio and Wosowoso) and pepper (*Capsicum annuum*, L. Var Legon 18). Metabolites of non-pathogenic fungi have been found to have adverse or beneficial effect on plants. Important observations include suppression on seed germination (Leelavathy, $1969_{a,b}$; Narain and Prakash, 1968; Odamtten and Clerk, 1985, 1988), malformation and retardation of growth of seedlings (Bowen and Rovira 1961; Curtis, 1958a,b; Odamtten and Clerk 1985) and root growth promoters (Kimura et al, 1992 a,b). Observations in this thesis extends the list of fungi whose metabolites have adverse effect on seed germination and radicle development of maize, pepper and tomato which are of economic importance in this country.

TABLE 22

POTENTIAL PRODUCTION OF MYCOTOXINS BY FOOD-BORNE FILAMENTOUS FUNGI IN MAIZE (ABELEEHI AND OBAATANPA) IN GHANA LISTED IN TABLE 1

FUNGAL SPECIES	MYCOTOXINS
Aspergillus candidus	Candidulin, terphenyllin, Xanthoascin.
Aspergillus alutaceus (*A. ochraceus*)	Emodin, Kojic acid, neospergillic acids, Ochratoxins penicillic acid, secalonic acid A, viomellein, Xanthomegnin.
Aspergillus flavus	Aflatoxins, aflatrem, aflavinin. aspergillic acids, cyclopiozonic acid, 3-nitropropionic acid, paspalinin.
Aspergillus fumigatus	Fumigaclavines, fumigallin, fumigatin, fumitoxins, fumitremorgins, gliotoxin, kojic acid, spinulosin
Aspergillus giganteus	Verruculogen, tryptiguivalins?.
Aspergillus niger	Malformins, naphthoquinones, nigragillin, oxalic acid, citric acid, itaconic acid, jawaherene, nigerone, 6-0-dimethyl, flaviolin, aspergillin piperazine-n-cinnamonyl-n-methyl-cis-2,5-dimethyl etc.
Aspergillus tamarii	Cyclopiazonic acid, fumigaclavine A.
Aspergillus terreus	Citreviridin, citrinin, gliotoxin, patulin, terrein, teirreic acid, terretonin, territrems, cytochalasin E, terredionol.
Aspergillus ustus	Austamid, austdiol, austins, austocystins, kojic acid, sterigmatocystin, Xanthocillin X.
Aspergillus versicolor	Nidulotoxin, sterigmatocystin.
Aspergillius wentii	Emodin, kojic avid, 3-nitropropionic acid, wentiliactin, phycocin.

DATA AFTER FRISVAD, (1988) AND NORTHOLT ANS SOENTORO, (1988)

TABLE 22 (CONT'D)

POTENTIAL PRODUCTION OF MYCOTOXINS BY FOOD-BORNE FILAMENTOUS FUNGI IN MAIZE (ABELEEHI AND OBAATANPA) IN GHANA LISTED IN TABLE 1

FUNGAL SPECIES	MYCOTOXINS
Paecilomyces carneus	Unknown
Paecilomyces puntoni	Unknown
Paecilomyces varioti	Patulin
Penicillium brevi-compactum	Brevianamides, mycophenolic acid, botryodiplodin
Penicillium citrinum	Citrinin
Penicillium digitatum	Patulin?
Penicillium expansum	Patulin, citrinin, roquefortine C
Penicillium funiculosum	-
Penicillium glabrum	Citromycetin
Penicillium nigricans	-
Penicillium verrucosum	Chemotype I, chratoxin A, Chemetype II, citrinin.
Chaetomium globosum	Chaetoglobosins, chaetomin, cochiodinol, chaetocin.
Cladosporium herbarum	Epi- and fagi- cladosporic acid
Emericella nidulans	Kojic acid, sterigmatocystin
Eurotium spp	Sterigmatocystin, gliotoxin xanthocillin
Fusarium moniforme	Fusarin C, Moniformin, Fusaric acid fusariocins A and C.
Mucor haemalis	Unknown structures
Rhizospus oryzae	Fumaric acid, other unknown structures

DATA AFTER FRISVAD, (1988) AND NORTHOLT ANS SOENTORO, (1988)

Interestingly, the laboratory observations of the inhibitory effect of the fungal metabolites of the three *Paecilomyces* species on Abeleehi and Obaatanpa maize varieties were reproduced in the field (Fig. 23). The height of plants, leaf length and leaf width of the growing seedlings were significantly depressed by the metabolites of *P. carneus, P. puntoni* and *P. varioti*. However, the toxic effect of the same fungal metabolites produced in culture before being used in moistening soil in the greenhouse was marginal. Presumably, the application of the cultural metabolites directly to soil rendered them less potent.

There have been failures in some instances to duplicate in soil admirable results of antagonism tests obtained in culture. The reasons for these failures includes obvious differences between growth of the fungus on agar, liquid culture and in soil. Secondly, the known toxins are either too unstable to persist in soil or if stable, will be rapidly inactivated by adsorption on soil colloids. For example, Entsie (1991) found that *Aspergillus niger* failed to depress vegetation growth of cocoa seedlings in non-sterile native cocoa farm soil in contrast with the severe depression of growth reported by Odamtten and Clerk (1985; 1988) using sterile vermiculite.

In this project however, the severe depression of vegetative growth of maize (Abeleehi and Obaatanpa) by metabolites of *Paecilomyces* species could be reproduced when the seeds were directly inoculated with fungus prior to sowing. For any substances to be effective in nature, it must be long - lived or it must be regenerated as rapidly as it is destroyed (Kuo and Alexander, 1967).

The photosynthetic apparatus of the growing seedlings was also affected (Chapter I). Chlorophyll a and b contents were lower in Abeleehi and Obaatanpa plants growing in the field

and inoculated with *P. carneus* followed by grains treated with *P. puntoni* (Table 5). Plants raised in pots in the greenhouse and moistened with the culture filtrates of *Paecilomyces* species behaved differently although chlorophyll a and b contents of both Abeleehi and Obaatanpa were significantly reduced by *P. puntoni* and *P. varioti*.

The process of photosynthesis occurs in two stages. The first is the light reaction which is that part in which light and chlorophyll a and b are involved. It is during the light reaction that light energy is converted to chemical energy. This chemical energy is used to synthesize carbohydrate from Carbon (IV) oxide in air entering through the stomata during the second part of photosynthesis called 'dark reaction' which does not require light. Therefore, reduction in the chlorophyll a and b content of leaf may presumably affect the efficiency of the light reaction stage of photsynthesis involving the two pigments and subsequently the formation of photosynthates in the dark reactions stage. This presumably explains the variable adverse effects of the metabolites of especially *P. carneus* and *P. puntoni* on vegetative growth and dry matter accumulation by the shoot and root systems of Abeleehi and Obaatanpa maize varieties in the field (Figs 23-25 and Table 5).

Culture filtrate of the three *Paecilomyces* species affected the root system of Abeleehi and Obaatanpa in various ways. The root of maize seedlings growing in the field were thinner with reduced width of pith anf parenchyma tissue; narrower proto - and metaxylem and phloem cells were seen (plates 15 a, b to 16a b). This could adversly affect rate and efficiency of translocation of nutrients and photosynthates to and from the roots.

A fortituous condition is thus created in which the cultural metabolites from *Paecilomyces* species depress seed germination, reduce radicle development; decrease chlorophyll a and b

contents of leaf, and depress total dry matter accumulation by shoot and root systems of the seedlings. Consequently, there was reduction in yield of the treated seedlings resulting in smaller and narrower cobs with fewer grains as compared to the control (Plates 13&14). It will be interesting in future experiments to elucidate the differences in the composition of the metabolites produced by the *Paecilomyces* species and their specific effect on the photosynthetic apparatus of the developing maize seedlings. This thesis has provided evidence of the potential risk of long-term storage of maize seeds infected with *Paecilomyces* species and also provides data which could assist in formulating policies for safe long-term storage of Abeleehi and Obaatanpa. Indeed, studies in this laboratory (Hackman, 1995) have also provided evidence of the potential use of two local plants *Zanthoxylum xanthoxyloides* and *Kigelia africana* for biocontrol of *Paecilomyces* species, *F. moniliforme* and *P. digitatum* contaminating Abeleehi and Obaatanpa maize seed. There remains further work to formulate appropriate field application techniques to effect the control obtained in the laboratory.

In chapter J of this thesis, the changes in the rhizoshpere mycoflora of the seedlings inoculated with the three *Paecilomyces* species were investigated. The interaction between the plants and the microorganisms in soil has considerable significance for crop production and soil fertility. The plant roots create a unique subterranean habitat for microorganisms. The plant in turn is markedly affect by the populations it has stimulated since the root is the site for the absorption of inorganic nutrients through which many pathogens penetrate. The rhizosphere community may have in the final analysis either favourable or detrimental influence on plant development.

In both the field and greenhouse experiments, *P. carneus, P. puntoni* and *P. varioti* eliminated or adversely depressed the survival of some *Aspergillus* species namely *A. ustus, A. fumigatus* and *A sulphureus* in the rhizosphere region of both Abeleehi and Obaatanpa varieties. Only *A. flavus, A. tamarii, A. niger, A. alutaceus* (= *A. ochraceus*) and *A. versicolor* could somehow withstand, to some extent the antagonism from the three *Paecilomyces* species (Table 6,9,12,15).

Penicillium species, also behaved differently in the presence of the three *Paecilomyces species P. digitatum* phased out completely in both the rhizosphere and non-rhizosphere soil containing Abeleehi seed inoculate with *Paecilomyces puntoni* and *P. varioti*, while it was thriving in soil containing Abeleehi seeds inoculated with *P. carneus* at least up to 28 days after sowing (Table 7). *P. citrinum* was the only *Penicillium* species that thrived in antagonism with *Paecilomyces* species (Table 13 and 16) in most instance but at the same time showed depressed occurrence in soil (Table 10).

Fungi belonging to other general also exhibited variable tolerance to the antogonistic influence of the three *Paecilomyces* species. For example, in both the field and greenhouse experiment, *C. herbarum, F. moniliforme, Rhodotorula, T. viride, Mucor.* Yeast and *R. oryzae* survivied to varying extent, the antogonism of the three *Paecilomyces* species used in inoculating either Abeleehi or Obaatanpa maize variety (Tables 8, 11, 14, 17).

Antagonism in fungi involves three types of activity

1. Antibiosis and lysis. Antibiosis is the inhibition of one organism by a metabolic product of another. Although it is usually an inhibition of growth and sporulation, it may be lethal. The metabolite penetrates a cell and inhibits its activity by chemical toxicity. Lysis is the destruction, disintegration, dissolution or decomposition of biological materials (Lamanna and Malette, 1965). The agent responsible for lysis should not include enzymes of parasite that digest the wall of the living cells.

2. Competition: Broadly, competition means interaction between two or more species population which affect their growth and survival (Elton, 1946; Odum, 1959). In a narrower sense, it is the endeavour of two or more organisms to gain some particular thing, or to gain the measure each wants from the supply of a thing when that supply is not sufficient for both (Clements and Shelfold, 1931; Milne, 1961). Clark (1965), criticised the inclusion of water and space among the items competed for by microorganisms and insisted that microbial activity was more likely to produce water than to consume it. He added that seldom if ever is lack of space responsible for curtailment of microbial growth. In the presence of an initially favourable water supply in the soil, depletion of that supply is not caused by microbial activity, but by such factors as evaporation or salt accumulation or by transpiration carried out by higher plants. The only item Clark (1965) considered vital in competition among soil microorganisms are oxygen and nutrients.

3. Parasitism and Predation. The are several known instances of parasitism among microorganisms. Hyphae of *Trichoderma viride* (Pers) Fries, invade hyphae of *Penicillium vermiculatum* Dangeard, *Rhizopus oryzae* Went and Prinsen - Geerlings, *Actinomucor repens* Schostak, *Phycomyces* nitrans *Kunze Fr*, *Mucor pinosus* Van Teigham, *Zygorhynchus vuilleminic* Vuillemin and *Syncephalastrum racemosus* Cohn ex Schroet (Durell, 1968).

Owing to time limitation, the nature and type of antagonism between the fungal species in the rhizoshpere of Abeleehi and Obaatanpa inoculated with the three *Paecilomyces* species *(P. carneus, P. puntoni, P. varioti*) could not be elucidated. However, this could form the subject for further investigations.

In both field and greenhouse studies fungal species like *A. flavus, A tamarii, A. niger, A. alutaceus* (= *A. ochraceus*). *A versicolor, Penicillium citrinum, C. herbarum, F. moniliforme, Rhodotorula* sp *T. viride, Mucor, Rhizopus oryzae* and some Yeast survived to varying extent. The type of antagonism shown by the three *Paecilomyces* species against them, the role these listed 'resistant' species play in (either favourable or detrimental) in the development of Obaatanpa and Abeleehi is yet to be elucidated.

The practical conclusion from these findings is that the two newly developed maize varieties (Abeleehi and Obaatanpa) harbour many field and storage fungi some of which are of pathological importance such as *F. moniliforme, P. digitatum* and *Paecilomyces* species (*P. carneus, P puntoni, P. varioti*). Metabolites of these potential pathogens especially *Paecilomyces* spp depress seed germination, reduces radicle development, decrease chlorophyll

a and b content of leaf and depress total dry matter accumulation by shoot and root system, reduces yield of the crop and the length and number of grains on the cob. Long-term storage of seeds (maize, tomato, pepper) infected with these fungi can result in drastic reduction in germination capacity. A better understanding of the dynamics and phenology of microorganisms in the rhizosphere and rhizoplane of the crop as well as the nature of antagonism at play would help formulate effective biological control of these potential pathogens in the field.

SUMMARY

1. Mycoflora of two maize varieties Abeleehi and Obaatanpa stored at ERH's 55, 60, 65, 70, 75, 80, 85, 90 and 95% were assessed after 36-40 days at 28-31°c.

2. About thirty (30) different fungal species were iosloated from Abeleehi variety as compared to twenty-eight (28) from Obaatanpa variety stored under the same ERH conditions and temperature.

3. *Aspergillus* species (12) (*A. candidus*, *A. effusus*, *A. fumigatus*, *A. giganteus*, *A. niger* *A. alutaceus* (*A. ochraceus*) *A.sulphureus*, *A. tamari*, *A. ustus*, *A. versicolor*, *A. wentii* and *Aspergillus* sp.) predominated over the other species encountered followed by *Penicillium* (9) (*P. brevi-compactum*, *P. citrinum*, *P. verrucosum*, *P. digitatum*, *P. expansum*, *funiculosum*, *P. glabrum*, *P. nigricans*, *Penicillium* sp).

4. Other genera encountered were *Curvularia*, *Paecilomyces Chaetomium*, *Cladosporium*, *Emericella*, *Eurotium*, *Fusarium*, *Mucor*, *Neurospora* and *Rhizopus*.

5a. The species diveristy was influenced by grain variety and ERH at which they were incubated.

(b). *Aspergillus flavus* was ubiquitous and was isolated from Abeleehi and Obaatanpa stored at ERH 55-95%; *Fusarium moniliforme* was encountered at ERH 65-95%.

(c). Xerophilic or xerotolerance species like *A. gigantens*, *A. fumigatus*, *Paecilomyces carneus*, *P. puntoni* and *P. varioti* were isolated at ERH's 55-65% in both grain varieties.

6. Radial growth of *Paecilomyces* species on agar was influenced by the media and temperature of incubation; each *Paecilomyces* species behaved differently.

7. The optimum growth of *P. carneus* on all agar media used (Czapek-Dox, Malt Extract, Maize Meal (Abeleehi) Maize Meal (Obaatanpa) was obtained at a 30°C, a temperature of 40°C was clearly unsuitable or inferior for growth of *P. carneus* as the fungus remained static at this temperature after 2-4 days growth.

8. The best radial growth of *P. puntoni* was attained at between 30-35°C. Growth at 18°C initially lagged behind those kept at 30°C but approximated their growth rate after 6-7 days incubation period.

9. There was no statistical difference ($P \leq 0.05$) between growth of *P. puntoni* in all the media tested.

10. Temperature of 35°c and 40°c depressed radial growth of *P. varioti* in all media tested. The best temperature for growth of *P. varioti* was 30°c, 18°c was almost as suitable as 30°c for *P. varioti.*

11. Radial growth of *P. varioti* was slowest on Potato Dextrose agar as compared to the other media tested (Czapek-Dox, Malt Extract, Maize Meal (Abeleehi), Maize meal (Obaatanpa).

12. The mycological media as well as temperature of incubation influenced radial growth of all the *Aspergillus* species (*A. flavus*. *A. giganteus* and *A. alutaceus* (= *A. ochraceus*) tested.

13a. The optimum growth of *A. flavus* was obtained at between 30°c and 35°c.

(b). Growth of *A. flavus* was depressed at 40°c but not at 18°c.

(c). The best medium for growth of *A. flavus* was Maize Meal Agar prepared form Obaatanpa variety.

d. Radial growth of *A. flavus* was poorest on Potato Dextro Agar and Czapek-Dox Agar.

14a. *A. giganteus* grew best at 30°c followed by 18°c on all media tested. Growth on Czapek-Dox Agar and Malt Extract Agar lagged behind the remaining media.

b. A temperature of 40°c was unsuitable for *A. giganteus* as radial growth remained stationary after 2-3 days.

15. *A. alutaceus* (= *A. ochraceus*) grew best at 35°c on Czapek-Dox Agar and Malt Extract Agar and at 30°c on Maize Meal Agar. Radial growth of the fungus was considerably depressed at 40°c for all media tested except on Czapek-Dox Agar. The optimum growth for *A. alutaceus* was between 30 and 35°c.

16a. Vegetative growth of *P. digitatum* on all the five media was inferior to what existed for the *Paecilomyces* and *Asperigillus* species growing on the same media.

b. The best temperature for optimum growth of *P. digitatum* in this investigation was 30°c; 35-40°c was unsuitable and 18°c was intermediate between 30°c and 40°c.

c. Radial growth of *Fusarium moniliforme* followed a characteristic sigmoid curves with the best temperature for growth in all media attained at 30°c.

(d). Vegetative growth of *F. moniliforme* at 18°c was better than that at 35°c and 40°c. The fungus never grew significantly after 2 days at 40°c such that the diameter of the colony remained the same for 7 days.

(e). The best growth of *F. moniliforme* was obatined on Maize Meal Agar and Malt Extract Agar.

17a. The three *Paecilomyces* species (*P. carneus*, *P. puntoni* and *P. varioti*) produced their inhibitory metabolites in 2 days in the media (Maize Meal Broth and Potato Dextrose Broth) used to culture the species.

(b). There were varietal differences in the response of the germinating maize grains to the active ingredients in the culture metabolites of the three *Paecilomyces* spp.

(c). Percentage germination of maize grains (Abeleehi and Obaatanpa) was depressed by 10-75% by the undiluted, 2, 4 and 8 days old cultural filtrate of *Paecilomyces carneus*, *P. puntoni* and *P. varioti*.

(d). The inhibitory effect was gradually removed with increasing dilution (up to $1:10^{v}/_{v}$).

18a. Cultural filtrates of *P. carneus*, *P. puntoni* and *P. varioti* severely depressed length of emerging radicles of the two maize varieties by 45-90% at the highest concentration applied.

(b). The reduction in length of radicle was severer on Abeleehi variety as compared to Obaatanpa where culture metabolites of *P. carneus* and *P. varioti* were applied

(c). The inhibitory effect of the metabolites was however gradually removed with dilution such that the radicle lengths of the germinating grains in the presence of 1:10 v/v dilution of the filtrate nearly approximated that of the control in some instances.

19. The culture filtrate of *A. alutaceus* (= *A. ochraceus*) depressed seed germinated at the highest concentration by 50 to 70% and adversley depressed (60-90%) radicle development of the germinating maize grains.

20. The metabolites of *Fusarium moniliforme* and *P. digitatum* had similar deleterious effect on germination and radicle development of the two maize varieties.

21. The metabolites of *Paecilomyces carneus*, *P. puntoni*, and *P. varioti* also severely depressed seed germination and radicle development of two tomato varieties. (varieties Owusu-Bio and Wosowoso) and hot pepper (var. Legon 18).

(b). There were also varietal differences in the response of tomato and pepper seeds to the same metabolites. The inhibitory effect of the metabolites was highest on var. Owusu-Bio than on var. Wosowoso.

22a. The height, leaf length and leaf width of Abeleehi and Obaatanpa plants whose seeds were inoculateed with the mycelium/conidia of the three *Paecilomyces* species prior to sowing in the field were significantly depressed by the metabolites of the growing *Paecilomyces* species.

(b). The inhibitory effect was generally severer on Obaatanpa variety than on Abeleehi.

23. Reduction in plant height, leaf length and leaf width of Abeleehi and obaatanpa in pots in the greenhouse by the culture filtrate of the three *Paecilomyces* species were marginal and did not differ significantly from the control seedlings except in the case of Obaatanpa seedlings where the leaves were narrower (28 mm) than the untreated control (33 mm).

24. *P. carneus* metabolites exerted greater inhibitory effect on leaf width than that of *P. puntoni* and *P. varioti* (in decreasing order) Each plant part of the respective maize variety behaved differently in its response to the inhibitory principle in the metabolites of the test *Paecilomyces* species.

25a. There were varietal differences in the response of the maize grains to dry matter accumulation by shoot and root systems in the presence of the metabolites of the three *Paecilomyces* species. Each plant part behaved differently.

(b). The effect of the *Paecilomyces* metabolites on the dry matter accumulation by stem and root of Abeleehi and Obaatanpa seedlings were different and can be ranked as follows in decreasing order. *P. puntoni* > *P. varioti* > *P. carneus*

26a. The metabolites of *P. carneus* *P. puntoni* and *P. varioti* affected the chlorophyll content of the leaves of the growing seedlings of Abeleehi and Obaatanpa varieties both in the field and in greenhouse.

(b). Chlorophyll a and b contents were lowest in Abeleehi and Obaatanpa plants whose seeds were growing under the influence of *P. carneus* in the field followed by seeds inoculated with *P. puntoni*.

27. Total cholrophyll content of Abeleehi seedlings was lower in seedlings whose seeds were inoculated with *P. carneus* and *P. puntoni* but not with *P. varioti*.

28a. Seedlings of Abeleehi and Obaatanpa in the greenhouse which were treated with metabolites of the three *Paecilomyces* species behaved differently.

(b). Metabolites of *P. carneus*, *P. puntoni*, *P. varioti* severely reduced chlorophyll a and b contents of both Abeleehi and Obaatanpa, *P. puntoni* metabolites was more potent.

29. The metabolites of the three *Paecilomyces* species affected the root anatomy of the maize seedlings. The root of the untreated seedlings (control) was 2-3 times wider in diameter than those seedlings exposed to the metabolites of *P. carneus*, *P. puntoni*, *P. varioti*.

30. The pith parenchyma was sclerified and 2-3 times narrower in diamter in the treated plants exposed to the metabolites of the *Paecilomyces* spp.

31. The presence of *P. carneus*, *P. puntoni*, and *P. varioti* influence the rhizosphere mycoflora profile in both the field and greehouse experiments.

32. The metabolites of the three *Paecilomyces* species eliminated or adversely depressed some *Aspergillus* species namely *A. ustus*, *A. fumigatus*, and *A. sulphureus* in the rhizosphere region of both Abeleehi and Obaatanpa varieties.

33. Only *A. flavus*, *A. tamarii*, *A. alutaceus* (=*A. ochraceus*) and *A. versicolor* could withstand, to some extent, the antagonism exerted by the three *Paecilomyces* species.

34. *Pencillium* species behaved differently in the presence of the three *Paecilomyces* species. *P. digitatum* phased out completely in both the rhizosphere and non-rhizophere soil containing Abeleehi seedlings inoculated with *Paecilomyces puntoni* and *P. varioti*; *P. citrinum* was the only *Penicillium* species that could be isolated in the soil in competition with *Paecilomyces* species.

35. Fungi belonging to other genera also exhibited variable tolerance to the antagonistic influence of the three *Paecilomyces* species. In both the field and greenhouse exeperiments, *Cladosporium herbarum* , *F. moniliforme*, *Rhodotorula*, *T. viride*, *Mucor*, Yeast, and *R. oryzae* survived to varying extents.

36. The phenology of the soil mycoflora in the presence of the host plant and the three *Paecilomyces* species gives credence to the need to carry out further studies on the nature of the competitive inhibition that is at play in native soil sown with seeds harbouring potential pathogenic fungi.

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APPENDIX

APPENDIX 1a

RADIAL GROWTH OF FUNGAL SPECIES ON POTATO - DEXTROSE AGAR AT DIFFERENT TEMPERATURES

Fungal Species	Temp.	Mean diameter of culture (Mean + S.E) in mm after days						
	0C	1	2	3	4	5	6	7
Aspergillus flavus	180C	7.0 ± 1.8	15.0 ± 1.9	20.0 ± 1.8	27.0 ± 1.8	35.0 ± 2.7	41.0 ± 2.7	47.0 ± 3.2
	300C	26.0 ± 2.1	32.0 ± 1.9	49.0 ± 1.7	52.0 ± 2.1	53.0 ± 2.3	53.0 ± 2.3	54.0 ± 2.5
	350C	20.0 ± 2.3	23.0 ± 2.4	29.0 ± 1.6	35.0 ± 1.8	43.0 ± 1.3	43.0 ± 1.3	43.0 ± 1.3
	400C	8.0 ± 1.4	10.0 ± 1.6	12.0 ± 1.2	13.0 ± 1.4	13.0 ± 1.4	13.0 ± 1.4	14.0 ± 1.7
Aspergillus giganteus	180C	6.0 ± 1.3	13.0 ± 1.7	17.0 ± 1.5	21.0 ± 1.9	24.0 ± 1.8	27.0 ± 1.3	28.0 ± 1.6
	300C	15.0 ± 2.3	25.0 ± 2.7	31.0 ± 1.8	42.0 ± 2.2	54.0 ± 1.6	58.0 ± 1.1	58.0 ± 1.1
	350C	9.0 ± 1.3	11.0 ± 2.1	14.0 ± 1.3	16.0 ± 1.5	19.0 ± 1.8	21.0 ± 2.3	24.0 ± 1.4
	400C	4.0 ± 1.5	5.0 ± 1.3	5.0 ± 1.3	5.0 ± 1.3	6.0 ± 2.1	6.0 ± 2.1	6.0 ± 2.1
Aspergillus ochraceus = *A. alutaceus*	180C	8.0 ± 1.9	13.0 ± 1.6	13.0 ± 1.6	14.0 ± 1.7	14.0 ± 1.7	16.0 ± 1.3	17.0 ± 1.4
	300C	9.0 ± 0.8	15.0 ± 1.2	15.0 ± 1.2	16.0 ± 1.5	18.0 ± 1.9	25.0 ± 1.6	32.0 ± 2.1
	350C	14.0 ± 1.2	14.0 ± 1.2	15.0 ± 1.6	15.0 ± 1.6	15.0 ± 1.6	16.0 ± 1.9	17.0 ± 2.3
	400C	3.0 ± 0.8	4.0 ± 1.1	4.0 ± 1.1	5.0 ± 2.2	5.0 ± 2.2	5.0 ± 2.2	5.0 ± 2.2
Paecilomyces carneus	180C	11.0 ± 2.3	18.0 ± 2.1	26.0 ± 2.3	35.0 ± 2.4	44.0 ± 1.9	53.0 ± 1.7	60.0 ± 1.8
	300C	21.0 ± 1.8	28.0 ± 2.2	41.0 ± 3.2	50.0 ± 2.8	56.0 ± 3.2	63.0 ± 1.8	6.4 ± 2.7
	350C	15.0 ± 1.6	15.0 ± 1.6	15.0 ± 1.6	15.0 ± 1.6	15.0 ± 1.6	15.0 ± 1.6	1.6 ± 2.0
	400C	4.0 ± 1.2	4.0 ± 1.2	4.0 ± 1.2	4.0 ± 1.2	4.0 ± 1.2	5.0 ± 1.1	6.0 ± 2.3
Paecilomyces puntoni	180C	4.0 ± 1.8	17.0 ± 2.6	35.0 ± 2.7	55.0 ± 3.1	67.0 ± 1.8	89.0 ± 0.8	90.0 ± 0.0
	300C	72.0 ± 1.6	88.0 ± 0.8	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
	350C	59.0 ± 2.3	78.0 ± 2.1	89.0 ± 0.8	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
	400C	28.0 ± 1.7	38.0 ± 1.9	69.0 ± 1.6	79.0 ± 2.3	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
Paecilomyces varioti	180C	10.0 ± 2.3	17.0 ± 1.8	22.0 ± 2.1	24.0 ± 2.4	33.0 ± 2.1	47.0 ± 1.5	62.0 ± 1.7
	300C	17.0 ± 1.7	18.0 ± 2.3	19.0 ± 2.1	26.0 ± 1.7	29.0 ± 1.5	52.0 ± 1.9	65.0 ± 2.3
	350C	5.0 ± 1.1	7.0 ± 1.3	9.0 ± 1.6	13.0 ± 2.1	15.0 ± 3.1	16.0 ± 1.4	17.0 ± 2.4
	400C	3.0 ± 0.8	3.0 ± 0.8	3.0 ± 0.8	3.0 ± 0.8	3.0 ± 0.8	5.0 ± 1.1	6.0 ± 1.6
Penicillium digitatum	180C	5.0 ± 1.2	8.0 ± 1.6	10.0 ± 1.8	12.0 ± 2.1	13.0 ± 2.3	13.0 ± 2.3	14.0 ± 1.8
	300C	8.0 ± 2.1	12.0 ± 1.3	13.0 ± 1.5	16.0 ± 1.7	19.0 ± 1.8	19.0 ± 1.8	20.0 ± 2.0
	350C	10.0 ± 1.7	15.0 ± 1.5	16.0 ± 1.4	18.0 ± 1.6	18.0 ± 1.6	18.0 ± 1.6	19.0 ± 1.8
	400C	2.0 ± 0.3	3.0 ± 0.5	4.0 ± 0.4	5.0 ± 0.7	9.0 ± 0.9	11.0 ± 1.1	11.0 ± 1.1
Penicillium expansum	180C	4.0 ± 1.3	7.0 ± 1.5	8.0 ± 1.3	10.0 ± 1.2	13.0 ± 1.3	14.0 ± 1.7	14.0 ± 1.7
	300C	6.0 ± 2.1	9.0 ± 2.3	11.0 ± 2.1	11.0 ± 2.1	14.0 ± 2.3	16.0 ± 1.9	16.0 ± 1.9
	350C	13.0 ± 1.7	14.0 ± 1.9	18.0 ± 2.1	22.0 ± 1.7	24.0 ± 1.8	26.0 ± 1.7	27.0 ± 2.0
	400C	5.0 ± 1.2	8.0 ± 1.4	10.0 ± 1.7	12.0 ± 1.8	14.0 ± 1.9	15.0 ± 2.1	16.0 ± 1.8
Fusarium moniliforme	180C	13.0 ± 1.8	23.0 ± 1.7	30.0 ± 1.3	35.0 ± 2.1	40.0 ± 1.9	47.0 ± 1.9	48.0 ± 2.1
	300C	20.0 ± 1.5	34.0 ± 1.8	44.0 ± 2.3	53.0 ± 1.4	59.0 ± 1.7	64.0 ± 1.8	64.0 ± 1.8
	350C	14.0 ± 1.8	21.0 ± 2.1	22.0 ± 1.9	24.0 ± 1.6	24.0 ± 1.6	24.0 ± 1.6	24.0 ± 1.6
	400C	4.0 ± 1.2	5.0 ± 1.3	5.0 ± 1.3	6.0 ± 1.5	6.0 ± 1.5	7.0 ± 1.7	7.0 ± 1.7

APPENDIX 1b

RADIAL GROWTH OF FUNGAL SPECIES ON MAIZE MEAL AGAR (ABELEEHI) AT DIFFERENT TEMPERATURES

Fungal Species	Temp. 0C	Mean diameter of culture (Mean + S.E) in mm after days 1	2	3	4	5	6	7
Aspergillus flavus	180C	2.0 ± 0.3	20.0 ± 1.2	28.0 ± 2.1	35.0 ± 1.8	43.0 ± 2.5	46.0 ± 3.1	49.0 ± 2.1
	300C	18.0 ± 2.1	43.0 ± 1.7	59.0 ± 1.6	64.0 ± 1.5	67.0 ± 1.7	69.0 ± 2.4	71.0 ± 1.6
	350C	15.0 ± 1.2	29.0 ± 1.6	39.0 ± 1.4	46.0 ± 2.2	50.0 ± 1.9	52.0 ± 2.6	56.0 ± 1.2
	400C	7.0 ± 0.8	8.0 ± 0.9	9.0 ± 1.1	9.0 ± 1.2	11.0 ± 1.8	13.0 ± 1.3	15.0 ± 1.2
Aspergillus giganteus	180C	3.0 ± 0.3	13.0 ± 1.4	13.0 ± 1.4	23.0 ± 2.6	29.0 ± 2.6	33.0 ± 1.8	35.0 ± 1.5
	300C	15.0 ± 1.6	28.0 ± 2.3	35.0 ± 1.9	41.0 ± 1.9	43.0 ± 2.3	45.0 ± 1.7	46.0 ± 1.6
	350C	7.0 ± 1.2	13.0 ± 1.2	18.0 ± 1.2	23.0 ± 2.0	26.0 ± 1.8	29.0 ± 1.7	33.0 ± 2.1
	400C	3.0 ± 0.2	3.0 ± 0.2	4.0 ± 0.8	4.0 ± 0.8	5.0 ± 1.1	5.0 ± 1.1	5.0 ± 1.1
Aspergillus ochraceus = *A. alutaceus*	180C	3.0 ± 0.6	5.0 ± 1.2	14.0 ± 1.6	21.0 ± 1.8	24.0 ± 2.1	28.0 ± 1.8	28.0 ± 2.7
	300C	6.0 ± 2.1	13.0 ± 1.8	23.0 ± 1.5	26.0 ± 2.7	31.0 ± 3.1	33.0 ± 3.2	36.0 ± 3.0
	350C	3.0 ± 0.9	3.0 ± 0.8	4.0 ± 1.1	5.0 ± 1.2	6.0 ± 1.4	8.0 ± 1.6	10.0 ± 2.8
	400C	2.0 ± 0.7	3.0 ± 0.9	3.0 ± 0.9	4.0 ± 1.1	4.0 ± 1.1	6.0 ± 1.4	6.0 ± 1.4
Paecilomyces carneus	180C	21.0 ± 2.3	33.0 ± 2.5	53.0 ± 3.4	66.0 ± 3.2	78.0 ± 4.1	53.0 ± 1.7	60.0 ± 1.8
	300C	27.0 ± 2.8	54.0 ± 2.4	82.0 ± 2.6	88.0 ± 3.1	90.0 ± 0.0	63.0 ± 1.8	6.4 ± 2.7
	350C	11.0 ± 1.8	13.0 ± 2.4	18.0 ± 2.6	20.0 ± 3.1	20.0 ± 3.1	15.0 ± 1.6	1.6 ± 2.0
	400C	3.0 ± 0.7	3.0 ± 0.7	4.0 ± 1.2	4.0 ± 1.2	5.0 ± 1.0	5.0 ± 1.1	6.0 ± 2.3
Paecilomyces puntoni	180C	7.0 ± 1.4	20.0 ± 1.6	42.0 ± 1.8	63.0 ± 1.5	72.0 ± 1.3	89.0 ± 0.8	90.0 ± 0.0
	300C	65.0 ± 1.6	73.0 ± 1.4	82.0 ± 1.7	88.0 ± 1.8	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
	350C	58.0 ± 1.3	63.0 ± 1.2	72.0 ± 1.5	80.0 ± 1.4	88.0 ± 1.6	90.0 ± 0.0	90.0 ± 0.0
	400C	28.0 ± 1.8	36.0 ± 1.3	68.0 ± 1.9	88.0 ± 1.3	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
Paecilomyces varioti	180C	19.0 ± 2.1	33.0 ± 1.6	52.0 ± 2.1	74.0 ± 1.8	78.0 ± 1.9	88.0 ± 1.1	90.0 ± 0.0
	300C	24.0 ± 3.2	43.0 ± 2.3	59.0 ± 2.4	75.0 ± 2.3	82.0 ± 1.8	90.0 ± 0.0	90.0 ± 0.0
	350C	4.0 ± 0.9	5.0 ± 1.1	7.0 ± 2.2	8.0 ± 1.8	10.0 ± 2.3	12.0 ± 1.3	15.0 ± 1.8
	400C	4.0 ± 0.4	4.0 ± 0.4	5.0 ± 0.6	6.0 ± 0.8	6.0 ± 0.8	6.0 ± 0.8	6.0 ± 0.8
Penicillium digitatum	180C	4.0 ± 1.1	9.0 ± 1.4	11.0 ± 1.6	13.0 ± 1.8	16.0 ± 1.8	19.0 ± 1.5	21.0 ± 3.2
	300C	8.0 ± 1.5	17.0 ± 1.2	22.0 ± 1.3	26.0 ± 1.9	29.0 ± 2.1	31.0 ± 1.6	32.0 ± 1.8
	350C	5.0 ± 0.9	5.0 ± 0.9	6.0 ± 1.0	7.0 ± 1.1	7.0 ± 1.1	9.0 ± 1.8	11.0 ± 2.1
	400C	2.0 ± 0.8	2.0 ± 0.8	3.0 ± 1.1	3.0 ± 1.1	3.0 ± 1.1	4.0 ± 1.3	4.0 ± 1.1
Penicillium expansum	180C	3.0 ± 2.1	9.0 ± 2.7	13.0 ± 2.8	14.0 ± 3.2	18.0 ± 3.4	18.0 ± 3.4	18.0 ± 3.4
	300C	14.0 ± 1.9	18.0 ± 2.6	22.0 ± 3.1	27.0 ± 1.8	32.0 ± 3.6	37.0 ± 2.8	39.0 ± 1.9
	350C	18.0 ± 1.6	22.0 ± 1.5	22.0 ± 1.5	24.0 ± 1.6	26.0 ± 1.8	29.0 ± 2.4	32.0 ± 1.9
	400C	3.0 ± 0.7	3.0 ± 0.7	3.0 ± 0.7	4.0 ± 0.9	4.0 ± 0.7	5.0 ± 1.2	5.0 ± 1.2
Fusarium moniliforme	180C	4.0 ± 1.2	34.0 ± 2.3	41.0 ± 2.5	58.0 ± 2.7	71.0 ± 3.2	77.0 ± 3.5	87.0 ± 4.1
	300C	5.0 ± 1.3	45.0 ± 2.5	66.0 ± 3.1	74.0 ± 3.4	77.0 ± 3.1	87.0 ± 3.2	89.0 ± 0.1
	350C	6.0 ± 1.4	10.0 ± 1.2	10.0 ± 1.2	12.0 ± 2.3	13.0 ± 2.4	15.0 ± 2.7	18.0 ± 3.1
	400C	4.0 ± 0.7	4.0 ± 0.7	4.0 ± 0.7	5.0 ± 1.1	5.0 ± 1.1	6.0 ± 0.9	6.0 ± 0.9

APPENDIX 1C

RADIAL GROWTH OF FUNGAL SPECIES ON CZAPEK - DOX AGAR AT DIFFERENT TEMPERATURES

Fungal Species	Temp. 0C	Mean diameter of culture (Mean + S.E) in mm after days 1	2	3	4	5	6	7
Aspergillus flavus	180C	3.0 ± 1.4	6.0 ± 1.2	10.0 ± 0.8	18.0 ± 1.1	24.0 ± 0.7	27.0 ± 0.7	29.0 ± 1.6
	300C	16.0 ± 0.3	21.0 ± 1.6	31.0 ± 0.7	37.0 ± 1.2	44.0 ± 1.2	47.0 ± 0.6	53.0 ± 2.0
	350C	19.0 ± 0.2	29.0 ± 1.3	32.0 ± 1.1	33.0 ± 1.0	36.0 ± 0.3	37.0 ± 1.4	52.0 ± 1.7
	400C	14.0 ± 1.2	25.0 ± 1.2	25.0 ± 1.2	26.0 ± 0.7	25.0 ± 1.1	25.0 ± 2.1	25.0 ± 1.1
Aspergillus giganteus	180C	6.0 ± 0.8	10.0 ± 1.1	13.0 ± 0.6	23.0 ± 0.3	28.0 ± 1.2	30.0 ± 1.1	31.0 ± 0.9
	300C	11.0 ± 1.2	16.0 ± 0.4	21.0 ± 0.8	26.0 ± 0.6	29.0 ± 1.4	30.0 ± 2.1	33.0 ± 1.8
	350C	5.0 ± 1.0	16.0 ± 1.6	22.0 ± 1.1	25.0 ± 1.0	28.0 ± 2.1	33.0 ± 0.3	34.0 ± 1.7
	400C	7.0 ± 0.8	13.0 ± 0.7	13.0 ± 1.4	14.0 ± 1.2	14.0 ± 2.4	14.0 ± 0.7	14.0 ± 1.2
Aspergillus ochraceus = *A. alutaceus*	180C	3.0 ± 0.3	6.0 ± 0.7	6.0 ± 0.8	13.0 ± 1.3	16.0 ± 1.2	18.0 ± 1.1	20.0 ± 1.4
	300C	6.0 ± 0.7	9.0 ± 0.4	16.0 ± 1.2	20.0 ± 1.1	27.0 ± 1.8	32.0 ± 1.3	37.0 ± 1.8
	350C	5.0 ± 0.8	16.0 ± 1.8	22.0 ± 1.8	28.0 ± 1.4	28.0 ± 1.4	33.0 ± 1.7	34.0 ± 1.7
	400C	7.0 ± 1.2	13.0 ± 1.2	13.1 ± 1.2	14.0 ± 0.0	14.0 ± 0.0	14.0 ± 0.0	14.0 ± 0.0
Paecilomyces carneus	180C	16.0 ± 1.6	26.0 ± 0.7	38.0 ± 0.7	48.0 ± 1.2	60.0 ± 0.7	67.0 ± 2.1	77.0 ± 1.8
	300C	23.0 ± 0.8	37.0 ± 0.8	67.0 ± 0.8	82.0 ± 1.4	86.0 ± 1.2	90.0 ± 0.8	90.4 ± 2.1
	350C	16.0 ± 1.2	33.0 ± 1.2	67.0 ± 1.0	72.0 ± 0.8	76.0 ± 1.3	82.0 ± 0.2	86.6 ± 1.1
	400C	22.0 ± 1.1	31.0 ± 1.3	33.0 ± 1.1	34.0 ± 0.8	34.0 ± 1.4	36.0 ± 1.2	37.0 ± 1.5
Paecilomyces puntoni	180C	5.0 ± 2.2	18.0 ± 1.4	36.0 ± 0.7	58.0 ± 1.2	72.0 ± 1.2	83.0 ± 1.1	90.0 ± 0.0
	300C	38.0 ± 2.1	63.0 ± 1.2	75.0 ± 1.2	83.0 ± 1.3	87.0 ± 2.3	90.0 ± 0.0	90.0 ± 0.0
	350C	57.0 ± 0.8	63.0 ± 1.4	72.0 ± 1.3	88.0 ± 1.6	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
	400C	27.0 ± 1.1	25.0 ± 0.8	65.0 ± 0.4	78.0 ± 1.2	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
Paecilomyces varioti	180C	14.0 ± 0.3	21.0 ± 0.3	29.0 ± 0.4	36.0 ± 1.1	42.0 ± 1.1	55.0 ± 0.2	29.0 ± 1.1
	300C	12.0 ± 0.4	19.0 ± 1.2	41.0 ± 1.2	45.0 ± 0.7	49.0 ± 0.5	57.0 ± 1.2	53.0 ± 0.4
	350C	5.0 ± 0.1	8.0 ± 0.4	10.0 ± 0.3	18.0 ± 0.5	22.0 ± 0.6	25.0 ± 0.7	52.0 ± 1.3
	400C	11.0 ± 0.5	13.0 ± 0.6	13.0 ± 0.5	14.0 ± 1.2	15.0 ± 1.1	15.0 ± 1.3	25.0 ± 1.1
Penicillium digitatum	180C	3.0 ± 0.2	6.0 ± 0.7	6.0 ± 0.6	8.0 ± 1.7	10.0 ± 0.9	10.0 ± 1.1	12.0 ± 1.1
	300C	7.0 ± 1.2	22.0 ± 1.4	42.0 ± 1.1	47.0 ± 2.1	48.0 ± 1.6	50.0 ± 0.0	50.0 ± 1.1
	350C	11.0 ± 1.3	23.0 ± 2.1	25.0 ± 1.8	28.0 ± 1.7	30.0 ± 1.2	32.0 ± 1.1	32.0 ± 1.2
	400C	8.0 ± 1.3	16.0 ± 2.3	21.0 ± 0.8	27.0 ± 1.8	29.0 ± 0.8	29.0 ± 1.2	29.0 ± 1.2
Penicillium expansum	180C	6.0 ± 1.2	7.0 ± 1.3	8.0 ± 1.2	8.0 ± 1.2	10.0 ± 0.7	13.0 ± 1.1	13.0 ± 1.2
	300C	10.0 ± 0.3	11.0 ± 1.2	14.0 ± 1.3	16.0 ± 1.0	17.0 ± 0.9	19.0 ± 0.1	19.0 ± 1.1
	350C	78.0 ± 1.2	8.0 ± 1.3	10.0 ± 0.7	13.0 ± 0.7	15.0 ± 1.1	16.0 ± 0.2	18.0 ± 1.2
	400C	18.0 ± 1.1	19.0 ± 0.8	19.0 ± 0.8	21.0 ± 0.7	21.0 ± 0.7	21.0 ± 0.7	21.0 ± 0.7
Fusarium moniliforme	180C	7.0 ± 1.2	15.0 ± 0.9	28.0 ± 0.2	38.0 ± 1.1	48.0 ± 1.2	58.0 ± 1.1	65.0 ± 1.1
	300C	150 ± 1.1	22.0 ± 0.4	46.0 ± 1.2	63.0 ± 1.2	73.0 ± 1.7	80.0 ± 0.7	90.0 ± 0.0
	350C	12.0 ± 1.8	19.0 ± 1.2	34.0 ± 1.7	37.0 ± 1.9	38.0 ± 1.2	39.0 ± 1.1	39.0 ± 1.2
	400C	18.0 ± 1.3	22.0 ± 0.0	22.0 ± 0.3	22.0 ± 0.7	22.0 ± 0.8	22.0 ± 0.8	22.0 ± 1.3

APPENDIX 1d

RADIAL GROWTH OF FUNGAL SPECIES ON MALT EXTRACT AGAR AT DIFFERENT TEMPERATURES

Fungal Species	Temp. 0C	Mean diameter of culture (Mean + S.E) in mm after days 1	2	3	4	5	6	7
Aspergillus flavus	180C	8.0 ± 2.1	6.0 ± 1.1	14.0 ± 0.7	21.0 ± 1.2	26.0 ± 1.7	27.0 ± 0.7	37.0 ± 1.2
	300C		21.0 ± 1.7	29.0 ± 1.2	30.0 ± 1.4	30.0 ± 1.8	47.0 ± 0.6	38.0 ± 1.4
	350C	12.0 ± 1.2	16.0 ± 1.9	23.0 ± 1.4	32.0 ± 1.3	32.0 ± 1.4	37.0 ± 1.4	54.0 ± 1.2
	400C	11.0 ± 1.5	8.0 ± 0.7	8.0 ± 0.6	8.0 ± 0.7	8.0 ± 0.7	25.0 ± 2.1	10.0 ± 0.9
		6.0 ± 0.7						
Aspergillus giganteus	180C	4.0 ± 1.2	8.0 ± 0.8	14.0 ± 0.7	17.0 ± 1.1	24.0 ± 1.2	30.0 ± 1.1	29.0 ± 1.2
	300C	10.0 ± 1.7	14.0 ± 1.2	21.0 ± 1.1	28.0 ± 1.6	30.0 ± 1.2	30.0 ± 2.1	38.0 ± 1.1
	350C	7.0 ± 0.4	9.0 ± 1.0	12.0 ± 0.7	13.0 ± 0.7	13.0 ± 0.8	33.0 ± 0.3	23.0 ± 1.4
	400C	4.0 ± 0.2	4.0 ± 0.2	4.0 ± 0.2	8.0 ± 0.7	8.0 ± 0.7	14.0 ± 0.7	9.0 ± 0.9
Aspergillus ochraceus = *A. alutaceus*	180C	3.0 ± 0.7	4.0 ± 0.7	8.0 ± 1.1	15.0 ± 0.9	20.0 ± 0.8	27.0 ± 1.1	42.0 ± 1.3
	300C	6.0 ± 0.9	10.0 ± 0.9	16.0 ± 1.0	21.0 ± 0.9	21.0 ± 0.9	24.0 ± 1.3	24.0 ± 1.3
	350C	5.0 ± 0.2	14.0 ± 0.7	25.0 ± 2.1	28.0 ± 1.4	41.0 ± 1.7	49.0 ± 1.6	54.0 ± 1.8
	400C	3.0 ± 0.3	5.0 ± 1.1	7.1 ± 0.7	9.0 ± 0.7	9.0 ± 0.8	9.0 ± 0.8	11.0 ± 1.0
Paecilomyces carneus	180C	12.0 ± 1.1	21.0 ± 1.4	35.0 ± 1.6	46.0 ± 0.9	55.0 ± 1.9	77.0 ± 1.2	81.0 ± 1.2
	300C	20.0 ± 2.1	30.0 ± 1.6	45.0 ± 1.8	55.0 ± 1.8	64.0 ± 2.1	82.0 ± 1.6	89.0 ± 2.4
	350C	14.0 ± 2.3	16.0 ± 1.7	19.0 ± 0.8	19.0 ± 0.5	19.0 ± 0.8	19.0 ± 0.8	20.0 ± 1.2
	400C	5.0 ± 1.0	5.0 ± 1.0	5.0 ± 1.0	9.0 ± 1.0	9.0 ± 1.0	10.0 ± 1.2	11.0 ± 1.1
Paecilomyces puntoni	180C	5.0 ± 0.7	18.0 ± 1.2	45.0 ± 2.1	70.0 ± 2.1	73.0 ± 1.2	88.0 ± 1.2	90.0 ± 0.0
	300C	72.0 ± 1.2	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
	350C	65.0 ± 2.1	76.0 ± 1.1	88.0 ± 0.9	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
	400C	29.0 ± 1.6	42.0 ± 1.7	88.0 ± 1.2	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
Paecilomyces varioti	180C	11.0 ± 1.2	18.0 ± 1.2	30.0 ± 1.6	40.0 ± 2.1	49.0 ± 1.1	64.0 ± 0.7	74.0 ± 1.2
	300C	13.0 ± 1.5	26.0 ± 1.4	40.0 ± 1.7	51.0 ± 1.6	60.0 ± 1.2	71.0 ± 0.9	81.0 ± 1.8
	350C	4.0 ± 0.7	4.0 ± 0.7	5.0 ± 1.8	5.0 ± 1.6	6.0 ± 1.3	7.0 ± 1.1	7.0 ± 1.1
	400C	4.0 ± 0.7	4.0 ± 0.7	4.0 ± 0.7	4.0 ± 0.7	5.0 ± 0.9	5.0 ± 0.9	5.0 ± 0.9
Penicillium digitatum	180C	4.0 ± 0.8	5.0 ± 0.9	6.0 ± 1.1	9.0 ± 1.2	9.0 ± 1.1	10.0 ± 1.1	11.0 ± 1.1
	300C	5.0 ± 1.2	7.0 ± 1.1	8.0 ± 1.3	11.0 ± 2.1	14.0 ± 1.8	18.0 ± 1.3	20.0 ± 1.2
	350C	5.0 ± 0.9	6.0 ± 1.2	7.0 ± 1.2	8.0 ± 1.2	10.0 ± 0.7	10.0 ± 0.7	10.0 ± 0.1
	400C	3.0 ± 0.1	3.0 ± 0.1	4.0 ± 0.7	6.0 ± 1.2	7.0 ± 1.2	8.0 ± 1.1	10.0 ± 1.1
Penicillium expansum	180C	3.0 ± 0.9	5.0 ± 0.7	8.0 ± 1.1	13.0 ± 1.4	15.0 ± 1.1	17.0 ± 2.1	22.0 ± 1.8
	300C	5.0 ± 1.1	5.0 ± 0.7	11.0 ± 1.9	13.0 ± 1.6	14.0 ± 1.3	17.0 ± 1.8	18.0 ± 1.7
	350C	4.0 ± 0.9	8.0 ± 1.2	7.0 ± 1.7	8.0 ± 1.6	12.0 ± 1.1	12.0 ± 1.1	12.0 ± 1.1
	400C	3.0 ± 0.8	5.0 ± 1.1	4.0 ± 1.1	6.0 ± 1.1	6.0 ± 1.1	7.0 ± 1.7	8.0 ± 1.3
Fusarium moniliforme	180C	6.0 ± 1.7	11.0 ± 1.7	24.0 ± 1.3	33.0 ± 1.2	46.0 ± 1.8	61.0 ± 1.4	70.0 ± 1.6
	300C	14.0 ± 1.8	24.0 ± 2.8	40.0 ± 2.1	56.0 ± 1.6	69.0 ± 1.2	83.0 ± 1.3	90.0 ± 0.0
	350C	8.0 ± 2.1	9.0 ± 1.8	11.0 ± 1.1	11.0 ± 1.1	11.0 ± 1.1	13.0 ± 2.1	19.0 ± 2.3
	400C	3.0 ± 0.2	3.0 ± 0.2	4.0 ± 0.7	6.0 ± 1.5	6.0 ± 1.5	7.0 ± 1.7	9.0 ± 1.8

APPENDIX 1d

RADIAL GROWTH OF FUNGAL SPECIES ON MALT EXTRACT AGAR AT DIFFERENT TEMPERATURES

Fungal Species	Temp. 0C	Mean diameter of culture (Mean ± S.E) in mm after days 1	2	3	4	5	6	7
Aspergillus flavus	180C	8.0 ± 2.1	6.0 ± 1.1	14.0 ± 0.7	21.0 ± 1.2	26.0 ± 1.7	27.0 ± 0.7	37.0 ± 1.2
	300C		21.0 ± 1.7	29.0 ± 1.2	30.0 ± 1.4	30.0 ± 1.8	47.0 ± 0.6	38.0 ± 1.4
	350C	12.0 ± 1.2	16.0 ± 1.9	23.0 ± 1.4	32.0 ± 1.3	32.0 ± 1.4	37.0 ± 1.4	54.0 ± 1.2
	400C	11.0 ± 1.5	8.0 ± 0.7	8.0 ± 0.6	8.0 ± 0.7	8.0 ± 0.7	25.0 ± 2.1	10.0 ± 0.9
		6.0 ± 0.7						
Aspergillus giganteus	180C	4.0 ± 1.2	8.0 ± 0.8	14.0 ± 0.7	17.0 ± 1.1	24.0 ± 1.2	30.0 ± 1.1	29.0 ± 1.2
	300C	10.0 ± 1.7	14.0 ± 1.2	21.0 ± 1.1	28.0 ± 1.6	30.0 ± 1.2	30.0 ± 2.1	38.0 ± 1.1
	350C	7.0 ± 0.4	9.0 ± 1.0	12.0 ± 0.7	13.0 ± 0.7	13.0 ± 0.8	33.0 ± 0.3	23.0 ± 1.4
	400C	4.0 ± 0.2	4.0 ± 0.2	4.0 ± 0.2	8.0 ± 0.7	8.0 ± 0.7	14.0 ± 0.7	9.0 ± 0.9
Aspergillus ochraceus = A. alutaceus	180C	3.0 ± 0.7	4.0 ± 0.7	8.0 ± 1.1	15.0 ± 0.9	20.0 ± 0.8	27.0 ± 1.1	42.0 ± 1.3
	300C	6.0 ± 0.9	10.0 ± 0.9	16.0 ± 1.0	21.0 ± 0.9	21.0 ± 0.9	24.0 ± 1.3	24.0 ± 1.3
	350C	5.0 ± 0.2	14.0 ± 0.7	25.0 ± 2.1	28.0 ± 1.4	41.0 ± 1.7	49.0 ± 1.6	54.0 ± 1.8
	400C	3.0 ± 0.3	5.0 ± 1.1	7.1 ± 0.7	9.0 ± 0.7	9.0 ± 0.8	9.0 ± 0.8	11.0 ± 1.0
Paecilomyces carneus	180C	12.0 ± 1.1	21.0 ± 1.4	35.0 ± 1.6	46.0 ± 0.9	55.0 ± 1.9	77.0 ± 1.2	81.0 ± 1.2
	300C	20.0 ± 2.1	30.0 ± 1.6	45.0 ± 1.8	55.0 ± 1.8	64.0 ± 2.1	82.0 ± 1.6	89.0 ± 2.4
	350C	14.0 ± 2.3	16.0 ± 1.7	19.0 ± 0.8	19.0 ± 0.5	19.0 ± 0.8	19.0 ± 0.8	20.0 ± 1.2
	400C	5.0 ± 1.0	5.0 ± 1.0	5.0 ± 1.0	9.0 ± 1.0	9.0 ± 1.0	10.0 ± 1.2	11.0 ± 1.1
Paecilomyces puntoni	180C	5.0 ± 0.7	18.0 ± 1.2	45.0 ± 2.1	70.0 ± 2.1	73.0 ± 1.2	88.0 ± 1.2	90.0 ± 0.0
	300C	72.0 ± 1.2	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
	350C	65.0 ± 2.1	76.0 ± 1.1	88.0 ± 0.9	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
	400C	29.0 ± 1.6	42.0 ± 1.7	88.0 ± 1.2	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
Paecilomyces varioti	180C	11.0 ± 1.2	18.0 ± 1.2	30.0 ± 1.6	40.0 ± 2.1	49.0 ± 1.1	64.0 ± 0.7	74.0 ± 1.2
	300C	13.0 ± 1.5	26.0 ± 1.4	40.0 ± 1.7	51.0 ± 1.6	60.0 ± 1.2	71.0 ± 0.9	81.0 ± 1.8
	350C	4.0 ± 0.7	4.0 ± 0.7	5.0 ± 1.8	5.0 ± 1.6	6.0 ± 1.3	7.0 ± 1.1	7.0 ± 1.1
	400C	4.0 ± 0.7	4.0 ± 0.7	4.0 ± 0.7	4.0 ± 0.7	5.0 ± 0.9	5.0 ± 0.9	5.0 ± 0.9
Penicillium digitatum	180C	4.0 ± 0.8	5.0 ± 0.9	6.0 ± 1.1	9.0 ± 1.2	9.0 ± 1.1	10.0 ± 1.1	11.0 ± 1.1
	300C	5.0 ± 1.2	7.0 ± 1.1	8.0 ± 1.3	11.0 ± 2.1	14.0 ± 1.8	18.0 ± 1.3	20.0 ± 1.2
	350C	5.0 ± 0.9	6.0 ± 1.2	7.0 ± 1.2	8.0 ± 1.2	10.0 ± 0.7	10.0 ± 0.7	10.0 ± 0.1
	400C	3.0 ± 0.1	3.0 ± 0.1	4.0 ± 0.7	6.0 ± 1.2	7.0 ± 1.2	8.0 ± 1.1	10.0 ± 1.1
Penicillium expansum	180C	3.0 ± 0.9	5.0 ± 0.7	8.0 ± 1.1	13.0 ± 1.4	15.0 ± 1.1	17.0 ± 2.1	22.0 ± 1.8
	300C	5.0 ± 1.1	5.0 ± 0.7	11.0 ± 1.9	13.0 ± 1.6	14.0 ± 1.3	17.0 ± 1.8	18.0 ± 1.7
	350C	4.0 ± 0.9	8.0 ± 1.2	7.0 ± 1.7	8.0 ± 1.6	12.0 ± 1.1	12.0 ± 1.1	12.0 ± 1.1
	400C	3.0 ± 0.8	5.0 ± 1.1	4.0 ± 1.1	6.0 ± 1.1	6.0 ± 1.1	7.0 ± 1.7	8.0 ± 1.3
Fusarium moniliforme	180C	6.0 ± 1.7	11.0 ± 1.7	24.0 ± 1.3	33.0 ± 1.2	46.0 ± 1.8	61.0 ± 1.4	70.0 ± 1.6
	300C	14.0 ± 1.8	24.0 ± 2.8	40.0 ± 2.1	56.0 ± 1.6	69.0 ± 1.2	83.0 ± 1.3	90.0 ± 0.0
	350C	8.0 ± 2.1	9.0 ± 1.8	11.0 ± 1.1	11.0 ± 1.1	11.0 ± 1.1	13.0 ± 2.1	19.0 ± 2.3
	400C	3.0 ± 0.2	3.0 ± 0.2	4.0 ± 0.7	6.0 ± 1.5	6.0 ± 1.5	7.0 ± 1.7	9.0 ± 1.8

APPENDIX 1e

RADIAL GROWTH OF FUNGAL SPECIES ON MAIZE MEAL AGAR (OBAATANPA) AT DIFFERENT TEMPERATURES

Fungal Species	Temp. 0C	Mean diameter of culture (Mean + S.E) in mm after days 1	2	3	4	5	6	7
Aspergillus flavus	180C	3.0 ± 0.2	6.0 ± 1.1	14.0 ± 0.7	21.0 ± 1.2	26.0 ± 1.7	27.0 ± 0.7	37.0 ± 1.2
	300C	12.0 ± 1.2	21.0 ± 1.7	29.0 ± 1.2	30.0 ± 1.4	30.0 ± 1.8	47.0 ± 0.6	38.0 ± 1.4
	350C	11.0 ± 1.5	16.0 ± 1.9	23.0 ± 1.4	32.0 ± 1.3	32.0 ± 1.4	37.0 ± 1.4	54.0 ± 1.2
	400C	6.0 ± 0.7	8.0 ± 0.7	8.0 ± 0.6	8.0 ± 0.7	8.0 ± 0.7	25.0 ± 2.1	10.0 ± 0.9
Aspergillus giganteus	180C	4.0 ± 1.2	8.0 ± 0.8	14.0 ± 0.7	17.0 ± 1.1	24.0 ± 1.2	30.0 ± 1.1	29.0 ± 1.2
	300C	10.0 ± 1.7	14.0 ± 1.2	21.0 ± 1.1	28.0 ± 1.6	30.0 ± 1.2	30.0 ± 2.1	38.0 ± 1.1
	350C	7.0 ± 0.4	9.0 ± 1.0	12.0 ± 0.7	13.0 ± 0.7	13.0 ± 0.8	33.0 ± 0.3	23.0 ± 1.4
	400C	4.0 ± 0.2	4.0 ± 0.2	4.0 ± 0.2	8.0 ± 0.7	8.0 ± 0.7	14.0 ± 0.7	9.0 ± 0.9
Aspergillus ochraceus = *A. alutaceus*	180C	3.0 ± 0.7	4.0 ± 0.7	8.0 ± 1.1	15.0 ± 0.9	20.0 ± 0.8	27.0 ± 1.1	42.0 ± 1.3
	300C	6.0 ± 0.9	10.0 ± 0.9	16.0 ± 1.0	21.0 ± 0.9	21.0 ± 0.9	24.0 ± 1.3	24.0 ± 1.3
	350C	5.0 ± 0.2	14.0 ± 0.7	25.0 ± 2.1	28.0 ± 1.4	41.0 ± 1.7	49.0 ± 1.6	54.0 ± 1.8
	400C	3.0 ± 0.3	5.0 ± 1.1	7.1 ± 0.7	9.0 ± 0.7	9.0 ± 0.8	9.0 ± 0.8	11.0 ± 1.0
Paecilomyces carneus	180C	12.0 ± 1.1	21.0 ± 1.4	35.0 ± 1.6	46.0 ± 0.9	55.0 ± 1.9	77.0 ± 1.2	81.0 ± 1.2
	300C	20.0 ± 2.1	30.0 ± 1.6	45.0 ± 1.8	55.0 ± 1.8	64.0 ± 2.1	82.0 ± 1.6	89.0 ± 2.4
	350C	14.0 ± 2.3	16.0 ± 1.7	19.0 ± 0.8	19.0 ± 0.5	19.0 ± 0.8	19.0 ± 0.8	20.0 ± 1.2
	400C	5.0 ± 1.0	5.0 ± 1.0	5.0 ± 1.0	9.0 ± 1.0	9.0 ± 1.0	10.0 ± 1.2	11.0 ± 1.1
Paecilomyces puntoni	180C	5.0 ± 0.7	18.0 ± 1.2	45.0 ± 2.1	70.0 ± 2.1	73.0 ± 1.2	88.0 ± 1.2	90.0 ± 0.0
	300C	72.0 ± 1.2	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
	350C	65.0 ± 2.1	76.0 ± 1.1	88.0 ± 0.9	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
	400C	29.0 ± 1.6	42.0 ± 1.7	88.0 ± 1.2	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
Paecilomyces varioti	180C	11.0 ± 1.2	18.0 ± 1.2	30.0 ± 1.6	40.0 ± 2.1	49.0 ± 1.1	64.0 ± 0.7	74.0 ± 1.2
	300C	13.0 ± 1.5	26.0 ± 1.4	40.0 ± 1.7	51.0 ± 1.6	60.0 ± 1.2	71.0 ± 0.9	81.0 ± 1.8
	350C	4.0 ± 0.7	4.0 ± 0.7	5.0 ± 1.8	5.0 ± 1.6	6.0 ± 1.3	7.0 ± 1.1	7.0 ± 1.1
	400C	4.0 ± 0.7	4.0 ± 0.7	4.0 ± 0.7	4.0 ± 0.7	5.0 ± 0.9	5.0 ± 0.9	5.0 ± 0.9
Penicillium digitatum	180C	4.0 ± 0.8	5.0 ± 0.9	6.0 ± 1.1	9.0 ± 1.2	9.0 ± 1.1	10.0 ± 1.1	11.0 ± 1.1
	300C	5.0 ± 1.2	7.0 ± 1.1	8.0 ± 1.3	11.0 ± 2.1	14.0 ± 1.8	18.0 ± 1.3	20.0 ± 1.2
	350C	5.0 ± 0.9	6.0 ± 1.2	7.0 ± 1.2	8.0 ± 1.2	10.0 ± 0.7	10.0 ± 0.7	10.0 ± 0.1
	400C	3.0 ± 0.1	3.0 ± 0.1	4.0 ± 0.7	6.0 ± 1.2	7.0 ± 1.2	8.0 ± 1.1	10.0 ± 1.1
Penicillium expansum	180C	3.0 ± 0.9	5.0 ± 0.7	8.0 ± 1.1	13.0 ± 1.4	15.0 ± 1.1	17.0 ± 2.1	22.0 ± 1.8
	300C	5.0 ± 1.1	5.0 ± 0.7	11.0 ± 1.9	13.0 ± 1.6	14.0 ± 1.3	17.0 ± 1.8	18.0 ± 1.7
	350C	4.0 ± 0.9	8.0 ± 1.2	7.0 ± 1.7	8.0 ± 1.6	12.0 ± 1.1	12.0 ± 1.1	12.0 ± 1.1
	400C	3.0 ± 0.8	5.0 ± 1.1	4.0 ± 1.1	6.0 ± 1.1	6.0 ± 1.1	7.0 ± 1.7	8.0 ± 1.3
Fusarium moniliforme	180C	6.0 ± 1.7	11.0 ± 1.7	24.0 ± 1.3	33.0 ± 1.2	46.0 ± 1.8	61.0 ± 1.4	70.0 ± 1.6
	300C	14.0 ± 1.8	24.0 ± 2.8	40.0 ± 2.1	56.0 ± 1.6	69.0 ± 1.2	83.0 ± 1.3	90.0 ± 0.0
	350C	8.0 ± 2.1	9.0 ± 1.8	11.0 ± 1.1	11.0 ± 1.1	11.0 ± 1.1	13.0 ± 2.1	19.0 ± 2.3
	400C	3.0 ± 0.2	3.0 ± 0.2	4.0 ± 0.7	6.0 ± 1.5	6.0 ± 1.5	7.0 ± 1.7	9.0 ± 1.8

APPENDIX If

RADIAL GROWTH OF FUNGAL SPECIES ON MAIZE MEAL AGAR (OBAATANPA) AT DIFFERENT TEMPERATURES

Fungal Species	Temp. 0C	Mean diameter of culture (Mean + S.E) in mm after days 1	2	3	4	5	6	7
Aspergillus flavus	180C	8.0 ± 2.1	15.0 ± 3.2	22.0 ± 3.4	28.0 ± 2.3	33.0 ± 2.5	37.0 ± 1.8	43.0 ± 2.6
	300C	26.0 ± 2.3	38.0 ± 2.7	52.0 ± 3.1	65.0 ± 1.8	72.0 ± 1.8	78.0 ± 2.2	90.0 ± 0.0
	350C	23.0 ± 1.6	30.0 ± 1.9	41.0 ± 2.4	43.0 ± 3.1	45.0 ± 2.9	51.0 ± 3.0	59.0 ± 2.8
	400C	7.0 ± 1.3	8.0 ± 1.7	10.0 ± 1.8	10.0 ± 1.8	13.0 ± 2.1	13.0 ± 2.1	14.0 ± 3.0
Aspergillus giganteus	180C	8.0 ± 2.4	13.0 ± 1.8	18.0 ± 3.1	25.0 ± 2.6	31.0 ± 2.5	36.0 ± 3.1	40.0 ± 1.8
	300C	18.0 ± 2.5	29.0 ± 1.8	35.0 ± 1.4	39.0 ± 2.1	51.0 ± 2.6	57.0 ± 1.8	63.0 ± 2.2
	350C	8.0 ± 0.9	10.0 ± 1.1	11.0 ± 1.2	11.0 ± 1.2	11.0 ± 1.2	12.0 ± 1.8	13.0 ± 2.1
	400C	2.0 ± 0.9	3.0 ± 1.0	3.0 ± 1.0	3.0 ± 1.0	4.0 ± 1.1	4.0 ± 1.1	4.0 ± 1.1
Aspergillus ochraceus = A. alutaceus	180C	7.0 ± 1.2	14.0 ± 1.6	18.0 ± 1.8	28.0 ± 2.0	36.0 ± 2.1	39.0 ± 2.3	39.2 ± 2.3
	300C	10.0 ± 1.8	15.0 ± 2.1	21.0 ± 2.3	27.0 ± 2.5	33.0 ± 2.1	38.0 ± 3.1	44.0 ± 2.1
	350C	3.0 ± 1.2	4.0 ± 1.6	5.0 ± 1.3	5.0 ± 1.3	5.0 ± 1.3	5.0 ± 1.3	5.0 ± 1.3
	400C	3.0 ± 1.6	3.0 ± 1.6	4.0 ± 1.8	5.0 ± 1.7	5.0 ± 1.7	5.0 ± 1.7	5.0 ± 1.7
Paecilomyces carneus	180C	10.0 ± 1.3	34.0 ± 1.8	36.0 ± 1.7	44.0 ± 2.7	52.0 ± 3.1	59.0 ± 3.2	67.0 ± 3.5
	300C	75.0 ± 2.8	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
	350C	63.0 ± 2.3	89.0 ± 0.7	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
	400C	3.0 ± 1.0	3.0 ± 1.0	5.0 ± 1.2	5.0 ± 1.2	6.0 ± 1.3	6.0 ± 1.3	6.0 ± 1.3
Paecilomyces puntoni	180C	3.0 ± 0.7	16.0 ± 1.2	40.0 ± 2.2	60.0 ± 2.4	71.0 ± 2.5	89.0 ± 1.1	90.0 ± 0.0
	300C	75.0 ± 1.2	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
	350C	63.0 ± 1.4	89.0 ± 0.8	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
	400C	37.0 ± 2.3	45.0 ± 2.4	79.0 ± 2.5	88.0 ± 0.9	90.0 ± 0.0	90.0 ± 0.0	90.0 ± 0.0
Paecilomyces varioti	180C	21.0 ± 1.8	30.0 ± 1.6	42.0 ± 2.1	52.0 ± 2.0	59.0 ± 1.8	66.0 ± 2.1	81.0 ± 2.2
	300C	23.0 ± 1.4	31.0 ± 1.8	38.0 ± 3.1	45.0 ± 3.2	53.0 ± 2.3	60.0 ± 1.1	68.0 ± 3.1
	350C	4.0 ± 1.2	5.0 ± 1.5	5.0 ± 1.5	5.0 ± 1.5	5.0 ± 1.5	5.0 ± 1.5	6.0 ± 1.7
	400C	3.0 ± 1.4	4.0 ± 1.6	4.0 ± 1.6	4.0 ± 1.6	4.0 ± 1.6	4.0 ± 1.6	5.0 ± 1.8
Penicillium digitatum	180C	6.0 ± 1.3	8.0 ± 1.5	10.0 ± 1.6	12.0 ± 1.9	12.0 ± 2.1	15.0 ± 1.4	15.0 ± 1.4
	300C	11.0 ± 2.7	16.0 ± 2.8	21.0 ± 3.2	25.0 ± 3.7	29.0 ± 4.1	33.0 ± 3.5	36.0 ± 2.8
	350C	5.0 ± 1.2	5.0 ± 1.2	7.0 ± 1.4	8.0 ± 1.3	9.0 ± 1.8	11.0 ± 2.1	11.0 ± 2.1
	400C	2.0 ± 0.9	3.0 ± 1.1	3.0 ± 1.1	4.0 ± 1.4	4.0 ± 1.4	5.0 ± 1.8	9.0 ± 1.8
Penicillium expansum	180C	6.0 ± 1.2	8.0 ± 2.1	9.0 ± 1.8	10.0 ± 1.2	10.0 ± 1.2	11.0 ± 1.4	14.0 ± 1.6
	300C	9.0 ± 1.5	13.0 ± 1.7	17.0 ± 1.3	19.0 ± 1.4	19.0 ± 1.4	24.0 ± 1.7	26.0 ± 1.8
	350C	5.0 ± 1.1	5.0 ± 1.1	7.0 ± 1.4	7.0 ± 1.4	8.0 ± 1.3	10.0 ± 1.8	10.0 ± 1.8
	400C	3.0 ± 0.8	3.0 ± 0.8	3.0 ± 0.8	4.0 ± 1.1	4.0 ± 1.1	5.0 ± 1.7	5.0 ± 1.7
Fusarium moniliforme	180C	130 ± 2.1	24.0 ± 2.3	36.0 ± 2.5	45.0 ± 3.8	61.0 ± 4.3	67.0 ± 3.4	78.0 ± 2.9
	300C	25.0 ± 1.8	41.0 ± 2.3	56.0 ± 2.4	70.0 ± 3.2	81.0 ± 2.8	86.0 ± 3.2	89.0 ± 0.0
	350C	7.0 ± 1.3	11.0 ± 2.1	13.0 ± 2.3	19.0 ± 2.1	19.0 ± 2.1	19.0 ± 2.1	19.0 ± 2.1
	400C	4.0 ± 0.8	4.0 ± 0.5	5.0 ± 1.2	5.0 ± 1.2	7.0 ± 1.5	8.0 ± 1.8	8.0 ± 1.8

APPENDIX 2A

INFLUENCE OF THE METABOLITES OF INDICATED *PAECILOMYCES* SPECIES ON HEIGHT, LENGTH OF LEAF AND WIDTH OF LEAF OF MAIZE VARIETIES (*GREENHOUSE*) AT 28-31°C

MAIZE VARIETY	TREATMENT	PLANT PARTS	PERIOD OF GROWTH IN (DAYS) MEASUREMENT OF PLANTS PARTS (MM) 7	21	35	42	56
		Height	83	114	144	169	187
	Control	Leaf length	220	333	430	469	487
	(Distilled H_2O)	Leaf width	15	17	19	22	26
ABELEEHI							
	Paecilomyces	Height	84	103	133	150	170
	Carneus	Leaf length	220	322	415	430	455
		Leaf width	19	21	22	24	26
	P. puntoni	Height	83	108	130	163	183
		Leaf length	202	324	412	435	459
		Leaf width	15	17	18	19	21
	P. varioti	Height	82	109	140	157	177
		Leaf length	237	365	431	451	471
		Leaf width	17	18	19	21	24
	Control	Height	102	118	186	223	225
	(Distilled H_2O	Leaf length	260	384	479	522	534
		Leaf width	23	25	28	30	33
OBAATANPA							
	Paecilomyces	Heigth	94	112	154	169	179
	Carneus	Leaf length	238	354	463	489	499
		Leaf width	18	20	21	23	25
	P. puntoni	Height	87	110	148	163	173
		Leaf length	238	355	454	477	489
		Leaf width	18	21	22	25	28
	P. varioti	Height	101	122	155	167	177
		Leaf length	269	371	465	472	492
		Leaf width	19	23	25	28	32

APPENDIX 2B

INFLUENCE OF THE METABOLITES OF INDICATED *PAECILOMYCES* SPECIES ON HEIGHT, LENGTH OF LEAF AND WIDTH OF LEAF OF MAIZE VARIETIES (*IN THE FIELD*) AT 28-31°C

MAIZE VARIETY	TREATMENT	PLANT PARTS	PERIOD OF GROWTH IN (DAYS) MEASUREMENT OF PLANTS PARTS (MM)				
			7	21	35	42	56
		Height	83	90	123	169	188
	Control	Leaf length	276	282	420	479	492
	(Distilled H_2O)	Leaf width	16	20	33	42	52
ABELEEHI							
	Paecilomyces	Height	70	84	85	108	163
	Carneus	Leaf length	210	240	276	395	440
		Leaf width	18	22	28	32	38
	P. puntoni	Height	68	70	100	148	162
		Leaf length	222	241	318	457	465
		Leaf width	18	21	32	43	44
	P. varioti	Height	68	72	101	120	141
		Leaf length	204	215	314	415	428
		Leaf width	17	21	28	37	40
	Control	Height	77	95	188	264	335
	(Distilled H_2O	Leaf length	270	330	404	587	653
		Leaf width	20	23	54	65	73
OBAATANPA							
	Carneus	Heigth	72	93	120	123	142
		Leaf length	201	295	324	353	361
		Leaf width	19	20	37	38	41
	P. puntoni	Height	65	96	121	134	152
		Leaf length	221	270	360	393	402
		Leaf width	18	20	33	35	37
	P. varioti	Height	67	81	101	125	141
		Leaf length	201	231	296	323	346
		Leaf width	18	20	31	33	35

APPENDIX 2C

INFLUENCE OF THE METABOLITES OF INDICATED *PAECILOMYCES* SPECIES ON DRY MATTER ACCUMULATION BY LEAVES, SHOOTS AND ROOTS OF MAIZE VARIETIES (*GREENHOUSE*) AT 28-31°C

MAIZE VARIETY	TREATMENT		PERIOD OF GROWTH IN (DAYS) MEASUREMENT OF PLANTS PARTS (MM)				
			7	21	35	42	56
		Leaf	189	200	345	555	685
	Control	Shoot	39	48	125	145	165
	(Distilled H_2O)	Root	51	70	100	135	155
ABELEEHI							
	Paecilomyces	Leaf	110	180	425	565	640
	Carneus	Shoot	40	51	105	110	130
		Root	32	45	85	125	145
	P. puntoni	Leaf	112	190	330	520	637
		Shoot	32	45	85	103	123
		Root	11	16	20	40	70
	P. varioti	Leaf	175	233	360	560	660
		Shoot	36	46	100	140	160
		Root	29	35	65	85	105
	Control	Leaf	88	260	545	653	683
	(Distilled H_2O	Shoot	80	115	185	235	265
		Root	59	75	105	140	165
OBAATANPA							
	Paecilomyces	Leaf	41	245	445	520	550
	Carneus	Shoot	78	110	160	185	215
		Root	59	65	105	115	125
	P. puntoni	Leaf	92	208	395	625	648
		Shoot	59	120	175	215	240
		Root	25	39	45	75	108
	P. varioti	Leaf	76	210	370	410	490
		Shoot	69	100	165	210	262
		Root	50	59	75	90	115

APPENDIX 3a

CULTURE FILTRATE OF *PAECILOMYCES PUNTONI* GROWING IN POTATO DEXTROSE BROTH USED AS GERMINATION MEDIUM FOR MAIZE VARIETIES - ABELEEHI AND OBAATANPA

DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL	DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL
2 - DAY OLD			
(ABELEEHI)		(OBAATANPA)	
UNDILUTED	36	UNDILUTED	40
1:1	46	1:1	56
1:2	53	1:2	67
1:5	91	1:5	80
1:10	97	1:10	100
4 - DAY OLD			
UNDILUTED	26	UNDILUTED	24
1:1	33	1:1	24
1:2	48	1:2	38
1:5	65	1:5	73
1:10	76	1:10	76
8 DAY OLD			
UNDILUTED	40	UNDILUTED	54
1:1	58	1:1	65
1:2	78	1:2	81
1:5	85	1:5	84
1:10	96	1:10	94

APPENDIX 3b

CULTURE FILTRATE OF *PAECILOMYCES PUNTONI* GROWING ON MAIZE MEAL BROTH (ABELEEHI) USED AS GERMINATION MEDIUM FOR MAIZE VARIETIES - ABELEEHI AND OBAATANPA

DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL	DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL
2 - DAY OLD			
(ABELEEHI)		(OBAATANPA)	
UNDILUTED	25	UNDILUTED	23
1:1	30	1:1	30
1:2	39	1:2	34
1:5	61	1:5	40
1:10	94	1:10	61
4 - DAY OLD			
UNDILUTED	29	UNDILUTED	39
1:1	35	1:1	50
1:2	47	1:2	49
1:5	62	1:5	67
1:10	80	1:10	79
8 DAY OLD			
UNDILUTED	40	UNDILUTED	48
1:1	48	1:1	52
1:2	66	1:2	62
1:5	69	1:5	69
1:10	92	1:10	74

APPENDIX 3c

CULTURE FILTRATE OF *PAECILOMYCES PUNTONI* GROWING ON POTATO DEXTROSE BROTH USED AS GERMINATION MEDIUM FOR MAIZE VARIETIES - ABELEEHI AND OBAATANPA

DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL	DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL
2 - DAY OLD			
	(ABELEEHI)		(OBAATANPA)
UNDILUTED	25		
1:1	30	UNDILUTED	23
1:2	39	1:1	30
1:5	61	1:2	34
1:10	94	1:5	40
		1:10	61
4 - DAY OLD			
UNDILUTED	23	UNDILUTED	29
1:1	35	1:1	37
1:2	45	1:2	54
1:5	50	1:5	61
1:10	85	1:10	83
8 DAY OLD			
UNDILUTED	55	UNDILUTED	45
1:1	63	1:1	63
1:2	92	1:2	63
1:5	93	1:5	83
1:10	95	1:10	85

APPENDIX 3d

CULTURE FILTRATE OF *FUSARIUM MONILIFORME* GROWING ON POTATO DEXTROSE BROTH USED AS GERMINATION MEDIUM FOR MAIZE VARIETIES - ABELEEHI AND OBAATANPA

DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL	DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL
2 - DAY OLD			
	(ABELEEHI)		(OBAATANPA)
UNDILUTED	22		
1:1	25	UNDILUTED	21
1:2	61	1:1	30
1:5	85	1:2	46
1:10	95	1:5	86
		1:10	98
4 - DAY OLD			
UNDILUTED	12	UNDILUTED	16
1:1	33	1:1	28
1:2	69	1:2	47
1:5	72	1:5	60
1:10	83	1:10	90
8 DAY OLD			
UNDILUTED	56	UNDILUTED	58
1:1	74	1:1	73
1:2	82	1:2	82
1:5	92	1:5	88
1:10	95	1:10	95

APPENDIX 3e

CULTURE FILTRATE OF *FUSARIUM MONILIFORME* GROWING ON MAIZE MEAL BROTH (ABELEEHI) USED AS GERMINATION MEDIUM FOR MAIZE VARIETIES - ABELEEHI AND OBAATANPA

DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL	DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL
2 - DAY OLD			
	(ABELEEHI)		(OBAATANPA)
UNDILUTED	22		
1:1	25	UNDILUTED	19
1:2	33	1:1	24
1:5	73	1:2	53
1:10	87	1:5	69
		1:10	78
4 - DAY OLD			
UNDILUTED	19	UNDILUTED	20
1:1	65	1:1	29
1:2	67	1:2	54
1:5	81	1:5	56
1:10	92	1:10	82
8 DAY OLD			
UNDILUTED	10	UNDILUTED	20
1:1	58	1:1	45
1:2	86	1:2	79
1:5	96	1:5	88
1:10	92	1:10	95

APPENDIX 3f

CULTURE FILTRATE OF *FUSARIUM MONILIFORME* GROWING ON MAIZE MEAL BROTH (OBAATANPA) USED AS GERMINATION MEDIUM FOR MAIZE VARIETIES - ABELEEHI AND OBAATANPA

DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL	DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL
2 - DAY OLD			
	(ABELEEHI)		(OBAATANPA)
UNDILUTED	29		
1:1	34	UNDILUTED	23
1:2	61	1:1	53
1:5	84	1:2	65
1:10	89	1:5	72
		1:10	84
4 - DAY OLD			
UNDILUTED	22	UNDILUTED	44
1:1	55	1:1	68
1:2	64	1:2	72
1:5	72	1:5	80
1:10	81	1:10	90
8 DAY OLD			
UNDILUTED	23	UNDILUTED	21
1:1	35	1:1	39
1:2	64	1:2	64
1:5	80	1:5	71
1:10	86	1:10	81

APPENDIX 3g

CULTURE FILTRATE OF *PENICILLIUM DIGITATUM* GROWING ON MAIZE MEAL GROWTH (ABELEEHI) USED AS GERMINATION MEDIUM FOR MAIZE VARIETIES - ABELEEHI AND OBAATANPA

DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL	DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL
2 - DAY OLD			
	(ABELEEHI)		(OBAATANPA)
UNDILUTED	30		
1:1	32	UNDILUTED	33
1:2	50	1:1	58
1:5	59	1:2	69
1:10	64	1:5	71
		1:10	94
4 - DAY OLD			
UNDILUTED	16	UNDILUTED	16
1:1	26	1:1	47
1:2	57	1:2	70
1:5	81	1:5	76
1:10	97	1:10	93
8 DAY OLD			
UNDILUTED	15	UNDILUTED	21
1:1	30	1:1	23
1:2	32	1:2	37
1:5	37	1:5	51
1:10	56	1:10	60

APPENDIX 3h

CULTURE FILTRATE OF *PENICILLIUM DIGITATUM* GROWING ON MAIZE MEAL GROWTH (OBAATANPA) USED AS GERMINATION MEDIUM FOR MAIZE VARIETIES - ABELEEHI AND OBAATANPA

DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL	DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL
2 - DAY OLD			
	(ABELEEHI)		(OBAATANPA)
UNDILUTED	36		
1:1	42	UNDILUTED	39
1:2	64	1:1	50
1:5	85	1:2	63
1:10	97	1:5	83
		1:10	96
4 - DAY OLD			
UNDILUTED	21	UNDILUTED	20
1:1	38	1:1	28
1:2	52	1:2	36
1:5	77	1:5	57
1:10	83	1:10	84
8 DAY OLD			
UNDILUTED	25	UNDILUTED	25
1:1	42	1:1	48
1:2	50	1:2	63
1:5	69	1:5	75
1:10	81	1:10	79

APPENDIX 3i

CULTURE FILTRATE OF *PENICILLIUM DIGITATION* GROWING ON POTATO DEXTROSE BROTH USED AS GERMINATION MEDIUM FOR MAIZE VARIETIES - ABELEEHI AND OBAATANPA

DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL	DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL
2 - DAY OLD			
	(ABELEEHI)		(OBAATANPA)
UNDILUTED	33		
1:1	36	UNDILUTED	31
1:2	61	1:1	51
1:5	64	1:2	65
1:10	69	1:5	82
		1:10	90
4 - DAY OLD			
UNDILUTED	18	UNDILUTED	17
1:1	41	1:1	33
1:2	64	1:2	67
1:5	70	1:5	73
1:10	85	1:10	97
8 DAY OLD			
UNDILUTED	16	UNDILUTED	21
1:1	31	1:1	26
1:2	36	1:2	38
1:5	40	1:5	52
1:10	71	1:10	74

APPENDIX 3j

CULTURE FILTRATE OF *ASPERGILLUS OCHRACEUS* GROWING ON MAIZE MEAL BROTH (OBAATANPA) USED AS GERMINATION MEDIUM FOR MAIZE VARIETIES - ABELEEHI AND OBAATANPA

DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL	DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL
2 - DAY OLD			
	(ABELEEHI)		(OBAATANPA)
UNDILUTED	40		
1:1	50	UNDILUTED	57
1:2	55	1:1	62
1:5	60	1:2	76
1:10	80	1:5	86
		1:10	95
4 - DAY OLD			
UNDILUTED	20	UNDILUTED	28
1:1	33	1:1	43
1:2	48	1:2	54
1:5	75	1:5	69
1:10	82	1:10	70
8 DAY OLD			
UNDILUTED	32	UNDILUTED	26
1:1	44	1:1	51
1:2	63	1:2	67
1:5	84	1:5	82
1:10	88	1:10	93

APPENDIX 3k

CULTURE FILTRATE OF *ASPERGILLUS OCHRACEUS* GROWING ON POTATO DEXTROSE BROTH (OBAATANPA) USED AS GERMINATION MEDIUM FOR MAIZE VARIETIES - ABELEEHI AND OBAATANPA

DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL	DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL
2 - DAY OLD			
	(ABELEEHI)		(OBAATANPA)
UNDILUTED	36		
1:1	45	UNDILUTED	44
1:2	47	1:1	56
1:5	82	1:2	78
1:10	91	1:5	83
		1:10	89
4 - DAY OLD			
UNDILUTED	24	UNDILUTED	25
1:1	29	1:1	29
1:2	35	1:2	43
1:5	39	1:5	55
1:10	57	1:10	61
8 DAY OLD			
UNDILUTED	48	UNDILUTED	52
1:1	54	1:1	87
1:2	72	1:2	90
1:5	80	1:5	95
1:10	94	1:10	97

APPENDIX 31

CULTURE FILTRATE OF *ASPERGILLUS OCHRACEUS* GROWING ON MAIZE MEAL BROTH (ABELEEHI) **USED AS GERMINATION MEDIUM FOR MAIZE VARIETIES - ABELEEHI AND OBAATANPA**

DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL	DILUTION RATIO	RADICLE LENGTH AS % OF CONTROL
2 - DAY OLD			
	(ABELEEHI)		(OBAATANPA)
UNDILUTED	38		
1:1	50	UNDILUTED	70
1:2	54	1:1	76
1:5	65	1:2	81
1:10	77	1:5	90
		1:10	95
4 - DAY OLD			
UNDILUTED	20	UNDILUTED	6
1:1	22	1:1	16
1:2	35	1:2	28
1:5	41	1:5	30
1:10	74	1:10	80
8 DAY OLD			
UNDILUTED	21	UNDILUTED	18
1:1	31	1:1	36
1:2	72	1:2	55
1:5	81	1:5	73
1:10	97	1:10	83