STUDIES ON THE MYCOFLORA AND SOME PHYSICAL CHARACTERISTICS OF GHANAIAN MAIZE (*Zea mays* L) VARIETIES AND THE EFFECT OF EXTRACTS OF *ZANTHOXYLUM XANTHOXYLOIDES* LAM AND *KIGELIA AFRICANA* BENTH ON SOME OF THE CONTAMINANT FUNGI

BY

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DECLARATION

I hereby declare that, except for reference to other peoples' work which have been duly cited, this work is the result of my own original research work and that this thesis has neither in whole nor in part been presented for another degree elsewhere.

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Date: 28/12/95

DEDICATION

Dedicated to the Almighty God for His grace and guidance throughout this study, and making my dreams of acquiring university education a reality.

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ABSTRACT

Mycoflora of mixed maize grains and the newly developed Abeleehi and Obaatanpa varieties and airspora in the Warehouse of the Ghana Food Distribution, GFDC, at Balduzzi, Kumasi have been studied under normal and simulated ambient Environmental Relative Humidities (ERH's) representative of the Ghanaian conditions. Some important physical and processing characteristics of normal stackburned white and yellow maize (seed water absorption, swelling index, 1000-seed weight, fermentation parameters) and germination capacity of grains were also examined. To ascertain the ability of Abeleehi and Obaatanpa varieties to absorb and desorb moisture in relation to the development of attendant resident fungi, the moisture sorption isotherm at ERH's 55-95% were determined in simulated humidity chambers. Finally results of the use of aqueous, acetone and methanolic extracts of the dry leaves of *Zanthoxylum xanthoxyloides* and the dry leaves and dry fruit of *Kigelia africana* as biofungicides to control vegetative growth and sporulation of important potential pathogenic fungi *(Paecilomyces carneus, P.puntoni, P.varioti, Curvularia lunata, Fusarium moniliforme* and *Penicillium digitatum)* resident in Abeleehi and Obaatanpa varieties are reported.

Fifteen different fungal species *(Aspergillus flavus, A.niger, A.sulphureus, A.tamarii, Penicillium brevicompactum, P.chrysogenum, P.citrinum, P.cyclopium, P.digitatum, P.glabrum, P.oxalicum, Cladosporium herbarum, Fusarium moniliforme, F.roseum and Mucor haemalis)* were isolated from maize grains obtained from the GFDC Warehouse at Balduzzi, Kumasi. *Aspergillus species (A.flavus, A.niger, A.sulphureus, A.tamarii)* and *Penicillium species (Penicillium brevicompactum, P.chrysogenum, P.citrinum, P.cyclopium, P.digitatum)* predominated. The initial fungal population in the mixed grain variety was 4.8 - 5.4 $\log_{10}$ CFU/g but this decreased by 0.4 - 1.3 log cycle after 2 months. There was no statistical difference ($P < 0.05$) between the population of fungi isolated from grains sampled from the top, middle and bottom of the bagstacks. *Aspergillus flavus* was the most predominant fungi encountered constituting 41.7 - 44.0% of the species followed by *Mucor haemalis* (4.0 - 20.5%). Both *A.flavus* and *M.haemalis* occurred at all positions sampled. Twenty four different airspora of fungi *(Aspergillus flavus, A.clavatus, A.fumigatus, A.niger,*

A.ochraceus, A.parasiticus, A.sulphureus, A.tamarii, Penicillium chrysogenum, P.citrinum, P.cyclopium, P.digitatum, P.expansum, P.italicum, P.oxalicum Paecilomyces carneus, P.puntonii, P.varioti, Cladosporium herbarum, Curvularia lunata, Fusarium moniliforme, Mucor haemalis, Neurospora sitophila, Rhizopus oryzae) were isolated from the Balduzzi Warehouse. Species of airspora that were not found in the grains were *A.clavatus, A.ochraceus, A.parasiticus, A.fumigatus, P.expansum, Paecilomyces carneus, P.puntoni, P.varioti, Curvularia lunata* and *Rhizopus oryzae*. Generally mycological media used and the method used in isolation influenced the profile of fungal species encountered.

Thirty and 28 fungal species belonging to 13 genera were isolated from Abeleehi and Obaatanpa varieties respectively, and they are being recorded for the first time in Abeleehi and Obaatanpa varieties. The species diversity was influenced by grain variety, method of isolation, mycological media used, storage humidity and whether the grains were exposed in petri dishes or in woven polypropylene sachets. *A.flavus* was ubiquitous and was isolated from both Abeleehi and Obaatanpa stored at 55-95% ERH in both open Petri dishes and in woven polypropylene sachets; *Fusarium moniliforme* was encountered at ERH's 65-95% in open Petri dishes but not at 65 and 75 ERH in woven polypropylene sachets. Xerophilic species, like *Aspergillus giganteus, P.carneus, P.puntoni and P.varioti* were isolated at 55-65% ERH in both grain varieties. There was no statistical difference (analysis of variance $P.< 0.05$) between germination capacity of Abeleehi grains stored in woven polypropylene sachets at ERH 55-85%; seed germination was drastically reduced at 90 and 95% ERH after 2 months storage period. Data on grains kept exposed in Petri dishes to the same ERH's were similar. The same trend as above was observed for Obaatanpa grains. The storage ERH influenced the length of the emerging radicles of the germinating grains such that the higher the incubating ERH, the shorter the length of the emerging radicle. At ERH 95% radicle length was reduced by 39-69% (depending on the maize variety used). There was however a significant ($P< 0.05$) difference between the higher radicle length recorded in grains of both varieties stored in woven polypropylene sachets than same grains exposed in Petri dishes under the same ERH conditions.

Abeleehi and Obaatanpa varieties showed the characteristic sigmoid water absorption patterns of macromolecules. The equilibration period of grains stored at 65-85% ERH was 8-12 days; those stored at 90-95% ERH continued rising while there was decrease in moisture content of grains incubated at 55% ERH for both grain varieties. Analysis of variance to ascertain the influence of ERH, Packaging material (P), incubation period (I) and maize variety (V) on moisture sorption as well as the interaction of these factors showed that P, I and V significantly ($P< 0.05$) influenced moisture sorption. Moisture sorption by Obaatanpa was significantly higher than that of Abeleehi under the same environmental conditions.

Obaatanpa variety had a higher density (1000 - seed weight of 273.9g) than Abeleehi (268.9g); stackburned yellow (329.3 ± 5.4g) and white grains (275.3 ± 2.1g). The moisture content of stackburned grains (13.0 - 13.5 ± 0.1%) did not differ significantly ($P< 0.05$) from the normal grains of the same type (12.0 - 13.5 ± 0.1). Seed length of normal white maize soaked for 48h. was 2-3% greater than that of stackburned white maize. Swelling of normal yellow maize initially lagged behind that of stackburned samples but this was reversed after 24h. soaking resulting in 1-2% increase in seed length over that of the stackburned yellow maize. Similar trends were observed for seed width and seed thickness.

pH profile of wet and dry-milled maize (normal and stackburned) undergoing spontaneous fermentation was generally similar at least during the first 24-48 h. attended by a drop in pH from initial 5.0 - 6.5 to final pH 4.2 - 4.6. Steepwater of normal white maize was more acidic (pH 4.2 -4.3) than stackburned grains (pH 5.1 - 5.2) of the same grain variety.

Aqueous, acetone and methanolic leaf extract of *Zanthoxylum xanthoxyloides* and leaf and fruit extracts of *Kigelia africana* obtained with the same solvents variably prevented or depressed vegetative growth and sporulation by pathogenic fungi *(Paecilomyces carneus, P.puntonii, P.varioti, Fusarium moniliforme, Curvularia lunata, Penicillium digitatum)* in maize meal media amended with the extracts. The efficacy of the extracts in depressing vegetative growth of the test fungi can be

ng order:

Methanol > acetone > aqueous (water)

Extracts of leaf of *K.africana* was more potent at higher concentrations than extracts obtained from its own fruit or the leaf of *Z.xanthoxyloides*. *P. puntonii* appeared to be the most resistant fungus (among the other test fungi) to the biofungicides.

Analysis of variance showed that the effectiveness of the plant extracts of *Z.xanthoxyloides* and *K. africana* in suppressing sporulation of the test fungi at high concentration differed significantly and can be ranked as follows in descending order:

Leaves of *Z.xanthoxyloides* > leaves of *K.africana* > fruit of *K.africana.*

Although each test fungus responded and behaved differently *in vitro*, a fortuitous condition is created in which especially the methanolic extract not only prevent vegetative growth at higher concentration but also prevent sporulation. The possible methods of application of the results from this thesis are discussed and further studies suggested.

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I. INTRODUCTION AND LITERATURE REVIEW

Maize is one of the major cereal crop produced in the world for human consumption, animal feed, industrial processing and as seed for the next growing season. World maize production is estimated to be 526,410 metric tonnes per kilogram per hectare, and that of Ghana is estimated to be 580 metric tonnes per kilogram per hectare (FAO, 1992). Unfortunately, a large proportion of grains produced is lost through the activities of biodeterioration agents. Losses occur at different stages in the movement of grains from the field to the consumer either through improper handling and preservation or attack by insects and fungi and other microorganisms. In West Africa, post-harvest storage losses due to insects attack and microbial spoilage is estimated at 30 per cent (Adams, 1977) of the annual harvest.

Fungi are important spoilage microorganisms in stored foods because they are known to continue their development at the relatively low level of moisture at which most cereal crops are stored. Christensen (1964) recognized two distinct groups among grain mycoflora, namely, field fungi and storage fungi based on their moisture requirements and the stage at which they attack grains. Both field and storage fungi are reported to be present in the food grain at the time of harvest.

Field fungi invade grains or kernels while they are still developing on the plant in the field or after they have matured before they are harvested (Christensen, 1957). At that stage the moisture content of seeds is high and their tissues are metabolically active. Field fungi may be pathogenic or saprophytic in nature and major genera recorded are *Alternaria, Cladosporium, Curvularia, Epicoccum, Fusarium* and *Verticillium* (Christensen, 1957; Malone and Muskett, 1964). *Botryodiplodia theobromae, Fusarium moniliforme* and *Penicillium* sp. were recorded from maize left on the cob as field fungi (Broadbent 1967a, 1967b; Oyeniran, 1972).

Storage fungi are adapted to a life without free water and several common species invade grains stored with water contents of 13-18 per cent (Christensen, 1957). It has been established that storage fungi usually do not invade before harvest (Christensen and Kaufmann, 1969; Christensen, 1971) but they may be found

on the seed in very low percentages, nevertheless, providing inoculum of storage fungi for attack during storage (Tuite, 1959, 1961; Qasem and Christensen, 1958). They may be present in the grain not only as contaminants but as dormant mycelium within the tissues of pericarp or seed coat (Warnock and Preece, 1971).

Among the field and storage mycoflora associated with cereal grain products, members of the genus Aspergillus are the most predominant followed by *Penicillium* (Odamtten, 1981).

The role of storage fungi in quality deterioration of grains although well documented (Christensen, 1957; Christensen and Kaufmann, 1969; Lillehoj et al., 1976;) in the developed countries, there is insufficient information regarding these fungi on maize in West Africa and the role such fungi play in deterioration of food grain.

Generally, maize is stored when sufficiently dried. In the developing countries storage structures serve both for drying and for storage. In Ghana the most widely used modes of storage are storage in the field, farmhouse and storage huts (Neergaard, 1983). Variable traditional storage bins used in different sectors of Ghana have been collated and reviewed by Nyanteng (1972). In addition to these traditional storage structures, concrete, plywood, aluminium and butyl silos are mostly used. Some bulk grains are stored in either ventilated or non-ventilated cement warehouses. In the cement warehouses shelled maize usually in jute and recently in woven polypropylene sacks are stacked on wooden platform to raise the bags above the floor so as to prevent the grain from absorbing moisture from the ground below. Bagstacks are usually placed away from the walls and well below the roofing level to reduce grain damage due to condensation. Bagstacks may also be kept outdoor for many months if protected under tarpaulins. Dry grain that becomes wet by rain or condensation of moisture will heat. Heating may also be caused by insect infestation in either moist or dry grain. Recent adoption of woven polypropylene bags to replace jute for grain storage has introduced another type of heating damage (stackburn) the cause of which are not well understood. There are instances in Africa where dried maize grains of moisture content 12.0 - 12.5% placed in woven polypropylene bags have heated during storage. The internal temperature of the bags rose sharply beyond 40°C and much of the maize grains change colour to a light or dark shade of brown after prolonged storage beyond 5 months. This browning, the cause

of which is not well understood is called 'stackburn'. Cases of maize stackburn in Sub-Saharan Africa have been recorded in Angola, Ghana, Mozambique, Malawi, Tanzania and Zimbabwe. In Ghana, stackburn has been reported in the Warehouses of the Ghana Food Distribution Corporation in Accra, Kumasi and Sunyani.

Studies have indicated that hermetic or airtight structures are better than non-airtight structures for grain storage (Hyde and Okley, 1960). But in silos and storage bins under tropical conditions, even with 10% initial moisture content, thermogenesis, discolouration of grains and fungal growth develop within weeks of storage.

In considering storage potential of grains, the ambient equilibrium relative humidity (ERH) is an important parameter as it determines the amount of water available to microorganisms and hence an indication of the biological activity or potential activity of the product (Ayerst, 1965). Above 75% ERH products absorb moisture rapidly and fungi develop during storage, and heating of the product would produce subsequent deterioration and loss of quality. ERH below 75% is accepted as 'safe' for storage of food commodities eg. cereal grains. Moisture content in equilibrium with 70% ERH has been found to be 'safe' for most tropical crops (Davey and Elcoate, 1965, Hall, 1970; Adesuyi, 1973). The maximum moisture content for 'safe' storage of maize is 12.0 - 13.0% for 1 year and 11% for 5 years (Ross et al., 1979).

In recent years an increasing amount of attention has been given to sorption properties of stored food products with regard to their effect on the storage stability. Under the Ghana Grains and Legume Development Project, the agronomic performance of many improved maize varieties, including Obaatanpa and Abeleehi have been studied. However, there is hardly any information on moisture sorption and mycoflora associated with the newly developed varieties, Obaatanpa and Abeleehi. The pertinent literature is replete with information on the water sorption and desorption characteristics of cereal grains and their products (Chung and PFost, 1967; Labuza, 1968; Multon et al., 1980; Odamtten and Langerak, 1980; Pixton and Warburton, 1971, Babbitt, 1949; Hubbard et al., 1957) and grain Legumes (McCurdy et al., 1980; Chhinnan and Beuchat, 1985). Sorption isotherms are needed to assist in understanding the processing characteristics and storage stability of the grain in question.

In the production of low-moisture cereal grains such as maize, the state of seedwater is important for both processing and storage stability. Improvement of maize for industrial and nutritional quality has received considerable attention of maize breeders over the years. It is therefore necessary to study the processing and storage quality of any improved maize variety to ensure its acceptability by both farmers and consumers. The utilization of maize in Ghana follows a variety of processing procedures, including soaking, dehulling, grinding, roasting, boiling, fermentation and germination (Sefa-Dedeh, 1993). Therefore the performance of maize in each of these processing unit operations should be fully understood to assess its optional utilization. In these investigation the germination capacity, soaking and fermentation properties of Abeleehi and Obaatanpa were assessed. The studies included stackburned and non-stackburned white and yellow maize in order to document the effect of stackburn on the processing and physical characteristics of the grains. Would for instance, stackburnt maize absorb moisture and swells to a greater extent than the normal grain and if so what are the advantages and disadvantages of this finding?.

Maize is processed by dry or wet milling and the products are used in a wide range of foods. The degree of seed water absorption and swelling are important, and these may be used by the food processor to evaluate the acceptability of the grain (Sefa-Dedeh, 1993). Steeping does not only softens the grain, but the process has been associated with it swelling and the initiation of complex biophysical and biochemical changes. Sefa-Dedeh (1993) conducted extensive studies on processing qualities of different maize varieties - Aburotia, Composite W, Diamantes, Dobidi, Dorke, Golden crystal, Hilysine, La Posta, Local, Mixican, Pool 16, Safita and TZE SRW in Ghana. Based on their swelling properties, Local, Composite W, Dorke, Golden crystal, Pool 16, TZE SRW, Aburotia and Dobidi are the varieties classified as having high swelling index and therefore may be used by food processor. His studies did not include Abeleehi and Obaatanpa which are being assessed for the above-mentioned for the first time.

Traditionally, foods are fermented to preserve and increase their shelf life, to get rid of toxic substances, to impart special flavours and sometimes to increase their nutritional value (FAO, 1991). Despite the unhygienic conditions under which many traditional foods are prepared from fermented maize dough, the products are usually free from pathogenic microorganisms. This may be due to the proliferation of lactic acid bacteria

and their production of lactic acid to increase the acid level of the dough. Unlike lactic acid bacteria, most pathogenic microorganisms cannot thrive under high acid conditions (Bruner, 1951; Liggertt and Koffler, 1948). Nketia (1979) reported *Lactobacillus plantarum, L.fermentatum, Leuconostoc mesenteroides, L.lactic* and *Pediococcus cerevisiae* from maize dough as the lactic acid bacteria that initiate and sustain the fermentation. *Aspergillus niger, A.flavus* and yeast were isolated at the later part of the fermentation. The role of microorganisms in fermented maize dough are well documented by many workers (Wayoe, 1987, Mensah et al., 1991; Fapohunda, 1989; Greene et al., 1992; Bothast, 1991). The steeping process gives the impetus for fermentation microorganism to interact and produce chemical environment that preclude the development of pathogenic microorganism. Thus the steeping pH profile for the grains in this thesis were assessed to see if difference in pH would be detected.

The use of chemical grain protectants to control insects and fungi in stored cereals is well known. Application of methyl bromide, picrin, ethylene dibromide: methyl bromide (1:1) besides ammonia and sulphur dioxide for control of grain fungi have been reported (Majumder et al., 1955; Ragunathan et al., 1969; Tsuruta and Ishirava, 1966). For large scale fumigation, methyl bromide (1:3 at 32 g/m^3) has proved to be effective against insects and fungi when applied under tropical conditions. Unfortunately, there is increasing outcry against the use of chemical pesticides. Naturally occurring antifungal and antibacterial compounds in plants have received much attention. Biological and phytochemical evaluation have also been carried out on many higher plants. For example, *Piper guineense* dust or ethanol extract was found to be active in the protection of maize seeds from maize weevils. The amides isolated from *P.guineense* also possess antibacterial activity (Okoro, 1991). The use of powdered plant parts as admixture with maize for the control of insect infestation has been used by local traditional farmers. These include neem (*Azadirachta indica)*, tobacco leaves (*Nicotiana tobaccum*), sweet iris rhizomes (*Acorus colamus*) and debris tubers (*Derris elliptica*) (FAO, 1991).

The pertinent literature is replete with examples of several thousands species of higher plants with biopesticide and biofungicide activity (Wahyouno et al., 1992). The need to evaluate phytochemical constituents and their biological activities is not only important for the development of new therapeutic agents but the novel chemicals isolated from plants with some biological activity provide a guide line to the chemist to

synthesize useful semi-synthetic drugs (Mossa et al; 1983). The development of synthetic analogues from naturally occurring compounds come only after the initial biological tests on crude plant extract is performed. This has provided the basis for detailed phytochemical investigation and preliminary screening of plants.

A number of studies dealing with the antimicrobial activity of plant extracts have been reported by many workers (Adebajo et al., 1991; Agbedahunsi et al., 1993; Ferdous et al., 1992; Filho et al., 1993; Mehta et al., 1993; Odebiyi et al., 1979; Rawat et al., 1992; Demetzos et. al., 1990; Sakar et al., 1988; etc.). The antibacterial and antifungal effect of essential oil from plants has been demonstrated by many workers (Batra et al., 1985; Dikshit et al., 1984; Mehrotra, 1993; Odebiyi, 1985; Oloke et. al., 1988; etc.). For example, leaf extracts of 21 species of Eucalyptus were screened for their essential oils. Antimicrobial assays showed considerable inhibitory activity of the volatile constituents and the whole essential oil against the microorganisms tested. The test fungi and the yeasts were generally more sensitive than the bacteria to the inhibitory effect of the essential oil volatile constituents. This difference in activity was slighter when the whole essential oils were investigated (Hajji et al., 1993).

The extracts of Hypericum tested by many workers contain hypericin, pseudohypericin, xanthones, volatile oils, x-pyrone, hyperenon B, n-alkanes, n-1-alkanols and tannins (Sakar et al 1988). In addition, alkaloids, steroids, lactones (Sakar et al 1988), flavonoids (Krishnappan and Scetharaman, 1992; Wollenweber, 1982), Cordiaquinones A and B (Filho et al., 1993), Coumarins (Tsitsa-Tzardi et al., 1992), Saponins (Shibata, 1977), anthranoids (Gundidza, 1986), apocarotenoids (Diallo et al., 1991), etc. have been detected and tested for their antimicrobial activity.

Most plants contain secondary metabolites with peculiar individual properties and these constituents may differ from one plant species to another. Because of this variation in chemical constituents, plants differ in their fungistatic and antibacterial activities. Depending on the solvent and the method used for extraction the yield of the active compounds may vary. For example, Gopal et. al. (1992) found that chloroform extract of Vicoa indica yielded vicolides, and essential oil by steam distillation of fresh plant (2g/15kg), n-Hexane extract of Phelline comosa yielded flavonoids, steroids and terpenes while ethyl acetate extract yielded alkaloids, phenolics

and flavonoids (Adebajo et al., 1991). Odebiyi (1985) isolated citral, thymol and carvacrol as the active compounds from the petrol extract of Jatropha podogrica and flavonoid compound 5-hydroxy-7,4'-dimethoxyflavone from the methanol extract of the same plant.

In Ghana very little work has been carried out on phytochemical screening of Ghanaian medicinal plants for their antifungal activity. In this laboratory antifungal properties of some Ghanaian plant extracts has been reported (Boateng, 1986; Myles, 1986; Otoo, 1987). Recently, Apetorgbor (1991) tested water and methanol extracts of nineteen Ghanaian plants belonging to twelve different families for their antifungal and antibacterial activities. Nine plants, namely, *Zanthoxylum xanthoxyloides, Azadirachta indica, Alternanthera pungens (repens), Cassia roundifolia, Desmodium triflorum, Griffonia simplicifolia, Oxalis corniculata, Pergularia daemia* and *Voacanga africana* contained higher fungistatic activity against the vegetative growth of the test fungi *Aspergillus flavus, A.niger, Nigrospora sp.* and *Sclerotium rolfsii*, treated with aqueous and methanol extracts of the plants for varying period.

Owusu-Boaitey (1992) showed that methanol and water extracts of *Alternanthera pungens (repens), Azadirachta indica, Boerhavia diffusa, Desmodium triflorum, Oxalis corniculata* and *Zanthoxylum xanthoxyloides* depressed growth of *A.flavus, A.niger, Fusarium oxysporum, Helminthosporium sp.* and *Sclerotium rolfsii.*

The possible biofungicide activity of local plants against vegetative growth and sporulation of *Paecilomyces* species which were found to be pathogenic to the maize grains (Abeleehi and Obaatanpa vars) by Minamore (1995) have not been tried to date. As part of the on-going research in this laboratory, acetone, aqueous and methanol extracts of two local plants *(Kigelia africana* Benth. and *Zanthoxylum xanthoxyloides* Lam.*)* were tested for antifungal activity against three *Paecilomyces* species contaminating the newly developed Abeleehi and Obaatanpa maize. There is hardly any information in the pertinent literature on antifungal potential of *K.africana* in Ghana.

Kigelia africana has been used in traditional ethnomedicine in Ghana and elsewhere. The fruits are reported

to be used for dressing syphilitic sores and as purgative. The bark is used in treating rheumatism, dysentery and venereal diseases (Anonymous, 1959, 1986; Houghton et al., 1993). Small pieces of the fruit pickled in vinegar are reported to increase appetite and remove constipation. Fruit distillate is known to be very effective in removing kidney stones. The stones are reported to be crushed and pass out with the urine. Small doses of the fruit distillate is used to cure diarrhoea, abdominal pain, hyperacidity and expelling of intestinal worms (Sharma et al., 1993). The root is used as a vermifuge and for treatment of haemorrhoids and rheumatism (Irvine, 1961). In addition, a number of chemical compounds have been isolated from different parts of the fruits (El-sayyad, 1982); naphthaquinones and lignan from wood (Govindachari et al., 1971), sterols, coumarins, naphthaquinones and naphthaquinoids from roots (Inoue et al., 1981; Joshi et al., 1982); irodiods specioside I (El-Naggar et. al., 1980); verminoside II and minecoside III (Sticher et. al., 1979) from bark. Most of these active constituents from some plants have been well documented in the pertinent literature for their antimicrobial activity. This pertinent information provides impetus for further screening of *K.africana* for its antifungal potential.

Therapeutic application of *Z.xanthoxyloides* include the treatment of ulcer, syphilis, fever, poultice, conjunctivitis, laxative, anaemia, diarrhoea and whooping cough. Its antifungal potential has been shown by Apetorgbor (1991), Owusu-Boaitey (1992), and is known to contain benzoic acid derivatives, fagaridine, chelerythrine, skinmianine, dihydro-chelerythrine and arterine (Torto et. al., 1969; Ampofo, 1983; Odamtten et. al., 1988; Ayitey-Smith, 1989).

In this study mycoflora of local mixed maize stored in the Balduzzi Warehouse of the Ghana Food Distribution Corporation were examined to ascertain the species of fungi resident in the grains and their possible role in spoilage and the shortening of the shelf-life of the produce. There is hardly any information in the pertinent literature on the mycoflora of the newly developed Abeleehi and Obaatanpa maize variety and this thesis provides first preliminary list of resident mycoflora some of which have been found to be pathogenic to other maize varieties. In the concluding chapters of the thesis the possible use of two medicinal plants *Zanthoxylum xanthoxyloides* and *Kigelia africana* as biofungicides to control *Paecilomyces carneus, P.puntonii, P.varioti, Curvularia lunata, Fusarium moniliforme* and *Penicillium digitatum* were explored.

II. MATERIALS AND GENERAL METHODS

1. MATERIALS

(I) Maize Varieties:

The following maize (*Zea mays*) varieties were used: Abeleehi, Obaatanpa; Local mixed white (non-stackburned); Local mixed white (stackburned); Yellow maize (non-stackburned) and Yellow maize (stackburned).

(II) Plant Materials:

Leaves and fruit of *Kigelia africana* Benth. (Family: Bignoniaceae) and leaves of *Zanthoxylum xanthoxyloides* Lam. (Family:Rutaceae) used in these investigations were collected from Botanical Gardens, University of Ghana on March 3rd, 1994. The plant materials were solar-dried for two weeks and then stored at 28-31°C. The plants were selected on the basis of their known medicinal and antimicrobial properties (El-Said et al; 1970; Odebeyi and Sofowora, 1979; Apetorgbor, 1991; Owusu-Boaitey, 1992).

(III) Test Fungi:

The test fungi used were *Paecilomyces carneus* (Duché et (Hein) A.H. Brown and G. Smith; *Paecilomyces puntonii* (Vuilemin) Nannizzi, *Paecilomyces varioti* Bain., *Penicillium digitatum* Sacc., *Curvularia lunata* Boedjin. and *Fusarium moniliforme* Sheldon. These fungi were frequently isolated from maize samples from the warehouse.

(IV) Chemicals:

All Chemicals used in the media preparations and the extraction of plant materials were distributed by British Drug House, Poole, England and OXOID Limited, Basingstoke, Hampshire, England.

(V) Potato Tubers:

Tubers of Irish Potato (*Solanum tuberosum* L) used in the preparation of the Potato Dextrose Agar medium were purchased from the Makola Market in Accra. They were stored in the refrigerator until needed.

2. METHODS

(a) Airspora Assessment:

Petri dishes containing Oxytetracycline-Glucose-Yeast-Extract(OGYE) and Sabouroud's Dextrose agar were exposed at different positions in Balduzzi warehouse, Kumasi for 5 minutes and then closed.

The Petri plates were incubated at 28-31°C for 7 days. The colonies that appeared were counted after 3 and 7 days. The species of fungi isolated were identified by their morphological and cultural characteristics using standard reference texts and identification manuals (Thom & Raper, 1945; Smith, 1960; Barnett & Hunter, 1972; Ramirez, 1982; Samson & Reenen-Hoekstra, 1988).

(b) Isolation of Mycoflora of Stackburned and Non-stackburned Varieties:

(i) Blotter Method: A modified method of Tempe (1967) and Limonard (1966) was used. Ten surface-sterilized grains and ten non-surface sterilized grains were placed on sterile Whatmans's No.1 filter paper in 9cm-diameter sterile Petri dishes. The grains were surface-sterilized with 2% sodium hypochloride for 5-10 min. and rinsed in four changes of sterile distilled water. 250 grains of each treatment were incubated at 28-31°C for 5-7 days and the following quantitative assessment were made.

the percentage fungal grains infected.

the percentage occurrence of individual fungal species on the grains

the total number of fungal colonies appearing on the grains.

(ii) Serial Dilution Method: About 10g of maize samples were weighed into 250ml - Erlenmeyer flasks containing 100ml of diluent (0.1% Peptone) and were shaken in a Gallenkamp Model Orbital Shaker (100 rev./min.) for 30 minutes. Serial dilutions were prepared from the stock spore suspension up to $1:10^5$. Aliquots (1ml) of each appropriate dilutions were pipetted into 9cm - diameter sterile Petri dishes and 20ml of either Dichloran 18% glycerol agar (DG18) and Dichloran rose bengal chloramphenicol agar (DRBC) added. Each plate was then rotated in a circular fashion to mix the agar medium and the spore suspension thoroughly. There were four replicates for each dilution prepared and the plates were incubated at 28-31°C. Colonies appearing after 3 and 7 days were counted and the fungal population ($\log_{10}$ cfug^{-1} sample) were calculated employing conventional technique.

In both Blotter and serial dilution methods, the species of fungi were identified by their morphological and cultural characteristics using standard reference texts mentioned in 2(a) above.

(c) Germination Capacity Test:

Ten grains of each maize variety (Abeleehi and Obaatanpa) were placed on sterile Whatman's No.1

filter paper in sterile petri dishes. The filter paper was then moistened with 5ml sterile distilled water. There were ten replicates which were incubated at 28 ± 3°C for 7 days. Percentage seed germination and radicle lengths were then recorded.

(d) Moisture Content Determination:

Moisture content of each maize sample was determined using the oven dry method. Samples of the grains were ground using Moulinex Blender and 10g portions of their flour were dried in an electrically heated oven (Gallenkamp oven 300, plus series) at 105°C for 24h and cooled in a desiccator and then reweighed.

(e) Seed Water Absorption and Swelling:

The extent of water absorption and swelling by different maize varieties was assessed by soaking 100g seed in 200ml of tap water at 30°C for up to 30h. The amount of water absorbed was expressed as grains of water absorbed per 100g of dry sample (g/100g dry seed).

(f) Seed Dimensions:

Hundred grains of maize sample were soaked in 200ml of tap water at 30°C and changes in seed width, length and thickness were measured using a micrometer screw gauge (Mitutoyo Manufacturing Co. Ltd, Tokyo, Japan) on 100 randomly selected kernels. The means and the standard errors were calcu lated after measurements at 2h regular time intervals for up to 30h.

(g) 1000-Seed Weight:

1000 seeds were randomly selected from each maize samples and weight determined using electronic balance (Precisa 300C, PAG OERLIKON, AG, ZURICH, Switzerland). Four replicates samples were weighed and the mean weight and standard errors calculated.

(h) Maize Dough Fermentation Profile and pH of Steep Water:

Dough was prepared from maize kernels using two methods:

(i)About 100g whole maize kernels were soaked in 200ml water for 30h and ground into flour using a Moulinex Blender. The wet-milled maize flour was made into dough by adding 40ml of tap water.

(ii)Dry kernels were ground into flour and 80ml of tap water added to 100g of the flour to make a dough.

The dough was allowed to go through spontaneous fermentation for 3 days. The pH of the dough was determined after 0,12,24,48 and 72h using a pH meter (TOA pH meter, HM-60s. OSK-11478, OGAWA SEIKO CO.LTD., JAPAN).

Changes in pH of steep water from whole maize kernels were determined after 0,1,6,10,15,20,24 and 30h.

(i) Moisture Sorption Isotherms of Abeleehi and Obaatanpa:

Moisture sorption isotherms of dried maize grains was determined by a standard method of Odamtten and Kampelmacher (1986) using glycerol: water mixtures to provide Equilibrium Relative Humidity (ERH) values of 55,65,75,85,90 and 95%. The proportions of the glycerol: water mixtures used are shown in Table 1.

Samples of maize grains kept in either woven polypropylene sachets or open Petri dishes were exposed to the varying ERH(%) conditions (55-95%) in glass humidity chambers at 28 - 31°C. The extent of moisture sorption by the grains was followed by determining the moisture adsorbed (as expressed on dry weight basis) initially and then by oven dry method after 0,4,8,12,24 and 36 days. Percentage moisture content were then calculated.

(j) Maintenance of Stock Culture:

Stock cultures of the fungi were maintained on Potato Dextrose Agar slants in Universal or Macartney's tubes. The isolates were sub-cultured every 2 weeks. Samples not ready for use were stored in the refrigerator until required.

(k) Preparation of Plant Extracts:

Acetone, aqueous and methanol extracts were prepared from the leaves and fruit of *Kigelia africana* and also from leaves of *Zanthoxylum xanthoxyloides*. The plant materials were solar-dried and ground into powder using a Moulinex Blender. In each extract preparation 50g of the pulverized plant part was used. The aqueous extracts was made by placing 50g of appropriate blended sample in 500ml distilled water and then strained with cheese cloth after shaking in an Orbital Shaker (150 rev/min) for 30min. The supernatant liquid was filtered using a vacuum suction pump (Compton Vacuum Pump, Type D/351 Vn, England). The filtrate was made up to 1000ml with sterile distilled water.

TABLE 1

Glycerol: water mixtures and their corresponding Equilibrium Relative Humidities (ERH %).

ERH(%)	CONC. of glycerol (ml)	Vol. of water (ml)
55	75	25
65	68	32
75	58	42
85	45	55
90	35	65
95	32	78

Acetone and methanol extracts of the pulverized plant material was obtained using Soxhlet apparatus (Plate 1a). The extract was then concentrated to dryness using Rotary evaporator (Eyela Model, Japan) (Plate 1b) and stored in a refrigerator until required. A stock solution was prepared by suspending the resulting residue in 1000ml sterile distilled water.

(l) Culture Media:

Potato Dextrose Agar:

About 200g of peeled Irish potato was thoroughly washed dismembered and boiled at 100°C for 15min. in 500ml of distilled water. The extract was then strained and made up to one litre with distilled water; 20g Agar and 20g Dextrose were added.

Solid Medium

Maize Meal Agar medium was prepared from Abeleehi and Obaatanpa varieties. 500ml of distilled water was added to 100g of maize flour and heated for few minutes without boiling and then strained using vacuum suction pump. The supernatant filtrate made up to 1,000ml. 20g Dextrose and 20g Agar were added. Acetone, aqueous (water) or methanol plant extracts were used in amending the maize medium to obtain solid agar media of concentrations, undiluted, 1:1, 1:2 and 1:5 v/v dilution of the extracts. The media prepared were heated in a water bath to melt the agar and then dispensed into medicinal flats for autoclaving at 1.1kg/cm^2 (121°C for 15min.)

Liquid medium:

"Abeleehi" and "Obaatanpa" maize varieties were used in the media preparations. 500ml of distilled water was added to 100g of dry-milled maize flour and heated for few minutes without boiling, strained and made up to 1,000ml; 20g Dextrose was added. The medium was then amended with acetone, aqueous or methanol plant extracts to provide varying concentrations of undiluted, 1:1, 1:2 and 1:5 v/v dilution of the appropriate plant extracts.

250ml Erlenmeyer flasks containing 30ml of appropriate dilution of the extracts were plugged with non-absorbent cotton wool and then autoclaved ready for inoculation with 2mm discs of the test fungi.

Plate 1a: Photographs showing Soxhlet apparatus used for the acetone and methanol extractions of the test plants ($x^1/_{10}$).

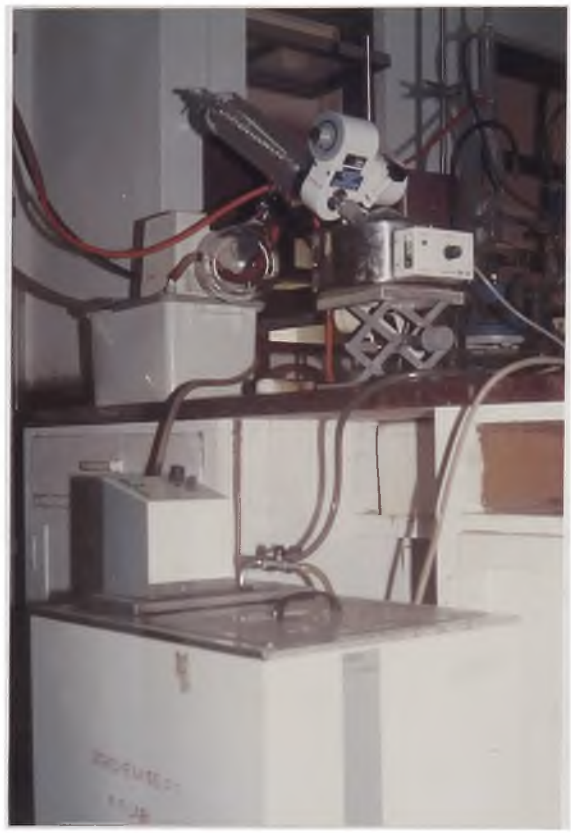


Plate 1b: Photograph showing Rotary evaporator used for concentrating extract (acetone and methanol) obtained with the Soxhlet apparatus shown in plate 1a.

(m) Method of Sterilization:

All media and distilled water used/sterilized by autoclaving at 1.1kg/cm^2 steam pressure (121°C) for 15min.

All glassware were sterilized by heating at 160°C for 18h in an electrically heated oven (Gallenkamp Model, Town & Mercer Ltd., Croydon, England).

All inoculations were done in the inoculating room under the Laminar Microflow Chamber. The air-conditioner and the Laminar Flower Cabinet were switched on for about 30min. to reduce air microflora in the room before inoculation was done. Inoculating pin, inoculating loop and cork borers were flame-sterilized prior to use.

(n) Assessment of Radial Growth on Solid Medium:

About 20ml of the appropriately amended medium was poured into 9.0cm diameter sterile Petri dishes and then allowed to solidify. Two lines along two diameter were drawn at the bottom of the Petri dishes. Each plate was inoculated at the intersection of the two diameters with 3-mm discs of the mycelium from the growing edges of 5-day old fungal culture. In the case of *Penicillium digitatum* the mycelium disc was used in touching the surface of the Agar medium with plate held in inverted positions. This method completely obviated the usual sprinkling of powdery spores on plate inoculated in the upright position. There were four replicates for each dilution level. The unamended medium served as control.

The plates were incubated at 28 ± 3°C and diameter of cultures were measured daily after inoculation for up to 7 days. The experiment was repeated and the percentage mycelial inhibition of the test fungi calculated to determine the fungitoxicity of the extracts of the test plants.

(o) Assessment of Vegetative Growth of Oven-dry Weight Method:

Vegetative growth in the liquid cultures was assessed by determining the dry weight of the harvested mycelium at the end of the required period of incubation. The mycelium was collected on a previously dried and weighed Whatman's No.2 filter paper and then dried in an electrically heated oven (Gallenkamp oven 300, plus series) at 75°C for 24h. Filter papers carrying the dried mycelium was weighed after being allowed to cool in a desiccator.

(p) Assessment of sporulation:

The degree of sporulation on the various media in Petri dishes was determined after 14 days. Four discs 10mm in diameter, were removed from each culture plate with No.8 cork borer from four symmetrical positions equidistant from the centre of the culture. The mycelium from the four discs of each plate was introduced into 10ml of sterile distilled water in a Macartney tube. The spores were detached by stirring. The suspension was then vigorously shaken for 15min. to dislodge the spores. The number of spores per ml of suspension prepared from each plate was determined with a haemacytometer (Gallenkamp B.S.748. Weber & Sons, Lancing, England). Data presented are the mean of 150 counts from four Petri plates.

(q) Experimental Precautions:

(i) Glassware cleaned with detergents were rinsed several times with tap water to remove all traces of detergent before air-drying.

(ii) Petri plates were only half-opened when pouring media in order to avoid contamination.

(iii) Inoculating needles and loops as well as cork borers were flame-sterilized just before use.

(iv) The Laminar Microflow Chamber in the inoculating room was cleaned with disinfectant and switched on for about half an hour before use.

(v) Spores serving as inoculum for all experiments were always obtained from 5 days old cultures.

(vi) Filter papers with oven-dried harvested mycelium were conveyed to the balance room in a desiccator to avoid absorption of moisture.

(v) Statistical Analysis:

The data, where necessary, were analyzed statistically using Analysis of Variance (ANOVA) and Ryan-Einot-Gabriel-Welsch Multiple Range Test for variable (SAS/STAT Users's Guide, 1988). Results are quoted as statistically significant at 5% ($P \leq 0.05$) level of significance.

III. EXPERIMENTAL PROCEDURE

A. MYCOFLORA OF MIXED MAIZE GRAINS FROM THE GHANA FOOD DISTRIBUTION CORPORATION WAREHOUSE AT BALDUZZI, KUMASI.

The mycoflora of any grain batch depends on source, handling, moisture content and the prevailing local storage and environmental conditions. In this chapter the fungal flora of mixed maize grains purchased by Ghana Food Distribution Corporation (GFDC), and stored in woven polypropylene sacks in GFDC warehouse at Balduzzi, Kumasi were examined.

The details of the methods used were spelled out under section 2(a) of Materials and General Methods. Data collected included airspora and mycoflora of grains. The species which were identified and their frequency of occurrence are shown in Tables 2 - 6.

B. MYCOFLORA OF "ABELEEHI" AND "OBAATANPA" MAIZE VARIETIES STORED AT VARYING ERH'S (55 - 95%) FOR 36 DAYS AT 28 - 31°C.

The mycoflora associated with newly developed maize varieties, namely, Abeleehi and Obaatanpa were studied. Samples of the maize grains from each variety were stored at ambient temperature and ERH'S (55,65,75,85, 90 and 95%) representative of our local ambient conditions for up to 36 days with the view of isolating and identifying mycoflora of the maize samples at these varying ERH'S. The grains were kept in either woven polypropylene sachets (12.0x8.0cm) or in open Petri dishes inside glass desiccators (27.5 X 26.0cm).

Direct plating and serial dilution techniques were used in the assessment of resident mycoflora (see Materials and General Methods). Results obtained are presented in Tables 7 - 15.

C. STUDIES ON SOME PHYSICAL CHARACTERISTICS OF SELECTED MAIZE VARIETIES

In this chapter, seed water absorption and swelling, seed dimension, pH of dough and steeping water, germination capacity, seed-weight test and moisture content of Abeleehi and Obaatanpa were studied to provide more information on both processing and agronomical performance of these improved maize varieties. The methods used are spelled out in the Materials and General Methods Section.

For comparison purposes, the work was extended to include Local Mixed White (non-stackburned and stackburned) and Yellow (non-stackburned and stackburned) maize.

Results obtained are presented in Figs 1-9, Table 16 and Appendices 1-9.

D. MOISTURE SORPTION ISOTHERMS OF "ABELEEHI" AND "OBAATANPA" MAIZE VARIETIES.

Sorption isotherms, that plot the functional relationship between water activity and equilibrium water content of a food at constant temperature and pressure, are used extensively to study the water binding properties of food materials.

In considering storage potential, however, the ERH is of prime importance, as it measures the availability of water to microorganisms and hence give an indication of the biological activity, or potential activity, of the product (Ayerst, 1965; Jones, 1969).

In this chapter, samples of maize grains (Abeleehi and Obaatanpa) kept in either woven polypropylene sachets or in open petri dishes were incubated at varying ERH'S (55-95%) inside glass desiccators (27.5cm x 26cm) at 28-31°C.

Moisture sorption isotherms of the two maize varieties was determined by a standard method outlined in the Materials and General Methods using glycerol: water mixtures to provide Equilibrium Relative Humidity (ERH) values of 55,65,75,85,90 and 95%.

Results obtained are presented in Figs. 10-13 and Appendices 10-13.

E. VEGETATIVE GROWTH OF THREE PAECILOMYCES SPECIES IN MAIZE MEAL BROTH AMENDED WITH VARYING DILUTIONS OF AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE LEAVES OF *Z. XANTHOXYLOIDES*

A search for new natural compounds in plants having potential activity against fungi and bacterial in this laboratory and elsewhere (Sanuna,1990, Apetorgbor, 1991; Owusu-Boaitey, 1992) is now the order of the day.

In this chapter, dry leaves of *Z. xanthoxyloides* were tested for possible antifungal activities against three *Paecilomyces* spp; namely, *P carneus, P. puntonii* and *P. varioti* isolated from maize grains var. Abeleehi and Obaatanpa.

Maize meal broth (using Abeleehi or Obaatanpa) was amended with either aqueous, acetone or methanol dry leaf extracts of the plant to provide varying concentrations (undiluted, 1:1, 1:2 and 1:5 v/v dilution). The unamended medium served as control. Vegetative growth by dry matter accumulation was

assessed after 8 days by oven dry weight method (see Materials and General Methods).

Results obtained are presented in Tables 17 & 18 and in Plates 2 & 3.

F. RADIAL GROWTH OF THREE *PAECILOMYCES* SPP. ON MAIZE MEAL AGAR AMENDED WITH AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE LEAVES OF *Z. XANTHOXYLOIDES*

Investigations in Chapter E studied on the growth of the three *Paecilomyces* spp. in liquid medium amended with the plant extracts to obtain varying dilutions of the extracts.

Vegetative growth of many fungi in liquid medium may differ from their growth on agar. In this chapter, however, either aqueous, acetone or methanol extracts of the dry leaves of *Z. xanthoxyloides* were used in amending maize medium (using Abeleehi or Obaatanpa) to obtain solid agar media of concentrations, Undiluted, 1:1, 1:2 and 1:5 v/v dilution of the extracts. The unamended medium served as control.

Radial growth of the three *Paecilomyces* spp. was measured along two diameters drawn on the bottom of the Petri plates. Results obtained are presented in Figs.14 & 15, Appendices 14 & 19 and Plates 4 & 5.

G. VEGETATIVE GROWTH OF *CURVULARIA LUNATA*, *FUSARIUM MONILIFORME* AND *PENICILLIUM DIGITATUM* IN MAIZE MEAL BROTH AMENDED WITH VARYING DILUTIONS OF AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE LEAVES OF *Z. XANTHOXYLOIDES*

Extracts of same plant parts may show varying degrees of repression on the growth of fungal species if they contain active antifungal ingredients. Studies in Chapters E and F were extended to include other important storage fungi isolated from Abeelehi and Obaatanpa varieties.

Curvularia lunata, *Fusarium moniliforme* and *Penicillium digitatum* were used as test fungi. The procedures adopted were same as described in Chapter E. Results obtained are summarized in Tables 19 & 20 and Plate 6.

H. RADIAL GROWTH OF *C. LUNATA, F. MONILIFORME* AND *P. DIGITATUM* ON MAIZE MEAL AGAR AMENDED WITH AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE LEAVES OF *Z. XANTHOXYLOIDES.*

The same procedure was adopted as in Chapter F, but this time the test fungi were *C. lunata, F. moniliforme* and *P. digitatum*. Radial growth was assessed by measuring along two diameters drawn on the bottom of the Petri plates. Results obtained were presented in Figs. 16 & 17 Appendices 20-25, Plate 7; Tables 21a - 21f and 22a - 22f.

I. VEGETATIVE GROWTH OF THREE *PAECILOMYCES* SPP. IN MAIZE MEAL BROTH AMENDED WITH VARYING DILUTIONS OF AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE DRY FRUIT OF *KIGELIA AFRICANA*

The experiments reported in Chapters E - H were repeated, this time using dry fruit of *K. africana* (Bignoniaceae). In this chapter the procedure used was same as in Chapters E & G.

Three *Paecilomyces* spp. (*P. carneus, P. puntonii* and *P. varioti*) were used as test fungi.

Results obtained are presented in Tables 23 & 24

J. RADIAL GROWTH OF THREE *PAECILOMYCES* SPP. ON AGAR AMENDED WITH AQUEOUS, ACETONE OR METHANOL EXTRACTS OF THE FRUIT OF *K. AFRICANA.*

The growth assessment method used in this chapter were the same as those described in Chapters F&H. Would the extract of *K. africana* depress radial growth of *Paecilomyces* to the same or greater extent that what existed with the leaf extract of *Z. xanthoxyloides*? Results obtained are presented in Figs 18 & 19 and Appendices 26 - 31.

K. VEGETATIVE GROWTH OF *C. LUNATA, F. MONILIFORME* AND *P. DIGITATUM* IN MAIZE MEAL BROTH AMENDED WITH VARYING DILUTIONS OF AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE DRY FRUIT OF *K. AFRICANA*.

The experiments in Chapter I were repeated. *C. lunata, F. moniliforme* and *P. digitatum* were used as test fungi. Dry matter accumulation was assessed by oven dry weight method (See Materials and General Methods).

Results obtained are presented in Tables 25 & 26.

L. RADIAL GROWTH OF *C. LUNATA, F. MONILIFORME* AND *P. DIGITATUM* ON AGAR AMENDED WITH AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE FRUIT OF *K. AFRICANA*.

To ascertain whether *C. lunata, F. moniliforme* and *P. digitatum* would be inhibited by *K. africana*, the experiments in Chapter K were repeated this time growing the test fungi on agar medium instead of in broth. Differences in growth rate on agar and in liquid broth medium have often been detected in many investigations. In this chapter radial growth was assessed on agar medium amended with varying dilution of the extract as in Chapters F, H and J.

Figures. 20 & 21; and Tables 27a - 27f & 28a - 28f and appendices 32-37 summarize results obtained.

M. VEGETATIVE GROWTH OF THREE *PAECILOMYCES* SPECIES IN MAIZE MEAL BROTH AMENDED WITH AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE LEAVES OF *K. AFRICANA*

In the preceding Chapters (E - L), it was observed that the inhibitory effect of the plant extracts on the test fungi was variable. It was anticipated that there will be variation in the active ingredients available from other parts of the same plant. In this chapter sun-dried leaves of *Kigelia africana* were used to provide the potential active principles against the test fungi. The same procedure as in Chapter E was adopted and results are presented in Tables 29 & 30.

N. RADIAL GROWTH OF THREE *PAECILOMYCES* SPP. ON AGAR AMENDED WITH AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE LEAVES OF *K. AFRICANA*.

The inhibitory effect of varying dilutions of the extract of the leaves of *K. africana* on growth of three *Paecilomyces* spp. were assessed along two diameter as in Chapter F.

Results obtained are presented in Figs.22 & 23; Appendices 39 - 43 and Tables 31a - 31f.

O. VEGETATIVE GROWTH OF *C. LUNATA, F. MONILIFORME* AND *P. DIGITATUM* IN MAIZE MEAL BROTH AMENDED WITH AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE LEAVES OF *K. AFRICANA*.

The three fungi, namely, *C. lunata, F. moniliforme* and *P. digitatum* were cultured in maize meal broth amended with either aqueous, acetone or methanol extracts of the leaves of *K. africana*. Dry matter accumulation of the mycelium after 8 days at 28 - 31°C was assessed by oven dry weight method (see Materials and General Methods).

Results obtained are presented in Tables 32 & 33.

P. RADIAL GROWTH OF *C. LUNATA, F. MONILIFORME* AND *P. DIGITATUM* ON AGAR AMENDED WITH AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE LEAVES OF *K. AFRICANA*.

The aqueous, acetone and methanol dry leaf extracts of *K. africana* were tested for their ability to depress radial growth of *C. lunata, F. moniliforme* and *P. digitatum* on agar medium amended with the varying dilutions of the plant extracts. The methods employed and the radial growth assessment were the same as in Chapter F.

Results obtained are presented in Fig.24 & 25; Appendices 44-49 and Plates 8 & 9.

Q. COMPARATIVE FUNGITOXICITY OF EXTRACTS OF LEAVES OF *Z. XANTHOXYLOIDES* AND THE FRUIT AND LEAVES OF *K. AFRICANA* ON RADIAL GROWTH OF SIX TEST FUNGI.

The efficacy of the various extracts of the plant parts in depressing of radial growth of the six test fungi were compared. Fungitoxicity was estimated using the method of Misra and Dixit (1977).

The percentage of mycelial inhibition was calculated from the mathematical relationship:

$$\% \text{ Mycelial Inhibition (MI)} = \frac{dc - dt}{dc} \times 100$$

dc = diameter of culture in control medium

dt = diameter of culture in amended medium

The experiments in Chapters F,H,J,L,N & P were repeated and % Mycelial Inhibition were calculated for each fungal species tested in either the aqueous, acetone or methanol extract of the indicated plants.

Results obtained are presented in Tables 34 and 35.

R. INFLUENCE OF THE PLANT EXTRACTS OF THE LEAVES OF *Z. XANTHOXYLOIDES* AND THE FRUIT AND LEAVES OF *K. AFRICANA* ON SPORULATION OF THE TEST FUNGI.

The "active" principles in the plant extracts used in Chapters E - P variably depressed vegetative growth by dry matter accumulation and radial growth on agar. Owusu-Boaitey (1992) showed that vegetative growth and sclerotia formation by *Sclerotium rolfsii* on agar and in liquid medium was completely suppressed by methanol extract of *Cassia alata*.

Would the active principle in *Z. xanthoxyloides* and *K. africana* also prevent sporulation of the test fungi? The experiments in Chapters F,H,J,L,N and P were repeated. The incubation period was extended to 14 days to allow for possible sporulation of the test fungi. The details of the experimental procedure are spelled out in section 2(P) of the Materials and General Methods.

Results obtained are presented in Tables 36 - 41.

IV. RESULTS

A. MYCOFLORA OF MIXED MAIZE GRAINS VARIETIES FROM THE GHANA FOOD DISTRIBUTION CORPORATION WAREHOUSE AT BALDUZZI, KUMASI.

The total number of fungal colonies on non-sterilized grains increased by 13-19 colonies after 2 months storage (Table 2). However, the fungal species resident in the surface-sterilized grains also increased by 6-10 colonies during the same period. The corresponding initial population of fungi recorded in the grains was 4.8-5.4 $\log_{10}(cfug^{-1})$ and this decreased by 0.4-1.3 log cycles after 2 months (Table 2). There was no statistical difference between the data collected from top, middle and bottom of stack in the warehouse. OGYE was marginally better medium for fungal isolation than Sabouraud's Agar.

Aspergillus flavus was the most predominant fungal species appearing on whole grains by the Blotter Test method (Table 6). *Mucor haemalis* like *A. flavus* occurred at all positions sampled, constituting 4.0-20.5% of the species encountered (Table 6). The species diversity of mycoflora isolated varied with the position of sampling and whether the grains were surface-sterilized or not.

Rather curiously, the species diversity on grains obtained by the decimal dilution techniques (Table 4) varied from what existed in the direct plating method. However, inspite of these variation *A. flavus* was the most predominant species (24.2-38.1%) isolated followed by *M. haemalis* (3.4 - 21.4%). The use of two media enabled one to isolate a wider range of fungal genera and species (Table 4).

Twenty four different species of fungal airspora (Table 5) were isolated from the warehouse at Balduzzi (depending on sampling location and media used). *A. flavus* was isolated nearly throughout the 2 months storage period, followed by *M. haemalis*.

Aspergillus species predominated (*A. clavatus*, *A. flavus*, *A. fumigatus*, *A. niger*, *A. ochraceus*, *A. parasiticus*, *A. sulphureus* and *A. tamarii*) followed by *Penicillium* (*P.chrysogenum*, *P. citrinum*, *P. cyclopium*, *P. digitatum* and *P. expansum*). Species of airspora that were not found in the grains were *A. clavatus*, *A. ochraceus*, *A. parasiticus*, *A. funigatus*, *P. expansum*, *Paecilomyces carneus*. *P. puntonii*, *P varioti*, *Curvularia lunata* and *Rhizopus oryzae*.

The total number of colonies of the airspora are presented in Table 3. Again OGYE was a better medium than Sabouraud in this instance.

TABLE 2

Total number of colonies and total population (log_{10} cfu/g sample) on whole mixed maize variety kernels during two months (Nov - Dec. 1993) storage at the GFDC Warehouse at Balduzzi, Kumasi.

Period of sampling (months)	Total no. of colonies on whole grains			Media used	Total fungal population (log_{10} cfu/g)		
	Top	Middle	Bottom		Top	Middle	Bottom
0	17	13	15	OGYE	5.4	5.3	5·0
	(20)	(25)	(23)	SAB	5.2	5,1	4·6
2	25	23	21	OGYE	5.0	3.9	3·9
	(39)	(41)	(36)	SAB	4.3	3.8	3·5

key: ( ) non-surface-sterilized grains

OGYE: Oxytetracycline - Glucose Yeast Extract Agar

SAB: Sabouraud's Agar

TABLE 3

Airspora (total no. of fungal colonies) isolated from Ghana Food Distribution (GFDC) Warehouse at Balduzzi. Kumasi for two months (November - December 1993).

Period of assessment (months)	Medium used	Total no. of colonies from plates exposed at indicated positions of maize stacks						
		Top	Middle	Bottom	South	East	West	North
Initial (0)	OGYE	56	23	25	82	41	25	33
	SAB	9	11	18	13	13	10	13
2	OGYE	24	74	112	19	77	67	41
	SAB	20	36	45	10	17	12	26

TABLE 4

Frequency of occurence of individual fungal species isolated with indicated media from mixed maize grains stored at Balduzzi Warehouse for 2 months at 29-32°C and ERH 44-55%

Fungus recorded	% Frequency of occurence of indicated species at					
	Top		Middle		Bottom	
	OGYE	SAB	OGYE	SAB	OGYE	SAB
A. flavus	38.0	24.2	34.2	17.9	37.0	38.1
A. niger	12.0	13.8	13.2	8.9		
A. sulphureus				1.8		
A. tamarii	14.0		5.3			
P. citrinum	4.0	13.8	17.1		11.1	28.6
P. chrysogenum		3.4		10.7	7.4	9.5
P. cyclopium				16.1		
P. digitatum		17.2	7.9			
P. glabrum				23.2		
P. oxalicum	8.0	3.4				
F. moniliforme	12.0	20.8				
Mucor haemalis	12.0	3.4	7.9	21.4	14.8	
Yeasts			14.5		3.7	23.8

Nil

Table 5. Fungi constituting the airspora in the GFDC Warehouse at Balduzzi, Kumasi from November-December 1993 (ERH's 44.0-55% and 29-32°C.

Fungi Species	Sampling Location																							
	Top				Middle				Bottom				South				East				West				North			
	OGYE		SAB		OGYE		SAB		OGYE		SAB		OGYE		SAB		OGYE		SAB		OGYE		SAB		OGYE		SAB	
	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2
Aspergillus clavatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
A.. flavus	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	-	+	+	+	+	-	+	-	+
A. niger	+	-	+	-	-	+	-	+	-	-	-	+	-	-	-	+	-	+	-	+	+	-	+	-	-	+	-	+
A.ochraceus	-	-	-	+	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
A..parasiticus	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+
A. fumigatus	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-
A..sulphureus	-	-	-	+	-	+	-	-	-	-	-	+	-	-	-	+	-	+	-	+	-	-	-	-	-	-	-	-
A. tamarii	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aspergillus sp.	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Penicillium chrysogenum	+	-	-	-	-	-	+	-	-	-	-	-	+	-	+	-	-	-	-	-	+	+	+	+	-	-	-	-
P. citrinum	-	+	-	-	-	+	-	-	-	+	-	-	-	+	-	+	-	-	-	-	-	+	-	+	-	-	-	-
P. cyclopium	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
P. digitatum	-	-	-	-	-	+	-	+	+	-	-	-	+	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-
P. expansum	-	+	-	+	-	+	+	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-
P. oxalicum	+	-	-	-	+	-	-	+	-	+	-	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-

Table 5 Cont'd.

Fungi constituting the airspora in the GFDC Warehouse at Balduzzi, Kumasi from November-December 1993 (ERH's 44.0-55% and 29-32°C.

Fungi Species	Sampling Location																							
	Top				Middle				Bottom				South				East				West				North			
	OGYE		SAB		OGYE		SAB		OGYE		SAB		OGYE		SAB		OGYE		SAB		OGYE		SAB		OGYE		SAB	
	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2
Paecilomyces carneus	-	-	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	
P. puntonii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	
P. varioti	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
C. herbarum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	+	-	
Curvularia lunata	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	+	-	-	-	-	-	-	-	-	-	
Fusarium moniliforme	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	
Mucor haemalis	-	+	+	+	-	+	+	+	+	+	+	+	-	+	+	+	+	-	+	-	+	-	+	-	-	-	-	
Neurospora sitophila	-	+	-	-	+	-	-	-	+	+	+	-	+	+	-	-	+	-	+	+	+	-	+	-	+	+	-	
Rhizopus oryzae	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

\+ : Fungus species recorded
\- : Fungus species not recorded
o : Initial month
2 : After 2 months

TABLE 6

Percentage occurence of indicated individual fungal species on whole mixed maize kernels from Balduzzi Warehouse using the Seed Health Blotter Test at 26 - 32°C (Grains were stored from November - December 1993).

Fungus recorded	% Occurence of indicated species on whole kernel from					
	Surface-sterilized			Non-surface sterilized		
	Top	Middle	Bottom	Top	Middle	Bottom
Aspergillus flavus	44.0	43.5	42.9	46.2	41.5	41.7
A. sulphureus		17.4	14.3		9.8	11.1
A. tamarii		4.3	9.5			
Penicillium brevicompactum		4.3	9.5			
P. citrinum	16.0		4.8	5.1		
P. cyclopium	16.0	13.0				11.1
P. glabrum				10.2	14.6	13.9
Cladosporium herbarum	16.0				9.8	
Fusarium moniliforme				12.8	7.3	
Fusarium roseum				5.1		
Mucor haemalis	4.0	17.4	19.0	20.5	17.0	16.6
Yeasts						5.6

Nil

B. MYCOFLORA OF "ABELEEHI" AND "OBAATANPA" MAIZE VARIETIES STORED AT VARYING ERH'S (55-95%) FOR 36 DAYS AT 28-31°C

The species of fungi that were encountered varied (Tables 7 and 8) depending on maize variety, the method of isolation, the storage humidity and the media used in isolating the resident fungi. The packaging material also influenced the profile of fungi encountered (Table 9a & b, Tables 10a & b).

For example, using the direct plating method, *A. flavus* was ubiquitous and was isolated initially and after 2 months from Abeleehi and Obaatanpa grains stored at 55-95% ERH in both open Petri dishes and in woven polypropylene sachets. *Fusarium moniliforme* was encountered at all ERH'S of 65-95% in open Petri dishes (Table 9a) but not at 65 and 75% ERH in samples stored in woven polypropylene sachets (Table 9b). *Penicillium* sp.1 was isolated initially from both Abeleehi and Obaatanpa varieties but was not encountered thereafter in Abeleehi grains stored in open Petri dishes as compared to its isolation at all ERH'S (55-95%) in grains stored in woven polypropylene sachets (Table 9b). *Penicillium* sp.1 could not be isolated in Obaatanpa grains stored at ERH'S 55-95% for 2 months (Tables 10a and b).

Xerophilic species like *A. giganteus* occurred at low ERH of 65% in Abeleehi variety while *Paecilomyces puntonii* and *P. carneus* were isolated at 55.-65% ERH in both grain varieties (Tables 7 and 8). *Penicillium digitatum* was not isolated from Abeleehi at all ERH'S used (Tables 9a & b) but was encountered at ERH 90% in Obaatanpa grains (Tables 10a & b).

The serial dilution technique enabled one to encounter a wider spectrum of fungal species which were isolated on two different media. Species that were not isolated by the direct plating method but appeared in the serial dilution method are:

A. terreus, A. ustus, A. wentii, Emericella nidulans, P. nigricans and Paecilomyces varioti. Curiously, *F. moniliforme* was not encountered in the serial dilution method using Abeleehi grains (Tables 11a & b) but was present in Obaatanpa grains at ERH'S 55-85% exposed in Petri dishes but not in the same grains kept in woven polypropylene sachets (Tables 12a & b).

Total number of colonies in grains (direct plating) and total fungal population (by serial dilution) was higher in maize varieties stored (exposed) than the same grains kept in woven polypropylene sachets (Tables 13 & 14). Data on surface-sterilized grains give an idea about the resident mycoflora in the grains while information obtained with non-surface sterilized grains reflects the surface contaminants (Table 15) as well.

TABLE 7

List of fungi isolated by serial dilution technique and direct plating of 'Abeleehi' maize variety stored at Equilibrium Relative Humidities representative of the Ghanaian ambient conditions for 2 months.

Aspergillus candidus Link ex Fr. [2,5,6]
A.flavus Link Fr. [0,1,2,3,4,5,6]
A.fumigatus Fresenius [0,1,2,3,4,5,6]
A.giganteous Wehimer [0,2]
A. niger Van Tieghem [0,1,2,3,4,5,6]
A.ochraceus Wilhelm [1,2,4,5,6]
A.sulphureus (Fres.) Thom and Church [0,1,2,3,5,6]
A.tamarii Kita [2,3,4,6]
A. terreus Thom [1,5]
A. ustus (Bainer) Thom and Church [4,5]
A. wentii Wehmer [1]
Cladosporium herbarum (Persoon: Fries) Link [0,1,2,3,4,5,6]
Curvularia lunata Boedjen [0]
Emericella nidulans (Eidam) Vuillemin [1,2,4,5,6]
Eurotium sp. [2,3,4,5,6]
Fusarium moniliforme Sheldon [0,1,2,3,4,5,6]
Mucor haemalis Wehmer f. hiemalis [2,3,4,5]
Neurospora sitophila (Montagne) Saccardo [0]
Penicillium brevicompactum Dierckx [0,1,2,3,4,5,6]
P.citrinum Thom [0,1,2,3,4,5,6]
P.cyclopium Westling [2,3,4,5,6]
P.digitatum [0]
P.expansum Link ex S.F. Gray [0,4,5,]
P.glabrum (Wehmer) Westling [0,1,2,3,4,5,6]
P.nigricans Bainer [1,2]
Penicillium sp. [0,1,2,3,4,5,6]
Paecilomyces carneus (Duche' et Heim) A.H. Brown et G. Smith [0,1,2]
P.puntonii (Vuillemin) Nannizzi [1,2,3]
P.varioti Bainer [0,3]
Rhizopus oryzae West and Prinsen Geerlings [2,4,6]

Key: O, Initial 1: 55% ERH; 2: 65% ERH; 3: 75% ERH; 4: 85% ERH; 5: 90% ERH; 6: 95% ERH.

TABLE 8

List of fungi isolated by serial dilution technique and direct plating of 'Obaatanpa' maize variety stored at Equilibrium Relative Humidities representative of the Ghanaian ambient conditions for 2 months.

Aspergillus candidus Link ex Fr. [1,4,5]

A.effusus Tiraboschi [0,1,2,3,5]

A.flavus Link. Fr. [1,2,3,4,5,6]

A.fumigatus Fresenius [0,1,2,3,4,5]

A.niger Van Tieghem [0,1,2,3,4,5,6]

A.ochraceus Wilhelm [2,5,6]

A.tamarii Kita [1,3,4,5,6]

A.versicolor (Vuillemin) Tiraboschi[2,3,4,5,6]

Aspergillus sp.[6]

Chaetomium sp.[0,1,5,6]

Cladosporium herbarum (Persoon:Fries) Link[0,1,2,3,5,6]

Curvularia lunata [0]

Eurotium sp.[3,4,5,6]

Fusarium moniliforme Sheldon[0,1,2,3,4,5,6]

Penicillium brevicompactum Dierckx 0,1,2,3,4,5,6

P.citrinum Thom [0,1,2,3,4,5,6]

P.digitatum Sacc. [0,5]

P.expansum Link ex S.F. Gray [0,4,5,6]

P.funiculosum Thom [0,1,3,4,5,6]

P.glabrum (Wehmer) westling [2,3,4,5,6]

Penicillium sp.1 [0]

Paecilomyces carneus (Duche' et Heim) A.H. Brown et G. Smith [0,1,2]

Paecilomyces puntoni (Vuillemin) Nannizzi [0,1,2]

P.varioti Bainer [0,1]

Rhizopus oryzae West and Prinsen Geerlings [0,1,2]

Scopulariopsis brevicaulis (Sacc.) Bainer [1,4,6]

Key:

0, Initial 1:55% ERH; 2: 65% ERH; 3: 75% ERH; 4: 85% ERH; 5: 90% ERH; 6: 95% ERH

Table 9a. Record of individual fungal species isolated by direct plating (Blotter method) from Abelechi variety stored (in open Petri dishes) at ERH's 55-95% for 2 months at 28-31°C.

Fungal Recorded	% Occurrence of indicated individual fungal species at ERH's (%)													
	Initial		55		65		75		85		90		95	
	SS	NS	SS	NS	SS	NS	SS	NS	SS	NS	SS	NS	SS	NS
Aspergillus candidus				1.6								0.9	40.5	43.9
A. falvus	28.3	34.0	47.2	76.3	44.8	66.7	86.0	65.5	73.1	45.2	50.0			7.1
A. fumgatus			2.7	3.3	17.2	6.3	22.2	2.3	6.9	3.0	22.6	12.0	21.6	
A. niger	13.2	18.5	6.8	87.3	6.9			3.5		6.0		0.9		1.7
A. ochraceus		8.2		3.4		1.6					3.2			2.2
A. sulphureus	3.6	7.4												
A. tamarii								1.2						
Cladosporium herbarum	7.4	7.5							3.4					
Curvularia lunata	2.0	8.2												
Eurotium sp.												8.5		7.1
Fusarium moniliforme					17.2		16.7	3.5	13.8	3.0	3.2	11.1	10.8	14.4
Mucor haemalis					6.9	6.3	11.1	2.3	10.3	3.0				
Penicillium brevicompactum	16.1	9.0	2.8	10.2		11.1		1.2		9.0		15.1		8.3
P. citrinum			25.6		6.9	7.6				2.9	25.8	8.3	12.2	7.0
P. expansum	4.0		2.4			0.4								
P. glabrum			11.0										13.5	11.7
Penicillium sp.1	8.5	10.3												
Paecilomyces carneus	12.9	2.0												
P. puntonii	4.0	5.2			1.3	2.1								
Rhizopus oryzae													1.4	

SS: Surface sterilized
NS: Non-surface sterilized
-: Nil

Table 9b. Record of individual fungal species isolated by direct plating (Blotter method) from Abelechi variety stored (in open Petri dishes) at ERH's 55-95% for 2 months at 28-31°C.

Fungal Recorded	Initial		% Occurrence of indicated individual fungal species at ERH's (%) 55		65		75		85		90		95	
	SS	NS	SS	NS	SS	NS	SS	NS	SS	NS	SS	NS	SS	NS
Aspergillus candidus													17.1	13.3
A. flavus	31.8	33.3	1.5	36.7	56.0	50.0	39.3	53.6	44.7	39.2	40.0	35.0	34.1	29.7
A. fumigatus									18.4	15.9				
A. niger	40.0	20.0	6.9	6.7	6.3	6.9	7.1	5.4	7.9					
A. ochraceus														1.1
A. sulphureus											2.5	2.5	4.1	6.7
A. tamarii								5.4		2.9				
Cladosporium herbarum	2.0	3.7	13.8			3.4	42.9		23.7	6.8	35.0	8.8	7.3	
Curvularia lunata	6.0													
Eurotium sp.										8.1		10.2		7.1
Fusarium moniliforme			10.3	6.7					5.3		2.5		2.4	3.9
Mucor haemalis										1.4				
Penicillum brevicompactum	3.2	21.0										6.2		
P. citrinum	15.4	25.1		3.3				12.5					3.1	2.6
P. glabrum	9.0	9.0	3.4	3.3		1.6				3.0			17.1	13.3
Penicillium sp.1	8.1	5.9	31.0	46.6	46.6	27.6	10.7	23.2		22.9	20.0	28.8	22.0	16.4
Paecilomyces carneus	4.5		3.0											
P. puntonii	5.3				1.8	3.1								
Rhizopus oryzae										1.4				

SS: Surface sterilized
NS: Non-surface sterilized
: Nil

Table 10a. Record of individual fungal species isolated by direct plating (Blotter method) of Obaatanpa variety stored (in open Petri dishes) at ERH's 55-95% for 2 months at 29-31°C.

Fungal Recorded	% Occurrence of indicated individual fungal species at ERH's (%)													
	Initial		55		65		75		85		90		95	
	SS	NS	SS	NS	SS	NS	SS	NS	SS	NS	SS	NS	SS	NS
Aspergillus candidus												1.2		
A. effusus							-							5.6
A. flavus	30.2	32.9	60.2.	49.2	37.5	55.0	58.0	31.7	37.5	33.8	23.0	25.8	18.7	21.0
A. fumigatus				1.0		2.5								
A. niger	8.6	8.3	12.4	4.9	2.5	5.0		7.9	2.1	9.1	0.9	2.2		
A. ochraceus													1.5	
A. tamarii				1.6					1.0					
A. versicolor					8.8		1.3		3.1		14.2		22.4	
Aspergillus sp.														2.4
Cladosporium herbarium	13.2	13.1										2.2		5.6
Eurotium sp.														18.5
Fusarium moniliforme	33.0	18.4	12.4	14.8	21.3	20.0	2.6	23.8	16.7	20.8	17.7	11.7	26.7	18.5
Penicillium brevicompatum	3.9	6.1	6.0	13.1	2.5	7.5	5.3	20.7	1.0	16.9	5.3		2.2	
P. citrinum	7.1	12.2	9.0	13.1	27.4	2.5	32.9		38.5	2.4	30.1	16.1	26.3	8.9
P. digitatum												18.3		
P. expansum	1.1	3.1	-							10.5		11.7		6.5
P. funiculosum	-							15.9	6.5					
P. glabrum				-		5.0					8.8	10.8	2.2	13.0
Penicillium sp. I	2.3	5.9							-					
Paecilomyces puntonii						2.5								

SS: Surface-sterilized
NS: Non-surface sterilized.
- : Nil

Table 10b. Record of individual fungal species isolated by direct plating (Blotter method) of Obaatanpa variety stored in woven polypropylene sachets at ERH's 55-95% for 2 months at 29-31°C.

Fungal Recorded	Initial		% Occurrence of indicated individual fungal species at ERH's (%)											
			55		65		75		85		90		95	
	SS	NS	SS	NS	SS	NS	SS	NS	SS	NS	SS	NS	SS	NS
Aspergillus candidus				-						2.3				
A. flavus	29.1	37.5	36.8	22.2	27.6	20.7	56.0	35.1	30.3	15.9	45.3	30.7	24.3	32.0
A. fumigatus	-				6.9		4.9					-		
A. niger	20.3	4.6	10.5		27.6	1.7	17.1	8.1	6.1		7.5	4.6		
A.versicolor				-										20.0
Aspergillus sp.	-													20.0
Cladosporium herbarum	12.9	8.8											6.6	
Eurotium sp.				-				5.4					12.1	
Fusarium moniliforme	25.7	14.0		16.7	27.6	24.1	22.0		45.4	31.8	26.4	20.0	16.5	
Penicillum brevicompactum	4.1	5.7	5.3		10..3			2.7	18.2	2.3				
P. citrinum	5.7	8.8	47.3	61.1		51.7		48.6		38.6	13.2	41.5	14.2	44.0
P. digitatum			-								7.5			
P. expansum		4.5								-				
P. funiculosum		-						1.2						
P. glabrum				-		-				9.1			9.9	
Penicillium sp.1	1.2	16.3		-			-							
Paecilomyces puntonii				1.6										

SS: Surface-sterlilized
NS: Non-surface sterilized
- : Nil

Table 11a. Record of occurrence of individual fungal species isolated by serial dilution technique from Abelcch variety stored (in open Petri dishes) at ERH's 55-95% for 2 months at 28-31°C.
(Spores were raised in either DG18 or DRBC)

Fungal Recorded	% Occurrence of indicated individual fungal species at ERH's (%) and isolating media													
	Initial		55		65		75		85		90		95	
	DG18	DRBC	DG18	DRBC	DG18	DRBC	DG18	DRBC	DG18	DRBC	DG18	DRBC	DG18	DRBC
Aspergillus candidus					6.1			-	0.7		0.9	2.7		0.5
A. flavus	23.7		10.4	46.7	4.1	15.2	7.0		37.4	61.0	1.8	48.6	75.0	80.5
A. fumigatus	5.1	11.4	56.0	13.3	30.6	27.3	69.8	37.5	42.4	14.3	33.0		11.0	3.7
A. giganteus		25.0			7.3									
A. niger	3.4	3.4	8.3		8.2	6.1						2.7	1.8	0.5
A. ochraceus	5.1	6.8	4.2			3.0			0.7	2.6		2.7	2.4	3.3
A. sulphureus	-											2.7		0.5
A. tamarii.						3.0								
A. terreus			2.1								0.9			
A. ustus									1.4		5.4			
A. wentii			4.2											
Cladosporium herbarum	3.4		6.3	6.7	14.3	12.1	9.3		0.7	2.6	0.9	10.8		
Emericella midulans			4.2		8.2				10.1	5.2	44.6			3.3
Eurotium sp.					2.0						2.7	5.4		
Fusarium moniliforme	28.8	15.9												
Mucor haemalis					4.2		4.7							
Penicillium brevicompactum					8.2	6.1	9.3	6.3	4.3	3.9		2.7		
P. citrinum	23.7	22.7	4.2	13.3	4.1	18.2							3.7	
P. cyclopium					8.2			12.5	1.4	11.7		5.4	1.2	7.0
P. digitatum	6.8	2.3						25.0					4.9	0.9
P. expansum	-								0.7	2.6	0.9			

Table 11a cont'd.
Record of occurrence of individual fungal species isolated by serial dilution technique from Abelechi variety stored (in open Petri dishes) at ERH's 55-95% for 2 months at 28-31°C.
(Spores were raised in either DG18 or DRBC)

	% Occurrence of indicated individual fungal species at ERH's (%) and isolating media													
Fungal Recorded	Initial		55		65		75		85		90		95	
	DG18	DRBC	DG18	DRBC	DG18	DRBC	DG18	DRBC	DG18	DRBC	DG18	DRBC	DG18	DRBC
P. glabrum	10.2								2.6					
P. nigricans	-		6.7		4.1									
Penicillium sp.									1.3		10.8			
Paecilomyces carneus	-					6.1								
Paecilomyces-varioti								5.2						
Rhizopus oryzae						1.8								

Table 12a. Record of occurence of individual fungal species isolated by the serial dilution technique from Obaatanpa variety stored (in open Petri dishes) at ERH's 55-95% for (2 months) at 28 -31°C.
(Spores were raised in either DG18 or DRBC)

Fungi Recorded	% Occurrence of indicated individual fungal species at ERH's (%) and isolating media													
	Initial		55		65		75		85		90		95	
	DG18	DRBC	DG18	DRBC	DG18	DRBC	DG18	DRBC	DG18	DRBC	DG18	DRBC	DG18	DRBC
Aspergillus effusus		30.6	0.6			1.1	0.8				10.3		0.9	
A. flavus	27.5		14.9	3.5	0.6	0.6	15.7	21.6	60.0	67.3	4.5	7.7	9.1.	11.1
A. fumigatus											10.3			
A. niger	2.2		3.8							0.4	0.7			
A. ochraceus											0.7		17.4	
A. tamarii											0.7	2.6		12.2
A. versicolor			11.8		1.9		5.2		0.7		16.8	2.9	2.9	7.8
Chaetomium sp.		1.4		0.4								0.4		0.4
Cladosporium herbarum		6.9		0.4										
Curvularia lunata		2.8												
Eurotium sp.							2.2	2.5		0.4	0.7	2.6		
Fusarium moniliforme	28.6	20.8	30.2	50.0	96.2	98.3	1.5			0.8				
Penicillium brevicompactum		5.6						5.6						
P. citrinum	24.4	23.6	40.6	42.4	1.3		66.4	69.8	39.3	31.1	53.4	82.0	38.3	54.2
P. digitatum	9.8													
P. glabrum							8.2				1.9	1.8	26.5	22.1
Paecilomyces carmeus		4.2												
P. puntonii	1.1													
P. varioti	6.4			3.3										

Table 12b. Record of occurence of individual fungal species isolated by the serial dilution technique from Obaatanpa variety stored stored in oven polypropylene sachets at ERH's 55-95% for (2 months) at 28 -31°C.

(Spores were raised in either DG18 or DRBC)

Fungi Recorded	% Occurrence of indicated individual fungal species at ERH's (%) and isolating media													
	Initial		55		65		75		85		90		95	
	DG18	DRBC	DG18	DRBC	DG18	DRBC	DG18	DRBC	DG18	DRBC	DG18	DRBC	DG18	DRBC
Aspergillus Flavus	54.8	12.5	43.5	24.5	31.3	63.6	14.8	9.5	7.0	26.0	8.7	4.2	32.9	23.2
A. fumigatus		37.5							2.3					
A. niger	3.2	12,5	2.0	4.1		18.2			2.3	20.6			6.5	1.3
A. ochraceus						9.1				2.7				0.5
A. tamarii			4.8	4.1			7.4	9.5		1.4			5.1	
A. versicolor					12.5				23.3					
Cladosporium herbarum					6.3			4.8			5.8			
Eurotium sp.							7.4	1.4	4.7	1.4	53.4	57.1	1.9	
Fusarium moniliforme													5.5	
Neurospora sitophila	9.7	12.5												
Penicillium brevicompactum			1.4	8.2	18.8		11.1	4.8	16.3	12.3	3.9	16.8		
P. citrinum	3.2	25.0	46.3	51.9	12.3	9.1	59.3	65.2	41.0	24.7	28.2	19.0	43.5	37.5
P. funiculosum	12.9							4.8	2.3	5.5		2.9		2.2
P. glabrum			1.4	2.4									4.6	34.4
Paecilomyces carneus					6.3									
P. puntonii			0.6											
P. varioti	9.7			2.4										
Rhizopus oryzae	6.5				12.5									
Scopulariopsis brevicaulis	-			2.4						4.4				0.9

attended by a drop in pH from 5.0-6.5 to pH 4.2-4.6. The pH of normal and stackburned wet-milled maize continued rising from pH 4.4 to pH 5.1 and 5.5, respectively, in 72h (Fig.6c and Appendix 6).

(e) 1000 - Seed Weight of the Grains and Moisture Content

The 1000-seed weight of the grains is a reflection of the density or ability of grains to accumulate dry matter. Obaatanpa had a higher density (273.2g) than Abeleehi (268.9g); stackburned yellow and white maize had lower average 1000-seed weight than the normal grains (Table 16). The moisture content of normal grains did not differ from the stackburned samples of the same grain type (Table 16).

(f) Germination Capacity

There was no statistical difference (Analysis of variance $P \leq 0.05$) between germination of Abeleehi grains incubated at ERH'S 55-85% (Fig.8). However, seed germination was drastically reduced at 90 and 95% (Fig.8). Data on percentage germination of grains kept in woven polypropylene were similar to those grains exposed to the ambient ERH.

The same trend observed for Abeleehi grains was applicable to Obaatanpa variety except that the adverse effect of storage humidity on germination occurred only at ERH 95% (Fig.8). The storage environmental humidity influenced the length of the emerging radicle. The higher the incubation humidity the shorter the length of the emerging radicle (Fig.9) such that at 95% ERH radicle length was reduced by 39-61% depending on maize variety used.

Interestingly, there was a significant (student's t-test $p = 0.05$) difference between the higher radicles length recorded in grains of both varieties stored in woven polypropylene sachets than in some grains not kept in sachets (Fig.9).

TABLE 16

Comparative 1000-seed weight and moisture content of indicated maize varieties

Variety	Average 1000-seed Weight(g)	Moisture Content(%)
ABI	268.9+4.2	11.0
OBA	273.2+1.2	10.0
WStacb*	275.3+2.1	13.0
WnStacb*	237.8+1.9	12.0
YStacb*	331.7+ 5.4	13.5
YnStacb*	329.3+4.5	13.5

*Mixed varieties in the sack

ABI: Abeleehi

OBA: Obaatanpa

WStacb: Local White Maize(Stackburned)

WnStacb: Local White Maize(Non-Stackburned)

YStacb: Yellow Maize(Stackburned)

YnStacb: Yellow Maize(Non-Stackburned)

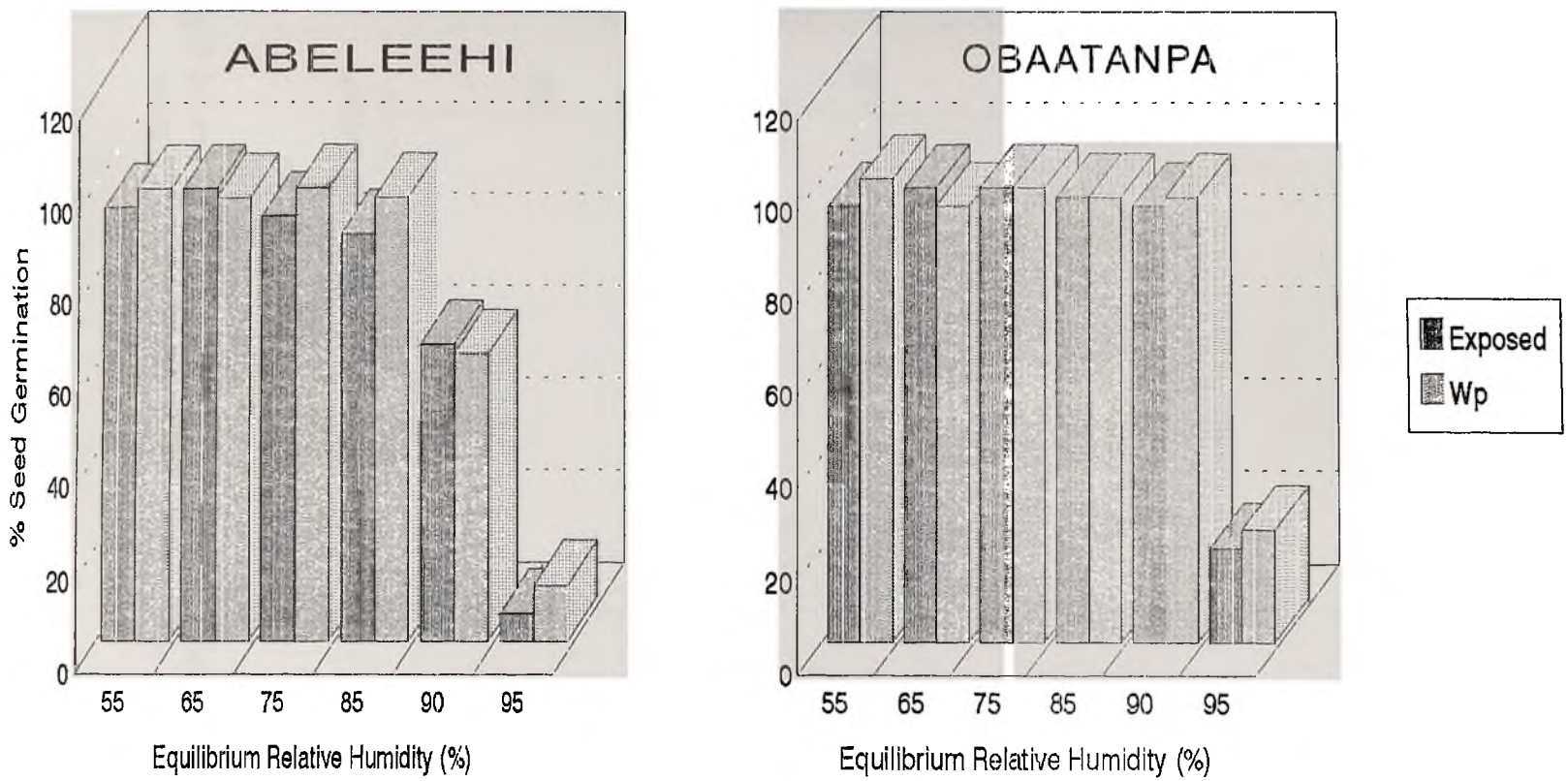


Fig.8. Germination Capacity of **Abeleehi** and **Obaatanpa** varieties stored either exposed (in Open Petri dishes) or in woven polypropylene (Wp) sachets at ERH 55-95% for 36 days at 28-31°C

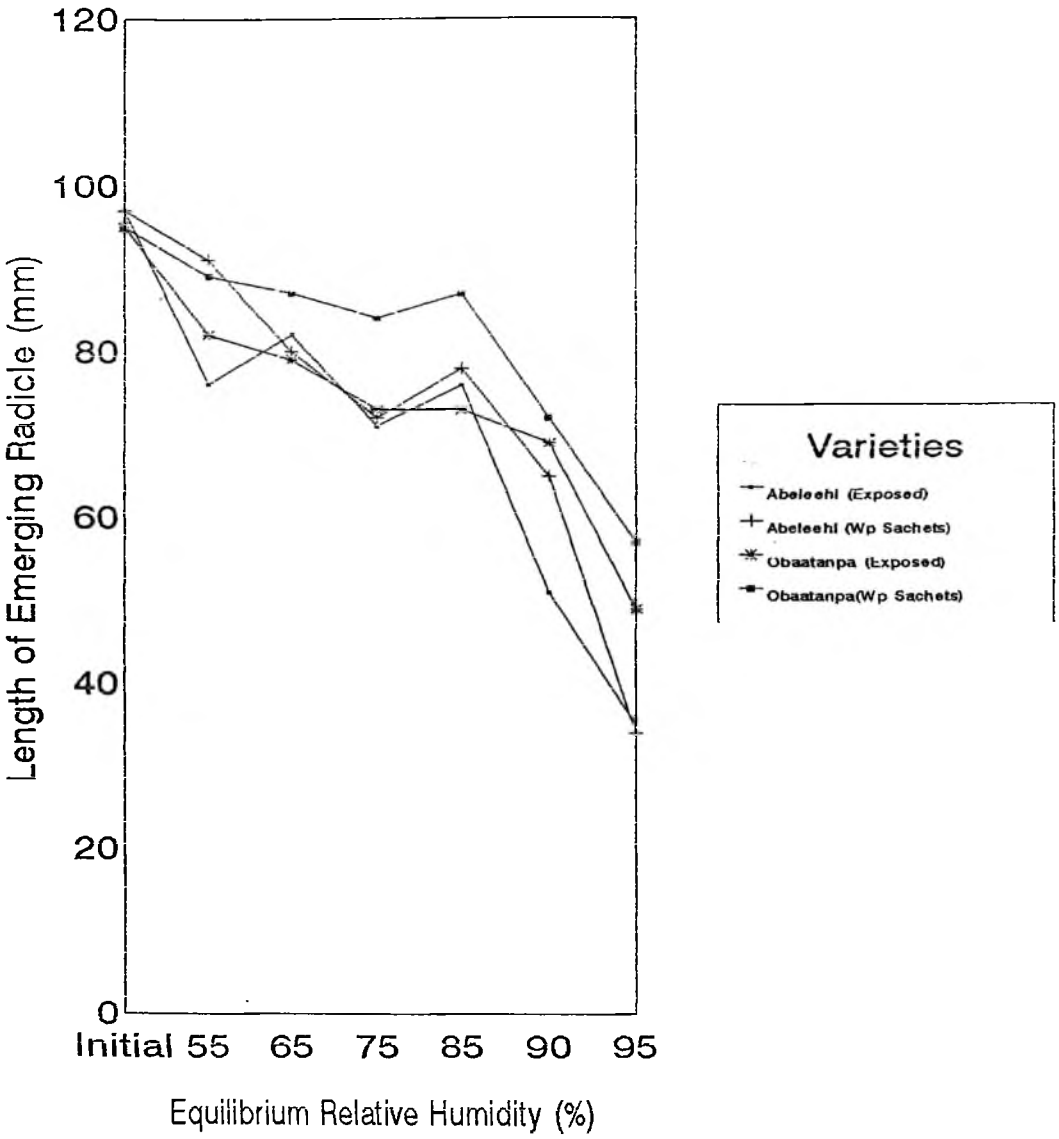


Fig.9. Influence of incubation/storage ERH(%) on the radicle length of germinating maize grains of the indicated varieties after storage at 28-31°C for 36 days

D. MOISTURE SORPTION ISOTHERMS OF "ABELEEHI" AND "OBAATANPA" MAIZE VARIETIES

Figs. 10 and 11 illustrate the moisture sorption isotherms of Abeleehi and Obaatanpa varieties, respectively. The equilibration period for grains stored at 65-85% ERH was 8-12 days. Moisture content of grains kept at 90-95% ERH continued rising while there was a decrease in moisture content of grains incubated at 55% ERH for both varieties (figs 10 and 11). The corresponding percentage changes in weight of the grains stored at ERH'S 55-95% are also presented in Figs. 12 and 13.

Application of Analysis of Variance to ascertain the influence of ERH, packaging material (P), incubation period (I) and maize variety (V) on moisture sorption as well as the interaction of these factors showed that P, I and V significantly ($P \leq 0.05$) influenced moisture sorption and desorption of the two maize varieties. Grains stored in Petri dishes significantly ($P \leq 0.05$) absorbed and desorbed moisture to a greater extent than same samples stored in woven polypropylene sachets. Moisture sorption by Obaatanpa variety was signifantly ($P \leq 0.05$) higher than Abeleehi variety under the same conditions (Appendices 8 and 9). The data used in plotting Figs. 10-13 are presented as Appendices 10 to 13.

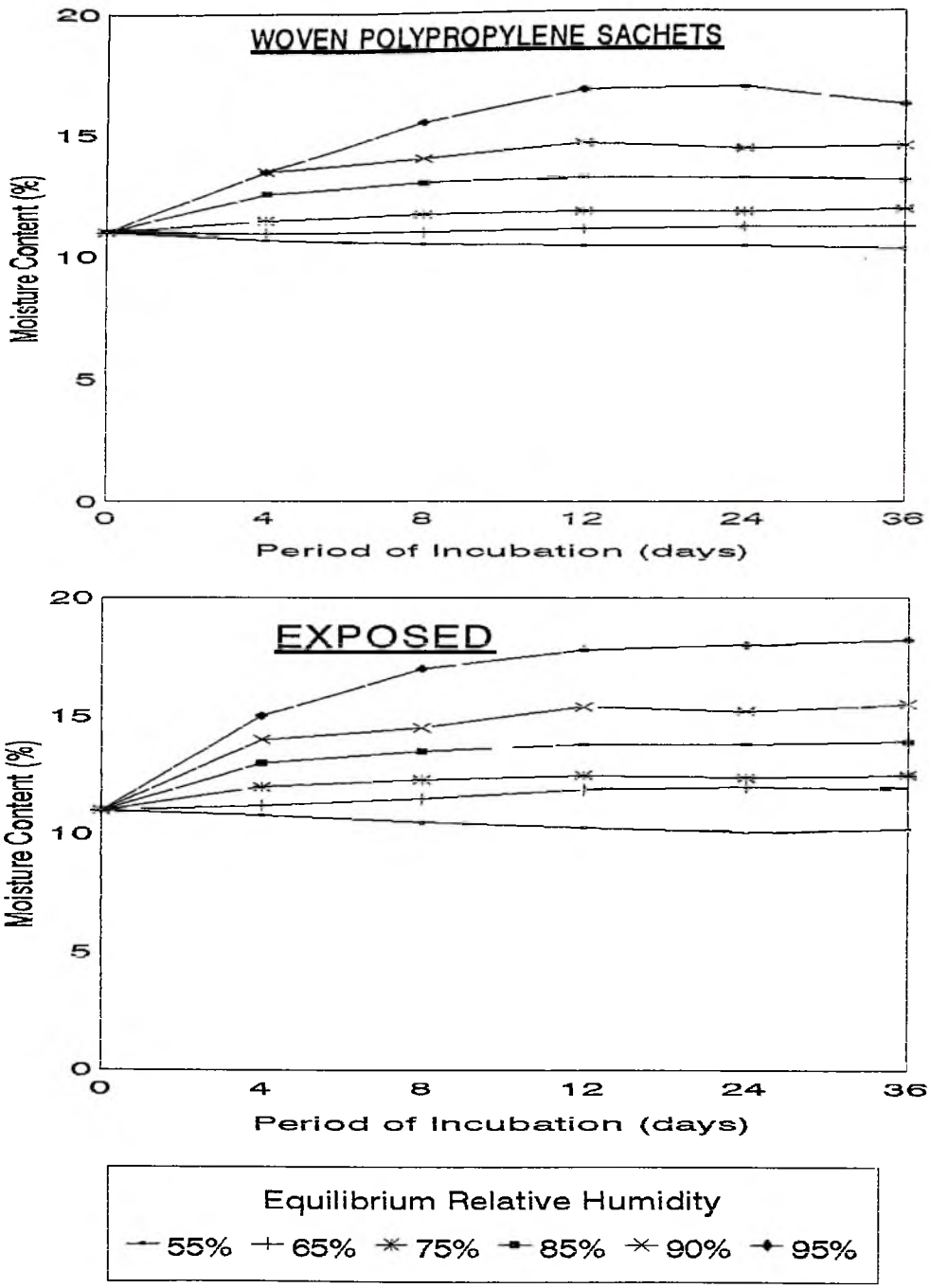


Fig.10. **Changes in moisture content of maize grains (ABELEEHI) incubated at ERH 55-95% for the indicated period at 28-31°C.**

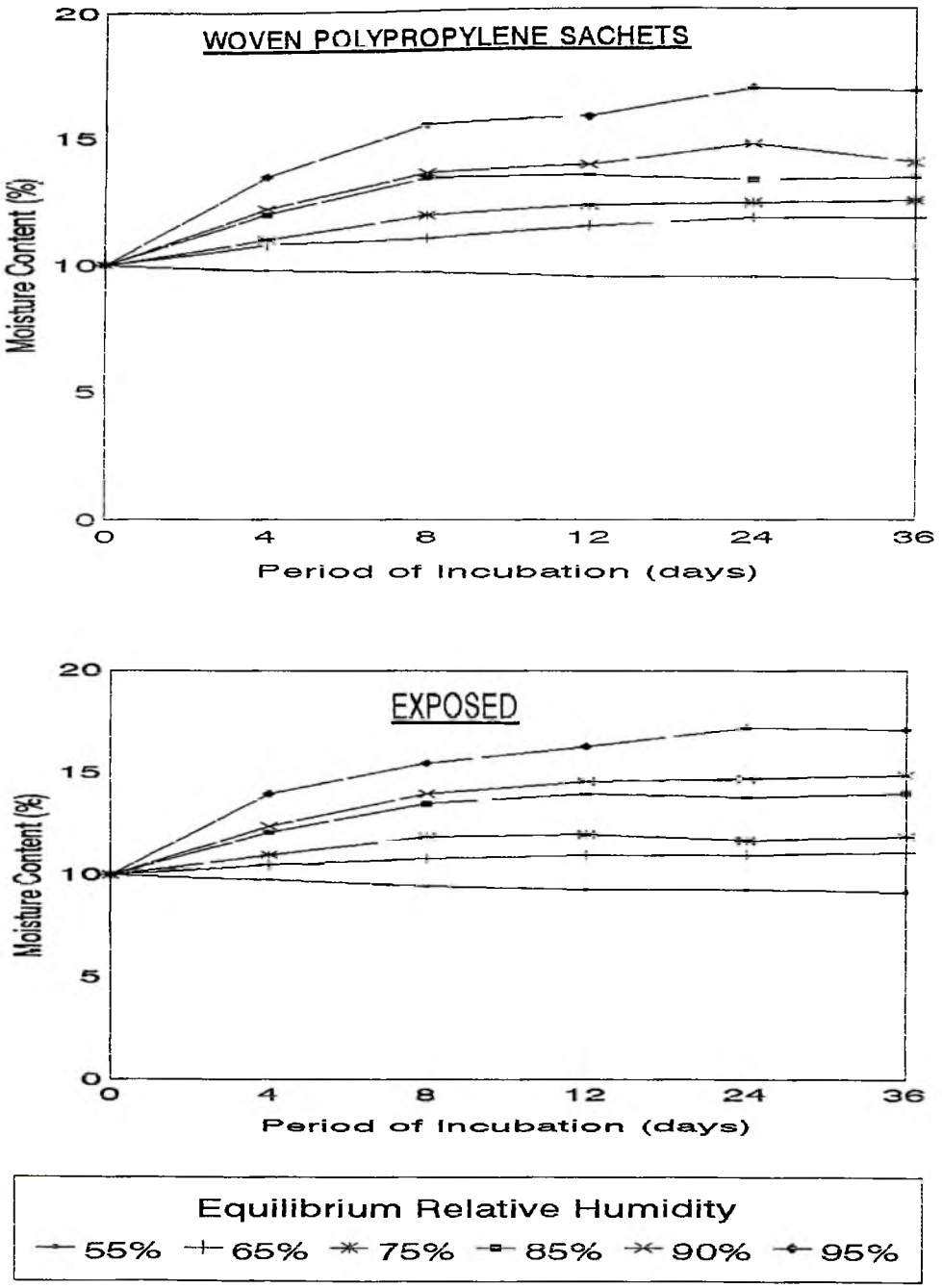


Fig.11. Changes in moisture content of maize grains (OBAATANPA) incubated at ERH 55-95% for the indicated period at 28-31°C.

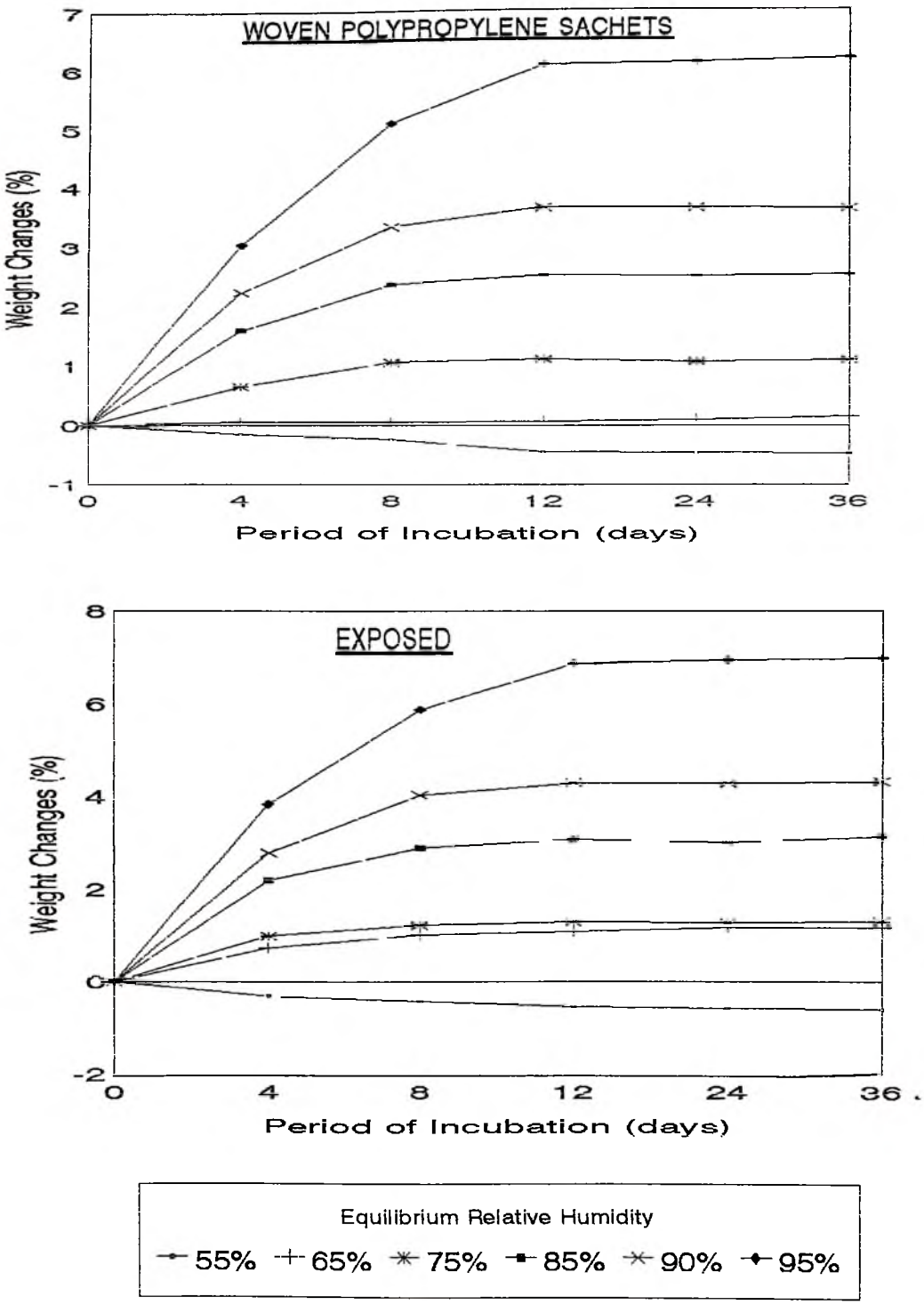


Fig.12. Influence of packaging material (Woven polypropylene) on moisture adsorption by maize (ABELEEHI) kept at ERH 55-95% for 36 days at 28-31°C.

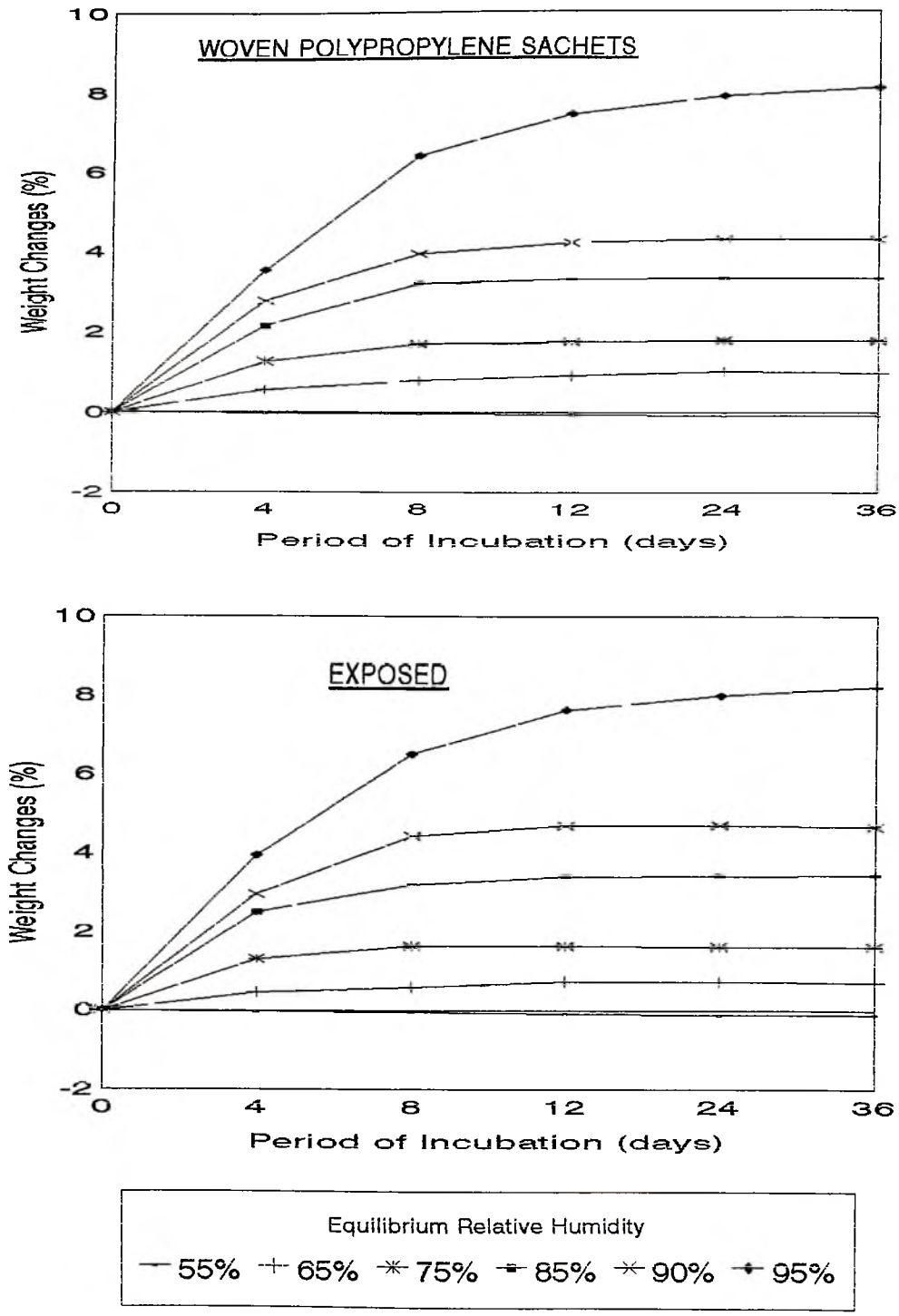


Fig.13. Influence of packaging material (Woven polypropylene) on moisture adsorption by maize (OBAATANPA) kept at ERH 55-95% for 36 days at 28-31°C.

E. VEGETATIVE GROWTH OF THREE *PAECILOMYCES* SPECIES IN MAIZE MEAL BROTH AMENDED WITH VARYING DILUTIONS OF AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE LEAVES OF *ZANTHOXYLUM XANTHOXYLOIDES*

The results obtained are presented in Tables 17 and 18. Aqueous, acetone or methanol extract of the leaves of *Z. xanthoxyloides* depressed vegetative growth of *Paecilomyces carneus, P. puntonii* and *P. varioti*. Mean dry matter accumulation of the three test fungi in each type of plant extracts differed significantly ($P \leq 0.05$). The efficacy of the extract in depressing vegetative growth of the three *Paecilomyces* species can be ranked as follows: methanol > acetone > aqueous (water).

The higher the concentration of extract, the severer the depression of vegetative growth. However, the inhibitory effect was gradually removed by dilution such that growth in 1:5 $^{v}/_{v}$ dilution nearly approximated that of the control (Tables 17 and 18, Plates 2 and 3). The pH of the aqueous, acetone and methanol extracts were 4., 4.4 and 4.0, respectively.

There was no statistical difference between the inhibitory effect of extracts on the three *Paecilomyces* species when used in amending maize meal broth prepared from either Abeleehi or Obaatanpa variety.

TABLE 17

Vegetative growth of indicated fungal species in maize dextrose broth (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Zanthoxylum xanthoxyloides* (Dry weight of mycelium was assessed after 8 days).

Fungal species	Dilution ratio of extract (v/v)	Dry weight of mycelium (mean ± S.E.) in mg in the indicated extract		
		Aqueous	Acetone	Methanol
Paecilomyces carneus	Undiluted	30 ± 1.43a	45 ± 1.20a	35 ± 1.80a
	1:1	155 ± 1.80b	230 ± 1.88b	180 ± 1.70b
	1:2	275 ± 2.28c	240 ± 2.32c	210 ± 2.14c
	1:5	275 ± 2.28c	255 ± 2.19d	230 ± 2.14d
	Control	295 ± 1.80d	260 ± 2.02d	280 ± 2.40e
P. puntonii	Undiluted	35 ± 1.80a	40 ± 1.70a	28 ± 1.11a
	1:1	195 ± 1.80b	145 ± 1.80b	160 ± 2.28b
	1:2	220 ± 2.54c	190 ± 2.14c	165 ± 2.54b
	1:5	240 ± 2.14d	275 ± 2.28d	175 ± 1.80bc
	Control	250 ± 2.14d	260 ± 2.47e	245 ± 2.28d
P. varioti	Undiluted	38 ± 1.12a	55 ± 1.20a	33 ± 1.80a
	1:1	180 ± 1.43b	210 ± 1.43b	120 ± 2.14b
	1:2	195 ± 2.44c	240 ± 2.71c	153 ± 1.80c
	1:5	235 ± 1.80d	285 ± 2.28d	170 ± 2.14d
	Control	295 ± 2.79e	275 ± 1.80d	245 ± 2.69e

By Multiple Range Test, means recorded for each species at the same type of extract and bearing the same letters are not significantly different at $P<0.05$.

TABLE 13

Fungal colonies recorded in Abeleehi and Obaatanpa varieties and incubated either exposed or in woven polypropylene sachets at 55-95% ERH and 29-31°C for 2 months.

Treatment	Grain Type	Total no. of colonies at indicated ERH's						
		Initial	55	65	75	85	90	95
Surface Sterilization	Abeleehi (Exposed)	35	36	29	18	29	31	74
	(Abeleehi (Wp)	29	29	32	28	38	40	41
Non-Surface Sterilization	Abeleehi (Exposed)	58	59	63	86	67	108	130
	Abeleehi (Wp)	63	60	58	56	74	80	118
Surface Sterilization	Obaatanpa (Exposed)	27	18	58	37	44	65	115
	Obaatanpa (Wp)	29	19	29	41	33	53	91
Non-Surface Sterilization	Obaatanpa (Exposed)	49	83	80	76	96	113	124
	Obaatanpa (Wp)	40	61	40	63	71	93	104

Wp - woven polypropylene sachets

TABLE 14

Total fungal population resident in Abeleehi and Obaatanpa varieties and incubated either exposed or in woven polypropylene sachets at 55-95% ERH and 29-31°C for 2 months.

Isolating Medium	Maize Variety	Fungal population (log_{10}cfu/g) at indicated ERH's						
		Initial	55	65	75	85	90	95
DG18	Abeleehi (Exposed)	4.0	5.1	4.8	4.8	5.2	5.5	5.8
	Abeleehi (Wp)	3.2	4.7	4.7	4.7	4.2	4.9	5.2
DRBC	Abeleehi (Exposed)	3.9	5.0	4.9	4.8	5.0	5.3	5.6
	Abeleehi (Wp)	1.9	2.1	2.1	3.3	3.1	3.5	4.2
DG18	Obaatanpa (Exposed)	4.3	5.1	5.1	4.3	4.3	5.5	6.3
	Obaatanpa (Wp)	3.5	4.1	3.3	3.8	3.6	5.9	5.9
DRBC	Obaatanpa (Exposed)	3.6	4.1	4.8	4.8	4.8	5.6	6.0
	Obaatanpa (Wp)	2.4	3.5	3.0	3.3	4.4	5.2	5.9

Wp - woven polypropylene sachets

TABLE 15

Extent of grain infection of Abeleehi and Obaatanpa varieties incubated either exposed or in woven polypropylene sachets at 55-95% ERH and 29-31°C for 2 months.

Treatment	Grain Type	% of Grain infection at indicated ERH's						
		Initial	55	65	75	85	90	95
Surface Sterilization	Abeleehi (Exposed)	59.0	75.0	63.3	47.5	56.7	73.3	100.0
	Abeleehi (Wp)	62.5	70.0	72.5	55.0	67.5	82.5	87.5
Non-Surface Sterilization	Abeleehi (Exposed)	81.0	80.0	82.0	92.0	96.0	98.0	100.0
	Abeleehi (Wp)	75.0	87.5	90.0	95.0	100	100	100.0
Surface Sterilization	Obaatanpa (Exposed)	60.0	60.0	78.0	66.7	80.0	83.3	93.3
	Obaatanpa (Wp)	53.0	45.0	47.5	67.5	77.5	82.5	100.0
Non-Surface Sterilization	Obaatanpa (Exposed)	87.5	90.0	92.0	82.0	86.0	96.0	100.0
	Obaatanpa (Wp)	70.0	90.0	87.5	97.5	92.5	100	100.0

Wp - woven polypropylene sachets

C. STUDIES ON SOME PHYSICAL CHARACTERISTICS OF SELECTED MAIZE VARIETIES

(a) Seed Water Absorption and Swelling Index

Fig.1a - c show the water absorption patterns of the indicated maize varieties. All the varieties show the characteristic sigmoid water absorption pattern of macromolecules. An initial high rate of water absorption was followed by a decrease at saturated point after which the grains seem not to pick up any more water (Fig.1a - c).

Improved maize varieties Obaatanpa showed a comparatively better water absorption level than Abeleehi (Fig. 1a). Similarly, local normal white maize absorbed better than the stackburned local white maize (Fig.1b). There was no statistical difference between normal yellow and stackburned yellow maize in terms of their water absorption capacities (Fig.1c). Data providing Fig.1a-c are summarised in Appendix 1

(b) Changes in Seed Dimensions

The swelling of the grains was measured as increase in grain dimension (length, width and thickness). Generally, grain dimension was increased with soaking time (Fig.2-4). After 24h of soaking, there was no statistical difference between the seed length of Obaatanpa and Abeleehi (Fig. 2a). Seed length of normal white maize was 2-3% more than that of stackburned white maize (Fig.2b). Swelling of normal yellow maize initially lagged behind that of stackburned samples but this was reversed after 15h soaking resulting in 1-2% increase in seed length over that of the stackburned yellow maize (Fig.2c). Similar trends were observed for seed width (Fig.3) and seed thickness (Fig.4). Appendices 2,3 and 4 represent data obtained.

(c) pH of Steeping Water

The pH of steep water of yellow maize grains (stackburned and non-stackburned) were very close throughout the soaking time of 30h (Fig. 5c). pH of steep water of non-stackburned local white maize was more acidic (4.2 - 4.3) than the stackburned grains of the same variety (pH 5.1-5.2) (Fig.5b). The pH of steep water of Abeleehi decreased from 5.9-4.6 after 10h-30h soaking as compared to pH 5.0-5.2 for Obaatanpa during the same period (Fig.5a and Appendix 5).

(d) Maize Dough Fermentation

pH profile of wet and dry-milled maize (normal and stackburned) undergoing normal spontaneous fermentation was generally similar at least during the first 24-48h (Figs. 6 and 7 and Appendix 6)

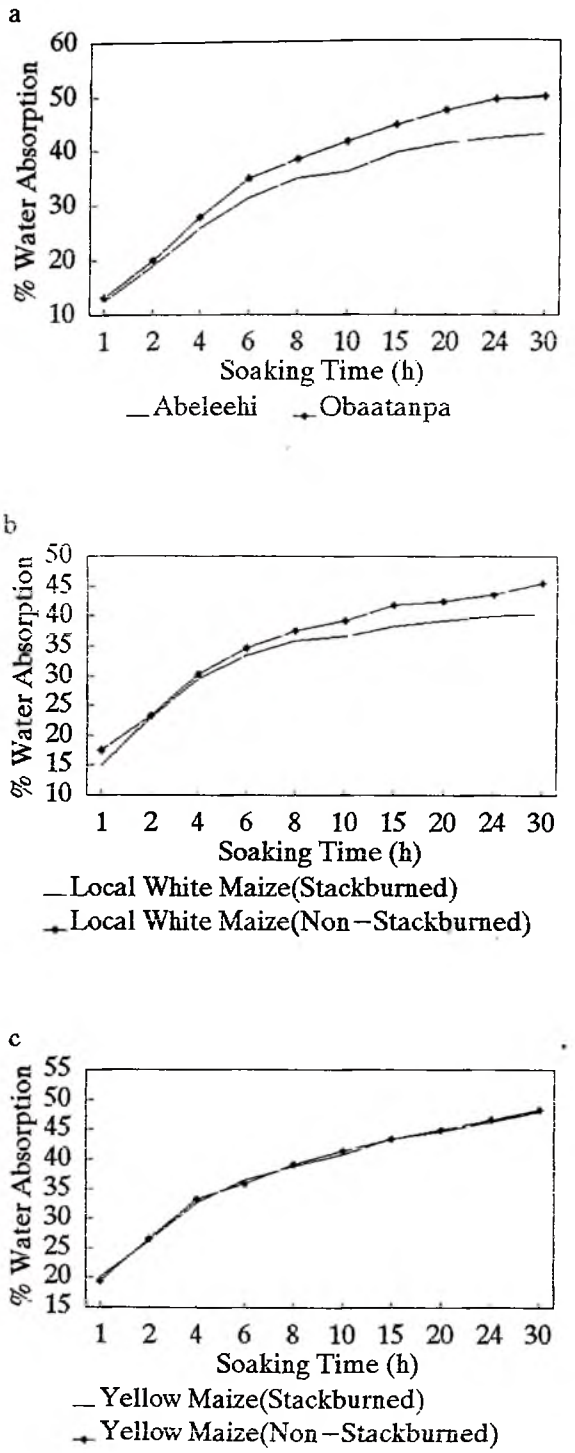


Fig.1. Percentage increase in water uptake by the indicated maize varieties at 30°C.

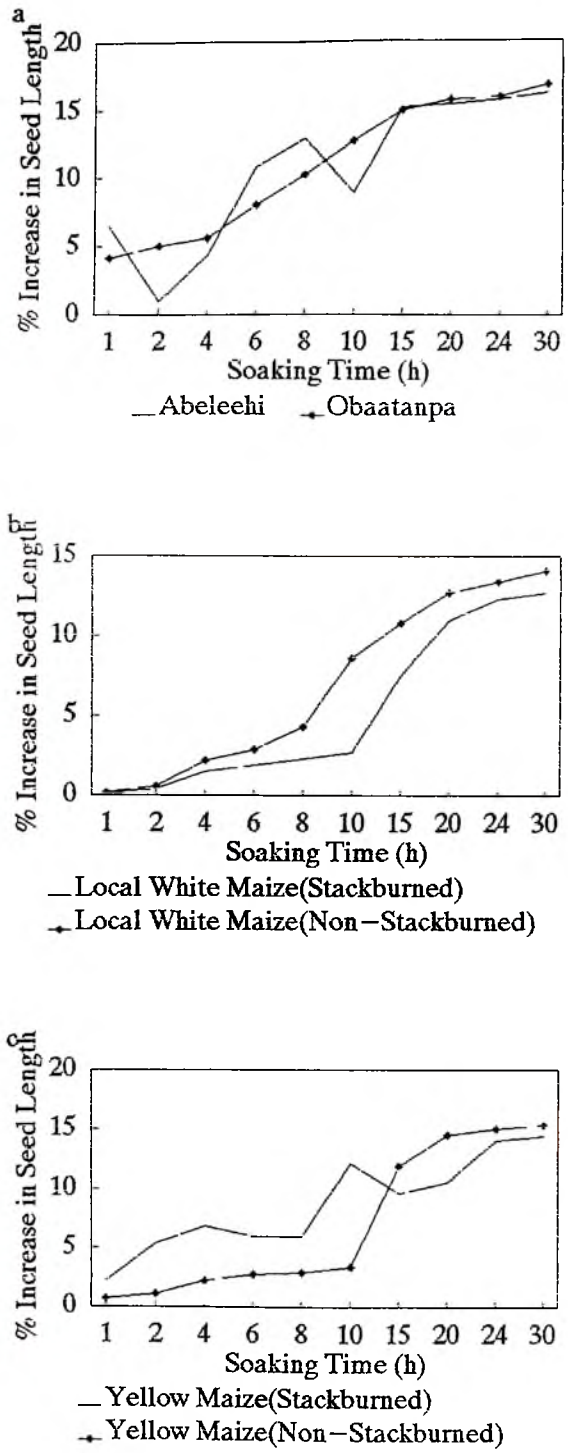
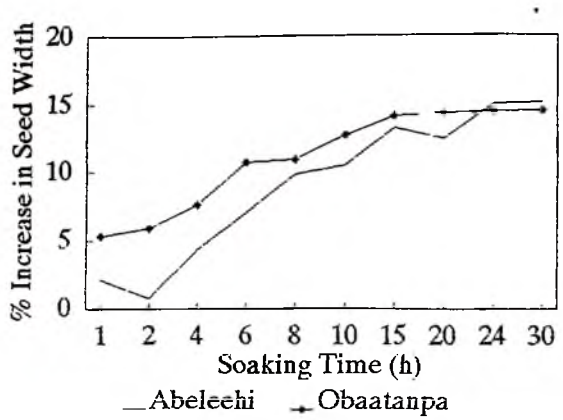
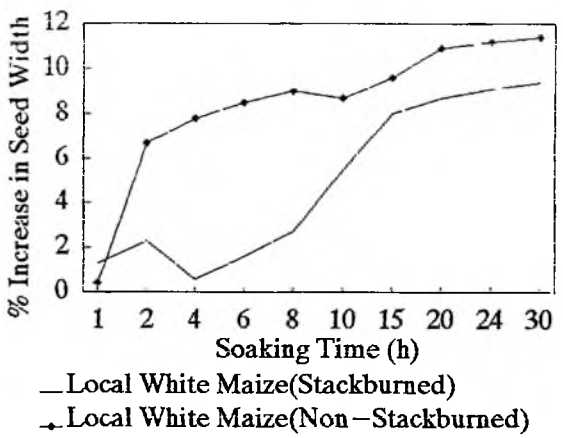


Fig.2. Change in seed length of the indicated maize varieties during soaking at 30°C.





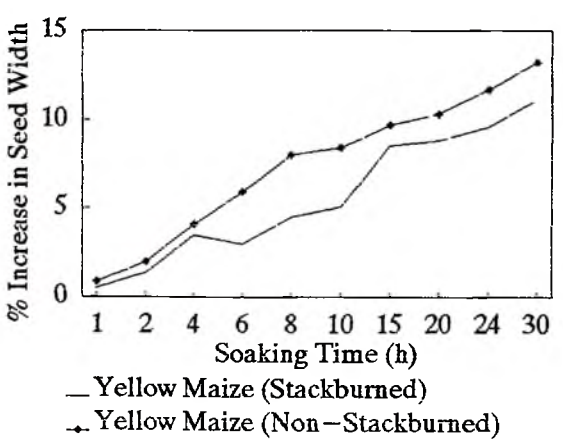
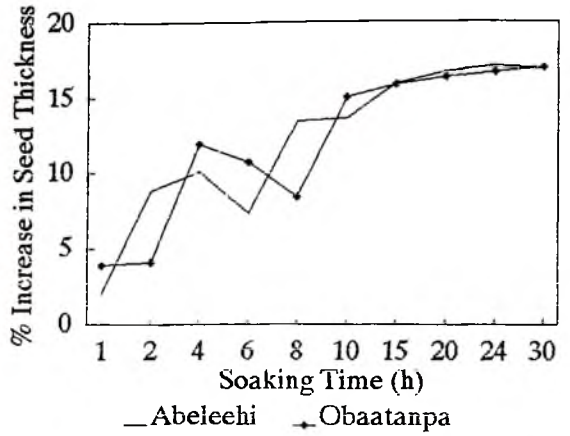
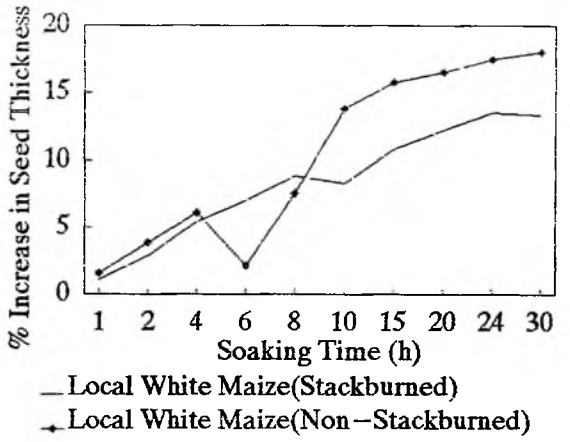


Fig.3. Change in seed width of the indicated maize varieties during soaking at 30°C.





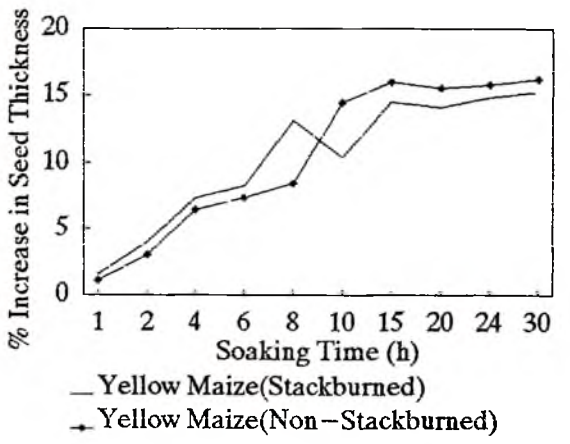
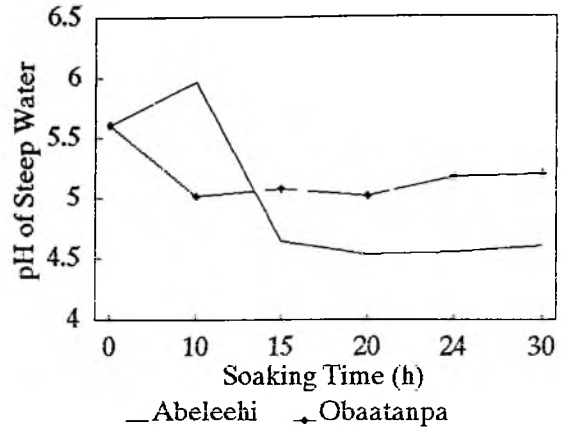
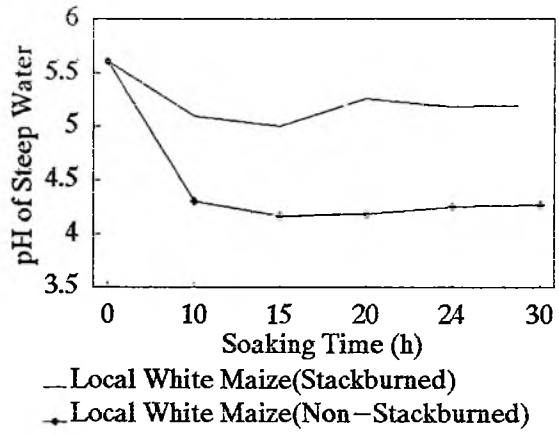


Fig.4. Change in seed thickness of the indicated maize varieties during soaking at 30°C.





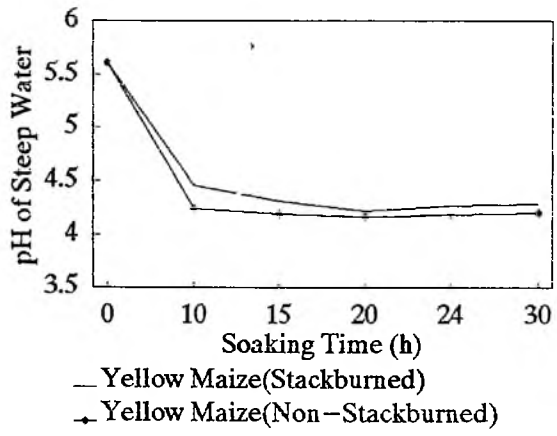
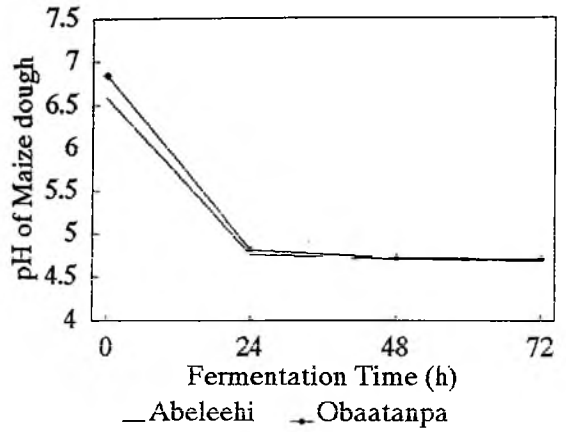
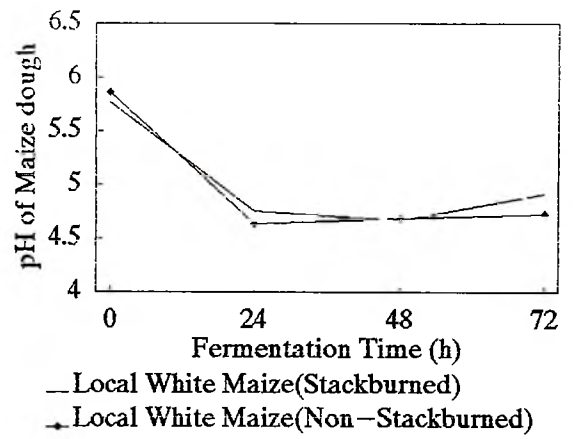


Fig.5. Change in pH of steep water during soaking of whole maize kernel at 30°C.





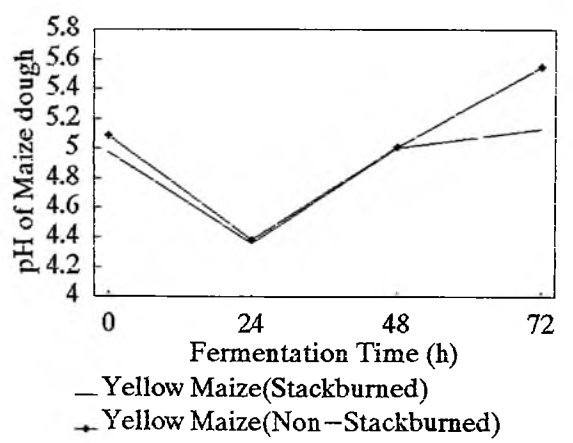
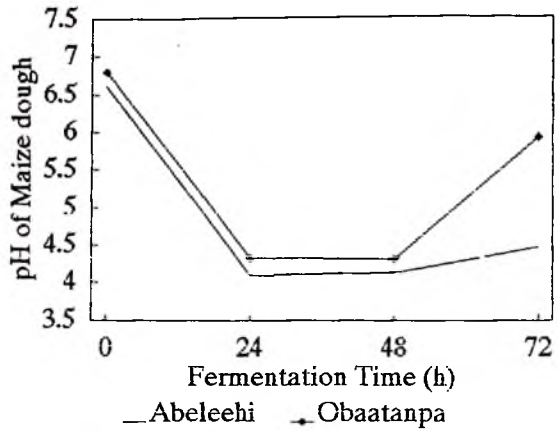
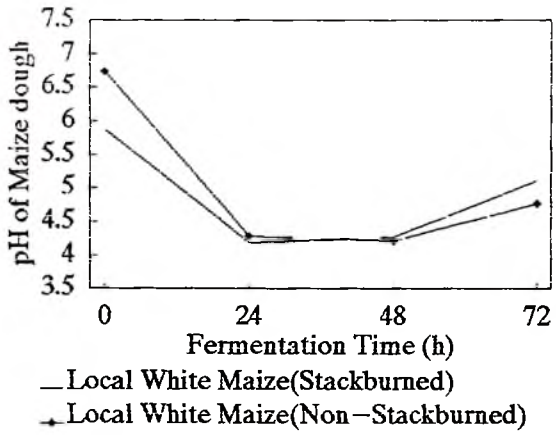


Fig.6. Change in pH of wet-milled maize during fermentation at 30°C for the indicated periods.





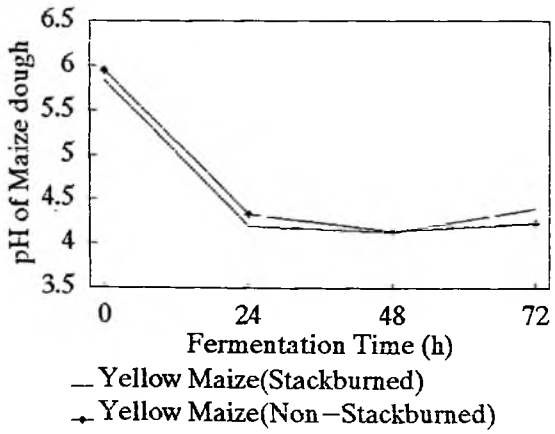


Fig.7. Change in pH of dry-milled maize during fermentation at 30°C for the indicated periods.

TABLE 18

Vegetative growth of indicated fungal species in maize dextrose broth (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of the leaves of *Zanthoxylum xanthoxyloides* (Dry weight of mycelium was assessed after 8 days).

Fungal species	Dilution ratio of extract (%v)	Dry weight of mycelium (mean ± S.E) in mg in the indicated extract		
		Aqueous	Acetone	Methanol
Paecilomyces carneus	Undiluted	30 ± 1.70a	35 ± 1.20a	40 ± 1.70a
	1:1	175 ± 2.28b	250 ± 2.14b	155 ± 1.80b
	1:2	265 ± 2.69c	285 ± 2.28c	195 ± 1.80c
	1:5	275 ± 2.44d	280 ± 2.14c	210 ± 1.43d
	Control	270 ± 2.02d	295 ± 2.44d	255 ± 1.80e
P. puntonii	Undiluted	25 ± 1.80a	48 ± 1.55a	43 ± 1.12a
	1:1	175 ± 2.28b	170 ± 1.70b	135 ± 2.14b
	1:2	210 ± 1.43c	230 ± 1.43c	140 ± 2.02c
	1:5	210 ± 2.13c	240 ± 1.43c	160 ± 1.20d
	Control	230 ± 1.43d	250 ± 2.54cd	175 ± 2.28e
P. varioti	Undiluted	28 ± 1.12a	43 ± 1.77a	35 ± 1.80a
	1:1	205 ± 1.80b	255 ± 2.28b	138 ± 1.55b
	1:2	240 ± 2.02c	270 ± 1.43c	173 ± 2.35c
	1:5	260 ± 2.14d	288 ± 2.77d	185 ± 2.08d
	Control	270 ± 1.70d	295 ± 2.44e	243 ± 2.07e

By Multiple Range Test, means recorded for each species at the same type of extract and bearing the same letters are not significantly different at $P<0.05$.

Plate 2: Vegetative growth of *Paecilomyces carneus* in Maize meal broth (using Obaatanpa variety) amended with methanol extract of *Zanthoxylum xanthoxyloides* and incubated at 28-31°C for 8 (x¼)

(From left: undiluted, 1:1, 1:2, 1:5 $^{v}/_{v}$ and control; Note the scanty mycelial growth the undiltued extract).

Plate 3: Vegetative growth of *P. varioti* in Maize meal broth (using Obaatanpa variety) amended with methanol extract of *z. xanthoxyloides* and incubated at 28-31°C for 8 days (x¼).

(From left: undiluted, 1:1, 1:2, 1:5 $^{v}/_{v}$ and control; Note the scanty growth of the mycelium in the undiluted extract).

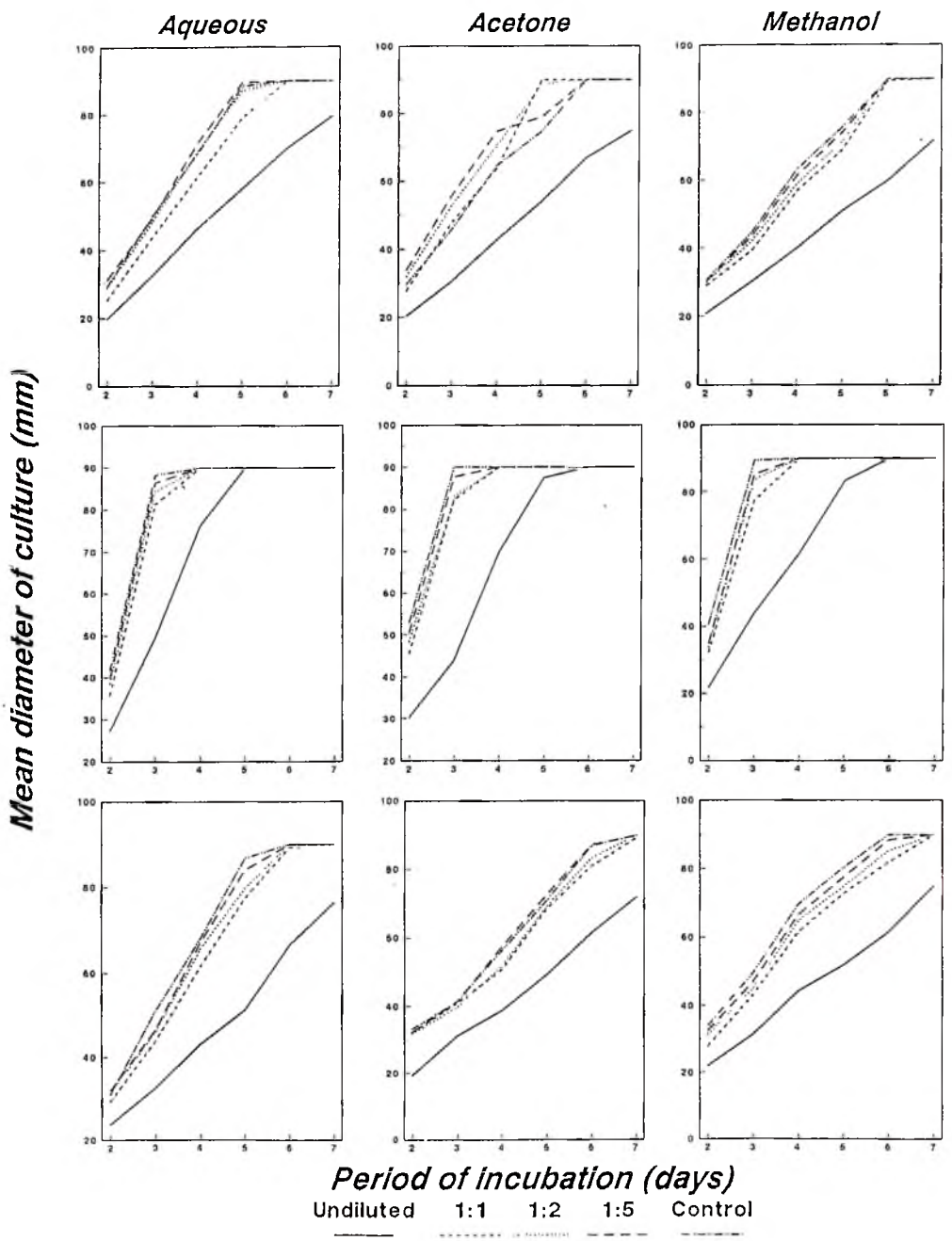
F. RADIAL GROWTH OF THREE *PAECILOMYCES* SPECIES ON MAIZE MEAL AGAR AMENDED WITH AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE LEAVES OF *Z. XANTHOXYLOIDES*

Results obtained are presented in Figs. 14 and 15 and Appendices 14-19.

Paecilomyces carneus, P. puntonii and *P varioti* behaved differently on agar medium (Figs 14 and 15). The inhibitory effect of the three extracts on radial growth of *P. puntonii* was initially pronounced in the undiluted extract. However growth of this fungus on the undiluted extract approximated that of the control after 5-7 days growth (Figs. 14 and 15).

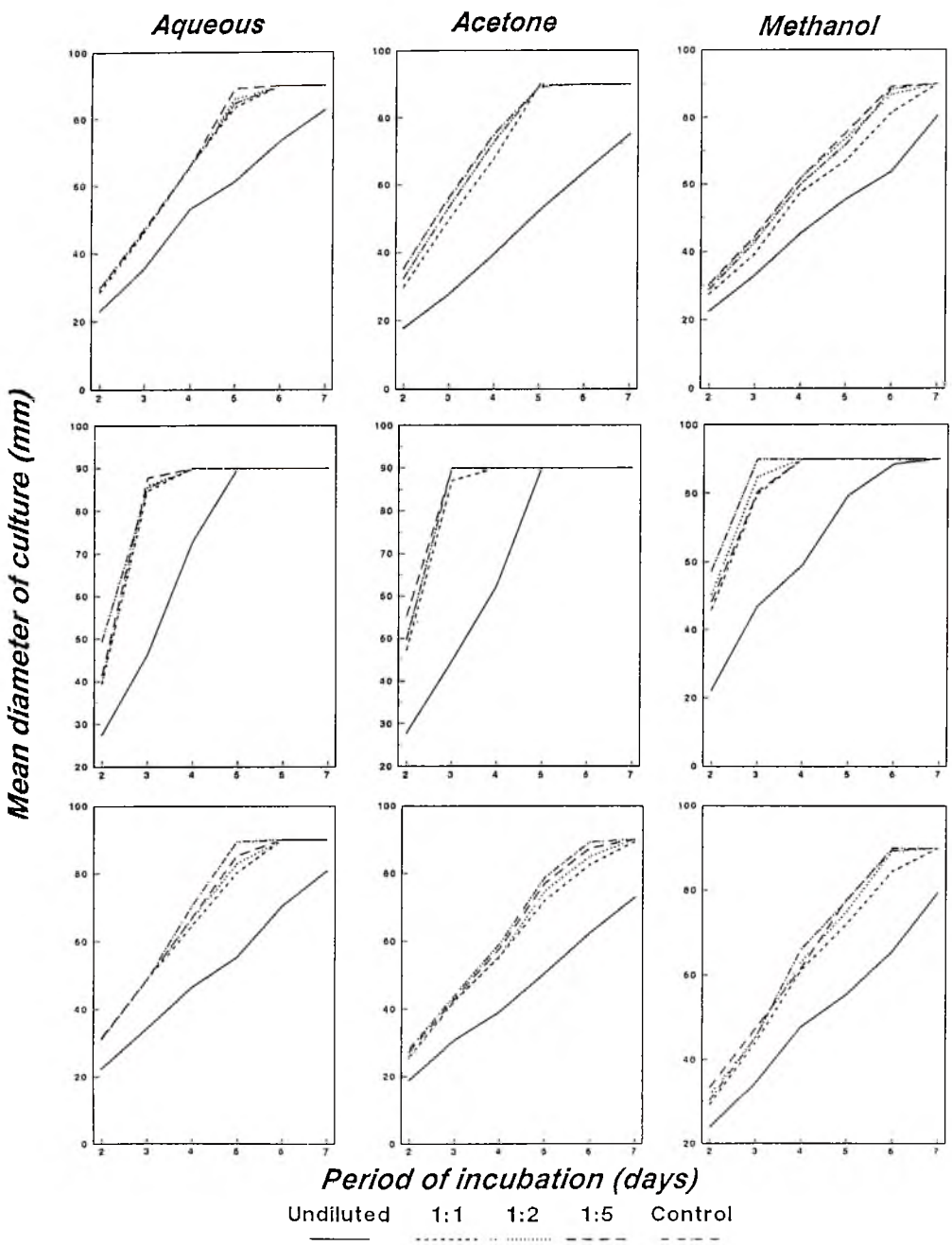
In the case of *P. carneus* and *P. varioti* the undiluted extract permanently impaired radial growth of the test fungi and on growth media amended with undiluted extracts significantly ($P \leq 0.05$) lagged behind what existed in the control (Figs. 14 & 15, Plates 4 & 5 and Appendices 14-19).

Fig. 14



Radial growth of *Paecilomyces carneus* (TOP), *P.puntonii* (MIDDLE) and *P.variotl* (BOTTOM) at 28-30°C on maize dextrose agar medium(ABELEEHI) amended with aqueous, acetone or methanol extracts of the leaves of *Zanthoxylum xanthoxyloides* .

Fig. 15



Radial growth of *Paecilomyces carneus* (TOP), *P.puntonii* (MIDDLE) and *P.varioti* (BOTTOM) at 28-30°C on maize dextrose agar *medium* (OBAATANPA) amended with aqueous, acetone or methanol extracts of the leaves of *Zanthoxylum xanthoxyloides* .

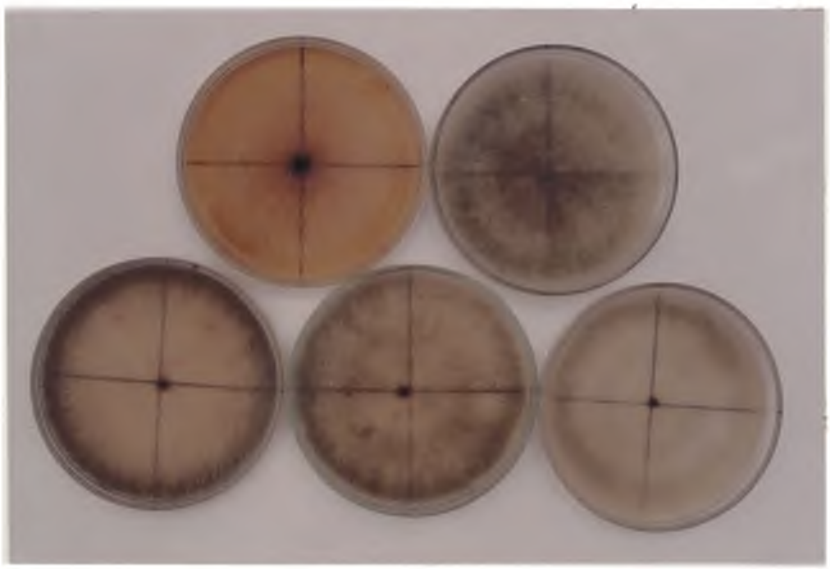


Plate 4: Radial growth of *P. puntonii* on Maize meal agar amended with methanol extract of the leaves of *Z. xanthoxyloides* and incubated at 28-31°C for 5 days (x½)

Top: Left, undiluted; right, control.

Bottom: Left: 1:1 v/v; middle, 1:2 v/v; right, 1:5 v/v.

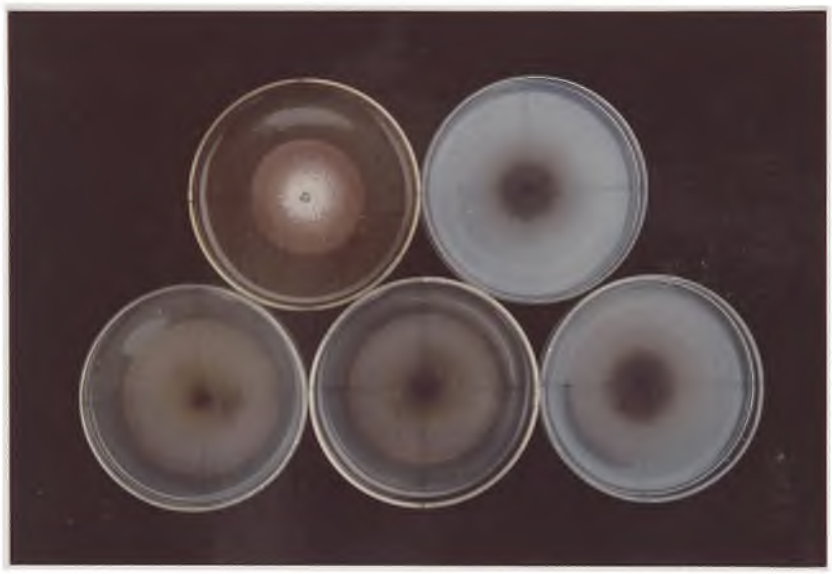


Plate 5: Radial growth of *P. carneus* in Maize meal agar amended with methanol extract of the leaves of *Z. xanthoxyloides* and incubated at 28-31°C for 7 days (x½).

Top: left, undiluted extract; right, control.

Bottom: left, 1:1 $^{v}/_{v}$; middle, 1:2 $^{v}/_{v}$; right 1:5 $^{v}/_{v}$

G. VEGETATIVE GROWTH OF *CURVULARIA LUNATA*, *FUSARIUM MONILIFORME* AND *PENICILLIUM DIGITATUM* IN MAIZE MEAL BROTH AMENDED WITH VARYING DILUTIONS OF AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE LEAVES OF *Z. XANTHOXYLOIDES*.

Depression of vegetative growth of the three test fungi decreased with increasing dilutions of the aqueous, acetone and methanol extracts of *Z. xanthoxyloides* (Tables 19 & 20). Plate 6 shows vegetative growth of *Curvularia lunata* taken after 8 days incubation at 28-30°C.

Generally, vegetative growth of all the test fungi in the undiluted extract varied from one fungus to the other. Growth was inhibited by 72.4 - 86.0% (*F. moniliforme*); 76.5 - 89.6% (*C. lunata*) and by 84.4 - 89.8%) (*P. digitatum*) as compared to the control (Tables 19 & 20). Methanol extract of the test plant was the most effective ($P \leq 0.05$) in depressing growth of all the test fungi compared to aqueous and acetone extracts. The respective pH's of methanol, aqueous and acetone extracts were 4., 4.7 and 4.5.

TABLE 19

Vegetative growth of indicated fungal species in maize dextrose broth (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of the leaves of *Zanthoxylum xanthoxyloides* (Dry weight of mycelium was assessed after 8 days).

Fungal species	Dilution ratio of extract (%v)	Dry weight of mycelium (mean ± S.E.) in mg in the indicated extract		
		Aqueous	Acetone	Methanol
Penicillium digitatum	Undiluted	33 ± 1.77a	38 ± 1.43a	40 ± 1.43a
	1:1	220 ± 1.70b	198 ± 2.07b	135 ± 2.28b
	1:2	270 ± 2.14c	200 ± 2.02b	170 ± 2.04c
	1:5	280 ± 2.54d	265 ± 2.69c	230 ± 2.14d
	Control	325 ± 2.28e	270 ± 2.54c	275 ± 2.28e
Curvularia lunata	Undiluted	40 ± 1.43a	43 ± 1.94a	38 ± 1.94a
	1:1	160 ± 2.54b	180 ± 2.14b	120 ± 2.02b
	1:2	170 ± 2.14c	190 ± 2.14c	135 ± 1.80c
	1:5	170 ± 1.43c	225 ± 1.80c	150 ± 2.14d
	Control	235 ± 1.80d	265 ± 2.79d	230 ± 2.47e
Fusarium moniliforme	Undiluted	35 ± 1.80a	30 ± 2.14a	25 ± 1.20a
	1:1	85 ± 1.20b	65 ± 1.20b	50 ± 1.43b
	1:2	120 ± 2.54c	95 ± 1.20c	80 ± 2.14c
	1:5	140 ± 2.02d	130 ± 1.70d	120 ± 2.14d
	Control	138 ± 2.07d	150 ± 1.43e	140 ± 2.54e

By Multiple Range Test, means recorded for each species at the same type of extract and bearing the same letters are not significantly different at $P<0.05$.

TABLE 20

Vegetative growth of indicated fungal species in maize dextrose broth (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of the leaves of *Zanthoxylum xanthoxyloides* (Dry weight of mycelium was assessed after 8 days).

Fungal	Dilution ratio of extract (%)	Dry weight of mycelium (mean ± S.E) in mg in the species indicated extract		
		Aqueous	Acetone	Methanol
Penicillium digitatum	Undiluted	35 ± 1.80a	45 ± 1.20a	38 ± 1.12a
	1:1	215 ± 1.80b	225 ± 2.28b	115 ± 1.80b
	1:2	230 ± 2.02c	250 ± 2.02c	130 ± 2.86c
	1:5	295 ± 2.79d	260 ± 2.14d	155 ± 2.44d
	Control	290 ± 1.43d	288 ± 2.07e	275 ± 1.80e
Curvularia lunata	Undiluted	30 ± 1.43a	35 ± 1.20a	35 ± 1.80a
	1:1	140 ± 1.43b	160 ± 2.14b	110 ± 1.70b
	1:2	185 ± 2.28c	210 ± 2.71c	125 ± 2.08c
	1:5	185 ± 2.43c	265 ± 1.80d	125 ± 1.80c
	Control	280 ± 1.70c	293 ± 2.50e	268 ± 1.77d
Fusarium moniliforme	Undiluted	30 ± 1.43a	25 ± 1.20a	20 ± 1.43a
	1:1	95 ± 1.80b	80 ± 2.47b	55 ± 1.80b
	1:2	125 ± 2.69c	135 ± 2.69c	70 ± 2.14c
	1:5	138 ± 1.80d	135 ± 1.20c	125 ± 1.80d
	Control	145 ± 1.20e	150 ± 1.43d	143 ± 1.55e

By Multiple Range Test, means recorded for each species at the same type of extract and bearing the same letters are not significantly different at $P<0.05$.

Plate 6: Vegetative growth of *Curvularia lunata* in Maize meal broth (using Obaatanpa variety) amended with methanol extract of *Z. xanthoxyloides* and incubated at 28-31°C for 8 days (x¼).

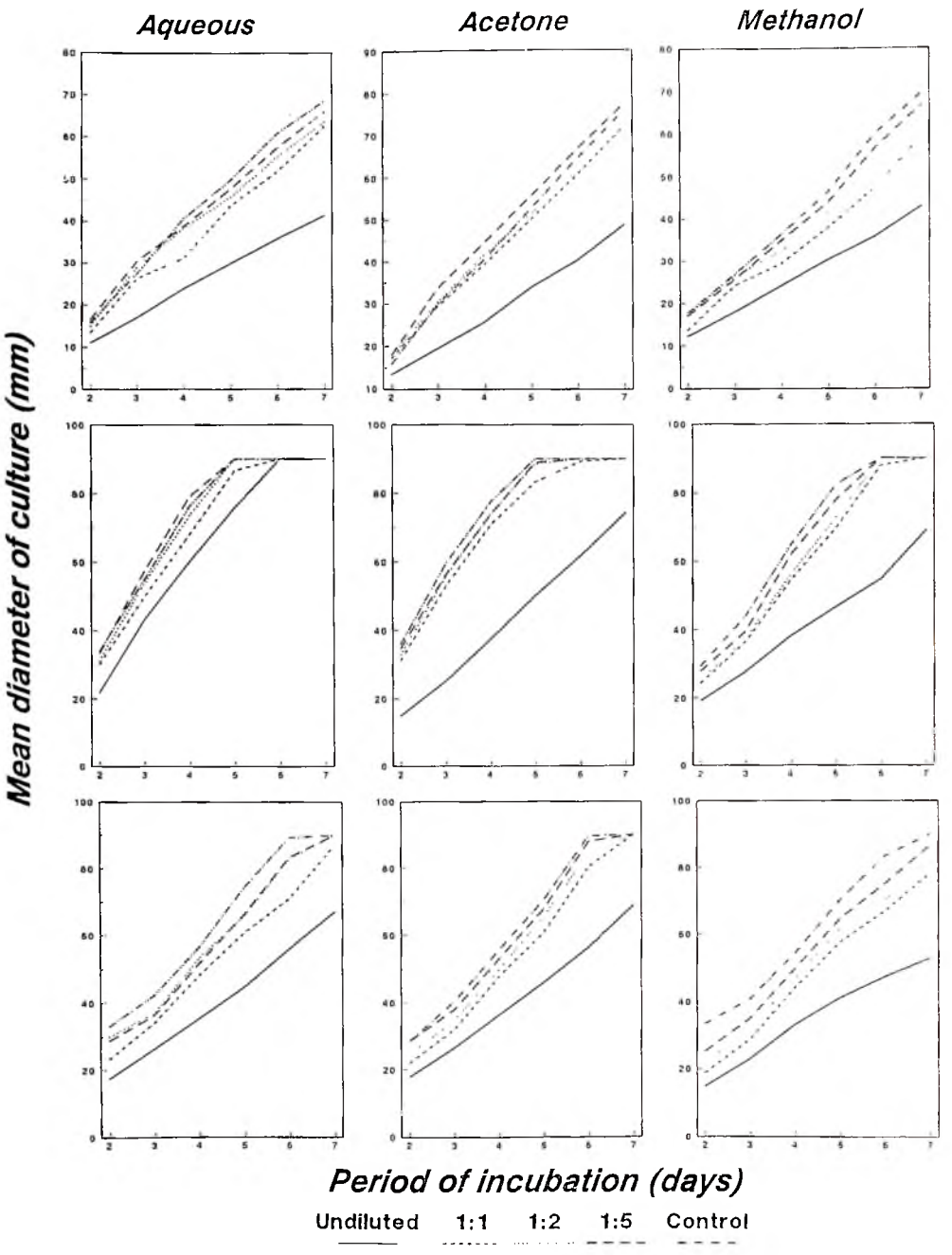
(From left: undiluted, 1:1, 1:2, 1:5 v/v and control; Note the scanty mycelial growth in the undiltued extract).

H. RADIAL GROWTH OF *C. LUNATA, F. MONILIFORME AND P. DIGITATUM* ON MAIZE MEAL AGAR AMENDED WITH AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE LEAVES OF *Z. XANTHOXYLOIDES*

Radial growth of the three test fungi in maize meal broth (prepared from Obaatanpa and Abeleehi) amended with 1:1 - 1:5 $^{v}/_{v}$ of the leaf extract of *Z. xanthoxyloides* approximated that of the control in most instances after 2-7 days growth (Figs. 16 & 17 and Appendices 20-25). On the other hand the undiluted extract significantly ($P \leq 0.05$) depressed radial growth of the three test fungi even after 7 days growth.

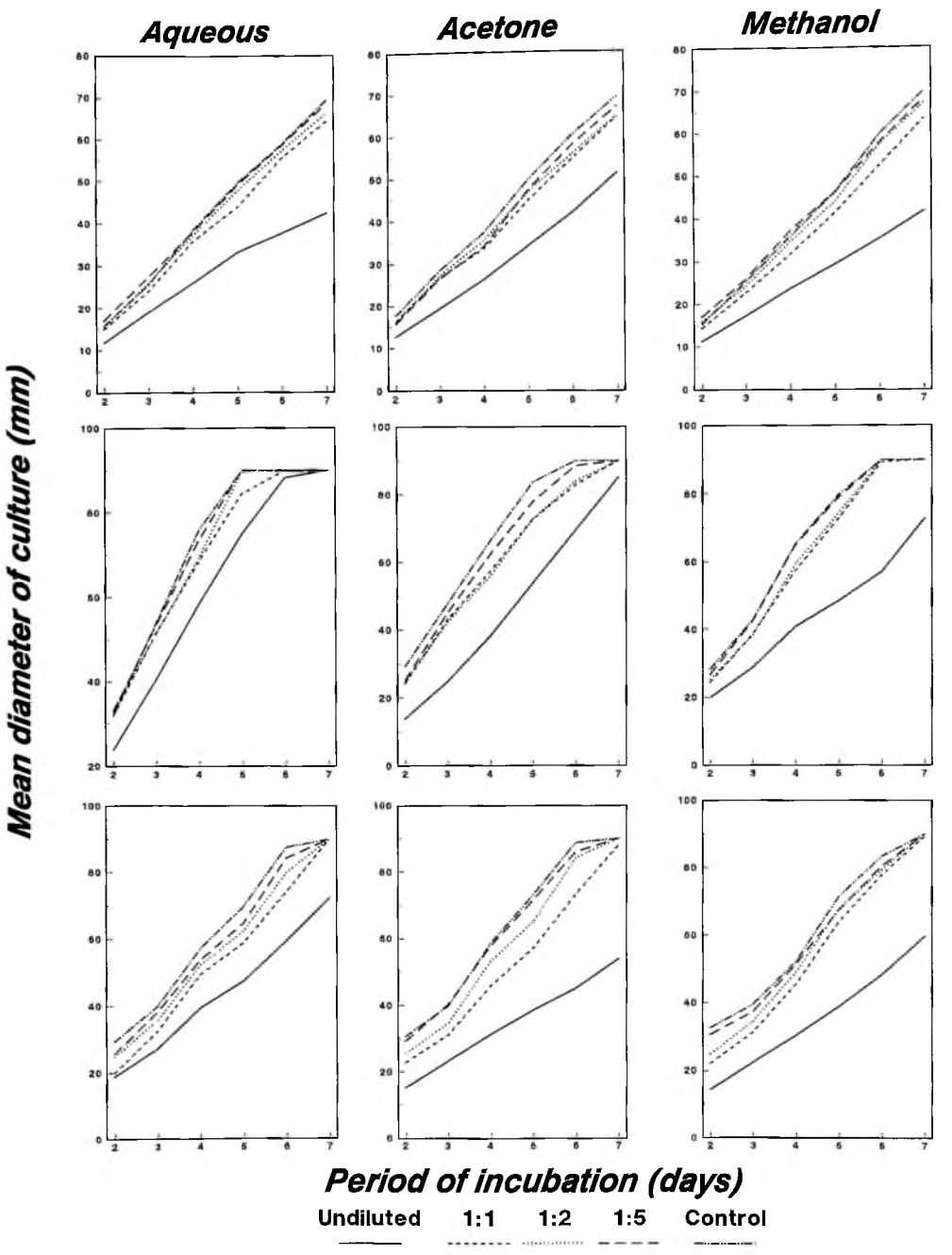
Statistical analysis (Multiple Range Test) showed that the efficacy of the inhibitory principle depended not only on the test fungus but also on the nature of the solvent used in extracting the active ingredient. Methanol was the best solvent followed by acetone and water in decreasing order (Tables 21a-21f). The efficacy of the inhibitory effect of the aqueous, acetone and methanol extracts of the leaves of *Z. xanthoxyloides* on the test fungi can be ranked as follows in decreasing order: *P. digitatum* > *F. moniliforme* > *C. lunata* (Tables 22a - 22f) Plate 7 illustrates the radial growth of *F. moniliforme* in the methanol extract of the leaves of *Z. xanthoxyloides*.

Fig. 16



Radial growth of *Penicillium digitatum*(TOP), *Curvularia lunata* (MIDDLE) and *Fusarium moniliforme* (BOTTOM) at 28-30 C on maize dextrose agar medium(ABELEEHI) amended with aqueous, acetone or methanol extracts of the leaves of *Zanthoxylum xanthoxyloides* .

Fig. 17



Radial growth of *Penicillium digitatum* (TOP), *Curvularia lunata* (MIDDLE) and *Fusarium moniliforme* (BOTTOM) at 28-30 C on maize dextrose agar medium (OBAATANPA) amended with aqueous, acetone or methanol extracts of the leaves of *Zanthoxylum xanthoxyloides* .

TABLE 21a

Multiple range analysis showing the effect of aqueous, acetone and methanol extracts of the leave of *Zanthoxylum xanthoxyloides* on the radial growth of *Curvularia lunata* on maize meal agar medium (ABELEEHI).

Type of Extract	Count	Mean	Homogeneous Grouping
Aqueous	16	85.700	A
Acetone	16	77.775	B
Methanol	16	66.853	C

TABLE 21b

Multiple range analysis showing the effect of aqueous, acetone and methanol extracts of the leaves of *Z. xanthoxyloides* on radial growth of *Fusarium moniliforme* on maize meal agar medium (ABELEEHI).

Type of Extract	Count	Mean	Homogeneous Grouping
Aqueous	16	59.425	A
Acetone	16	60.025	B
Methanol	16	56.425	C

TABLE 21c

Multiple range analysis showing the effect of aqeuous, acetone and methanol extracts of the leaves of *Z. xanthoxyloides* on the radial growth of *Penicillium digitatum* on maize meal agar medium (ABELEEHI).

Type of Extract	Count	Mean	Homogeneous Grouping
Aqueous	16	41.851	A
Acetone	16	47.850	B
Methanol	16	38.500	C

Means with the same letters are not significantly different.

TABLE 21d

Multiple range analysis showing the effect of aqueous, acetone and methanol extracts of the leaves of *Z. xanthoxyloides* on the radial growth of *Curvularia lunata* on maize meal agar medium (OBAATANPA).

Type of Extract	Count	Mean	Homogeneous Grouping
Aqueous	16	84.750	A
Acetone	16	69.403	B
Methanol	16	68.651	C

TABLE 21e

Multiple range analysis showing the effect of aqueous, acetone and methanol extracts of the leaves of *Z. xanthoxyloides* on the radial growth of *Fusarium moniliforme* on maize meal agar medium (OBAATANPA).

Type of Extract	Count	Mean	Homogeneous Grouping
Aqueous	16	58.453	A
Acetone	16	58.350	A
Methanol	16	63.025	B

TABLE 21f

Multiple range analysis showing the effect of aqueous, acetone and methanol extracts of the leaves of *Z. xanthoxyloides* on the radial growth of *Penicillium digitatum* on maize meal agar medium (OBAATANPA).

Type of Extract	Count	Mean	Homogeneous Grouping
Aqueous	16	43.650	A
Acetone	16	43.317	A
Methanol	16	40.325	B

Means with the same letters are not significantly different.

TABLE 22a

Multiple range analysis showing the effect of AQUEOUS extract of the leaves of *Z. xanthoxyloides* on radial growth of *C. lunata, F. moniliforme* and *P. digitatum* on maize meal agar medium (ABELEEHI).

Fungal species	Count	Mean	Homogeneous Grouping
C. lunata	16	85.700	A
F. moniliforme	16	59.425	B
P. digitatum	16	41.851	C

TABLE 22b

Multiple range analysis showing the effect of ACETONE extract of the leaves of *Z. xanthoxyloides* on radial growth of *C. lunata, F. moniliforme* and *P. digitatum* on maize meal agar medium (ABELEEHI).

Fungal species	Count	Mean	Homogeneous Grouping
C. lunata	16	77.775	A
F. moniliforme	16	60.025	B
P. digitatum	16	47.850	C

TABLE 22c

Multiple range analysis showing the effect of METHANOL extract of the leaves of *Z. xanthoxyloides* on radial growth of *C. lunata, F. moniliforme* and *P. digitatum* on maize meal agar medium (ABELEEHI).

Fungal species	Count	Mean	Homogeneous Grouping
C. lunata	16	66.853	A
F. moniliforme	16	56.425	B
P. digitatum	16	38.500	C

Means with the same letters are not signficiantly different

TABLE 22d

Multiple range analysis showing the effect of **AQUEOUS** extract of the leaves of *Z. xanthoxyloides* on radial growth of *C. lunata, F. moniliforme* and *P. digitatum* on maize meal agar medium (OBAATANPA).

Fungal species	Count	Mean	Homogeneous Grouping
C. lunata	16	84.750	A
F. moniliforme	16	58.453	B
P. digitatum	16	43.650	C

TABLE 22e

Multiple range analysis showing the effect of **ACETONE** extract of the leaves of *Z. xanthoxyloides* on radial growth of *C. lunata, F. moniliforme* and *P. digitatum* on maize meal agar medium (OBAATANPA).

Fungal species	Count	Mean	Homogeneous Grouping
C. lunata	16	69.403	A
F. moniliforme	16	58.350	B
P. digitatum	16	43.317	C

TABLE 22f

Multiple range analysis showing the effect of **METHANOL** extract of the leaves of *Z. xanthoxyloides* on radial growth of *C. lunata, F. moniliforme* and *P. digitatum* on maize meal agar medium (OBAATANPA).

Fungal species	Count	Mean	Homogeneous Grouping
C. lunata	16	68.651	A
F. moniliforme	16	63.025	B
P. digitatum	16	40.325	C

Means with the same letters are not significantly different.

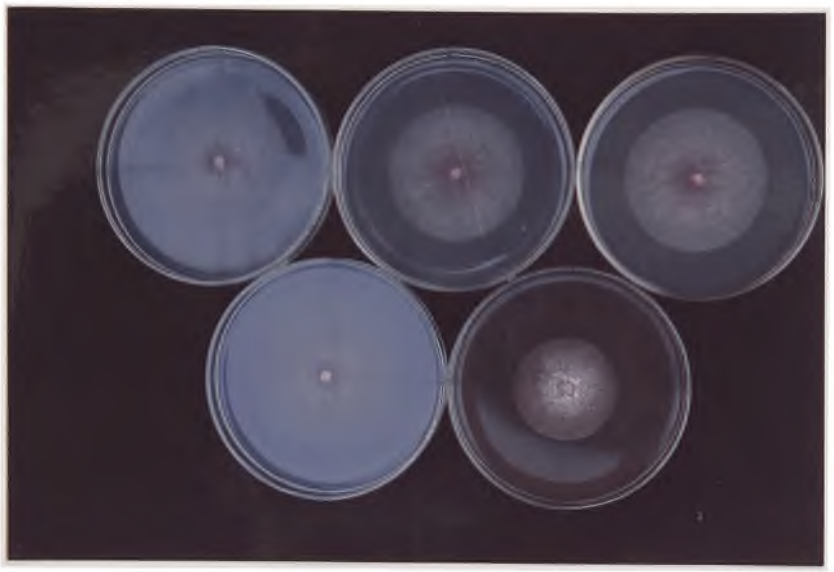


Plate 7: Radial growth of *Fusarium moniliforme* on Maize meal agar amended with methanol extract of leaves of *Z. xanthoxyloides* and incubated at 28-31°C for 5 days (x½).

Top: Left, undiluted extract; right, control.

Bottom: Left, 1:1 $^{v}/_{v}$; middle, 1:2 $^{v}/_{v}$; right, 1:5 $^{v}/_{v}$

I. VEGETATIVE GROWTH OF THREE *PAECILOMYCES SPP.* IN MAIZE MEAL BROTH AMENDED WITH VARYING DILUTIONS OF AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE DRY FRUIT OF *KIGELIA AFRICANA*.

The extracts of the fruit of *K. africana* also variably depressed vegetative growth of the three test fungi (*P. carneus, P. puntonii* and *P. varioti*). Growth depression (77.0 - 88.0%) of all the test fungi was observed at the highest concentration (undiluted extracts), and this depressive effect was gradually removed with increasing dilution of the extracts (Tables 23 & 24) such that in some instances growth in media amended with 1:5$^{v}/_{v}$ dilution of the extracts approximated that of the unamended medium (control). The pH of the aqueous, acetone and methanol extracts were 4.499, 4.383 and 4.274, respectively. Generally, the inhibitory effect of the methanol extract on vegetative growth was significantly ($P \leq 0.05$) severer than those recorded in media amended with acetone or aqueous extracts.

TABLE 23

Vegetative growth of indicated fungal species in maize dextrose broth (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of the fruit of *Kigelia africana* (Dry weight of mycelium was assessed after 8 days).

Fungal species	Dilution ratio of extract (%)	Dry weight of mycelium (mean ± S.E.) in mg in the indicated extract		
		Aqueous	Acetone	Methanol
Paecilomyces carneus	Undiluted	65 ± 2.23a	55 ± 1.80a	50 ± 1.43a
	1:1	230 ± 2.47b	230 ± 2.24b	190 ± 2.54b
	1:2	270 ± 2.14c	270 ± 2.14c	260 ± 1.70c
	1:5	335 ± 2.67d	300 ± 1.40d	275 ± 1.80d
	Control	340 ± 2.13d	340 ± 2.14e	315 ± 1.80e
P. puntonii	Undiluted	40 ± 2.14a	60 ± 1.43a	40 ± 1.70a
	1:1	160 ± 1.43b	180 ± 2.14b	120 ± 2.02b
	1:2	220 ± 1.43c	195 ± 1.80c	185 ± 1.80c
	1:5	250 ± 2.54d	210 ± 2.24d	190 ± 1.43c
	Control	295 ± 1.80e	285 ± 2.08e	265 ± 1.80d
P. varioti	Undiluted	58 ± 1.12a	50 ± 2.14a	45 ± 1.80a
	1:1	150 ± 2.54b	193 ± 2.24b	140 ± 1.42b
	1:2	275 ± 2.69c	270 ± 1.43c	190 ± 2.14c
	1:5	290 ± 1.70d	305 ± 1.20d	250 ± 2.02d
	Control	300 ± 1.43e	320 ± 2.02e	293 ± 1.55e

By Multiple Range Test, means recorded for each species at the same type of extract and bearing the same letters are not significantly different at $P<0.05$.

TABLE 24

Vegetative growth of indicated fungal species in maize dextrose broth (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of the fruit of *Kigelia africana* (Dry weight of mycelium was assessed after 8 days).

Fungal species	Dilution ratio of extract (v/v)	Dry weight of mycelium (mean ± S.E) in mg in the indicated extract		
		Aqueous	Acetone	Methanol
Paecilomyces carneus	Undiluted	80 ± 2.14a	65 ± 1.80a	40 ± 1.70a
	1:1	220 ± 2.02b	205 ± 1.80b	170 ± 2.02b
	1:2	285 ± 1.80c	270 ± 2.14c	250 ± 1.43c
	1:5	345 ± 1.80d	310 ± 2.02d	280 ± 2.86d
	Control	348 ± 2.27d	325 ± 2.28e	333 ± 2.26e
P. puntonii	Undiluted	45 ± 1.20a	53 ± 2.14a	30 ± 1.43a
	1:1	113 ± 1.55b	130 ± 2.14b	100 ± 1.70b
	1:2	230 ± 2.47c	240 ± 2.54b	210 ± 2.71c
	1:5	255 ± 2.43d	260 ± 2.47c	240 ± 2.54d
	Control	270 ± 2.02e	250 ± 1.43c	290 ± 1.70e
P. varioti	Undiluted	73 ± 2.07a	58 ± 1.55a	35 ± 1.20a
	1:1	175 ± 1.80b	160 ± 2.14b	150 ± 2.47b
	1:2	205 ± 2.28c	230 ± 2.02c	215 ± 1.80c
	1:5	350 ± 1.70d	275 ± 1.80d	260 ± 1.42d
	Control	325 ± 2.28e	290 ± 2.14e	330 ± 2.54e

By Multiple Range Test, means recorded for each species at the same type of extract and bearing the same letters are not significantly different at $P<0.05$.

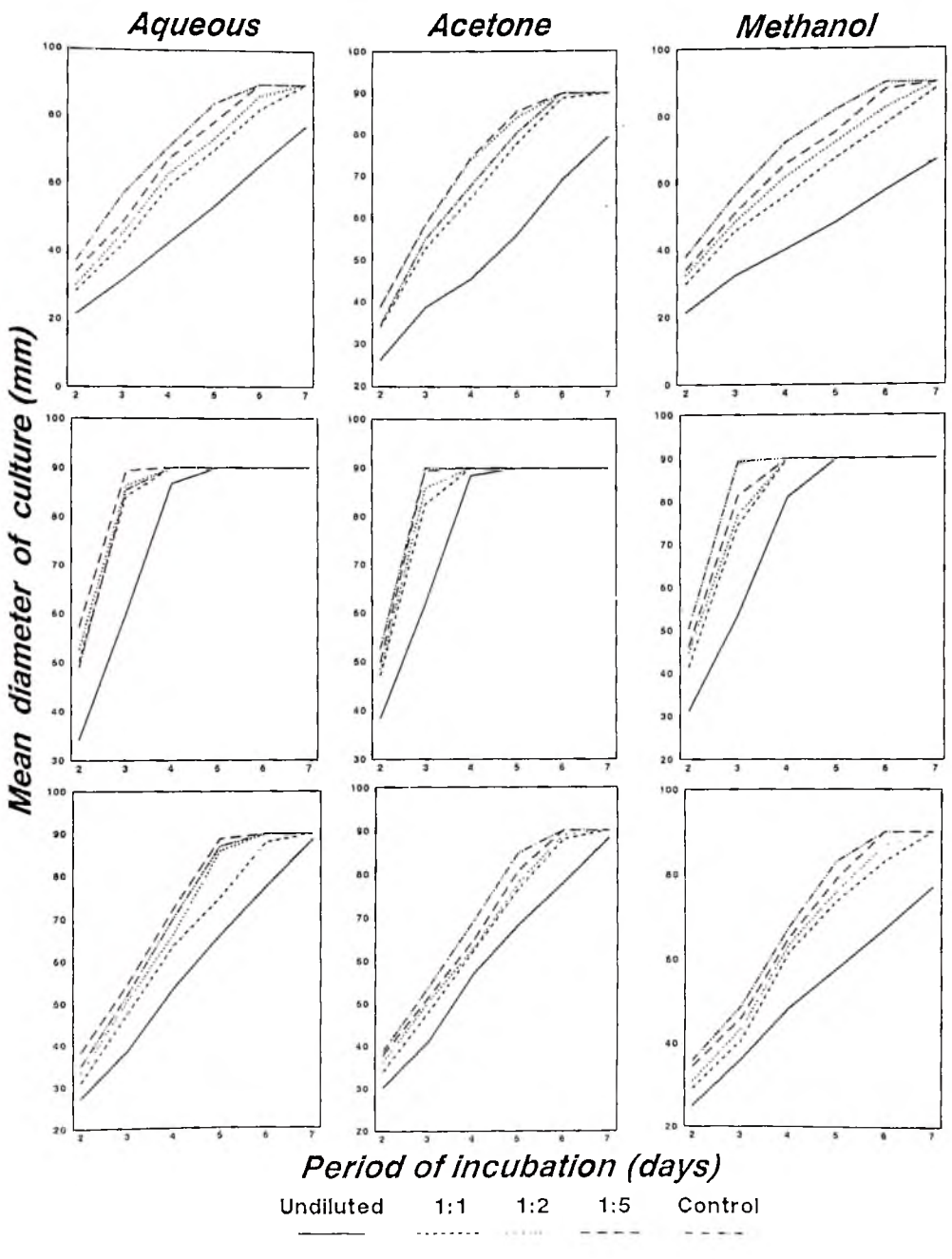
J. RADIAL GROWTH OF THREE *PAECILOMYCES* SPECIES ON MAIZE MEAL AGAR AMENDED WITH AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE FRUIT OF *KIGELIA AFRICANA*.

All the three *Paecilomyces* spp. grew exponentially at least during the early stages of the incubation on the agar medium amended with 1:1 - 1:5 $^{v}/_{v}$ dilution of the extracts (Figs. 18 & 19). Radial growth on agar amended with undiluted extracts lagged behind the control and 1:1-1:5 $^{v}/_{v}$ dilution except in the case of *P. puntonii* which grew faster, even in the medium of highest concentration of the plant extracts and covered the entire Petri plate in 4-5 days (Figs. 18 & 19; Appendices 26-31).

The methanol extract of the plant significantly ($P< 0.05$) inhibited the radial growth of *P. carneus, P. puntonii* and *P. varioti* than the aqueous and acetone extracts of the same plant part (Figs. 18 & 19; Appendices 26-31).

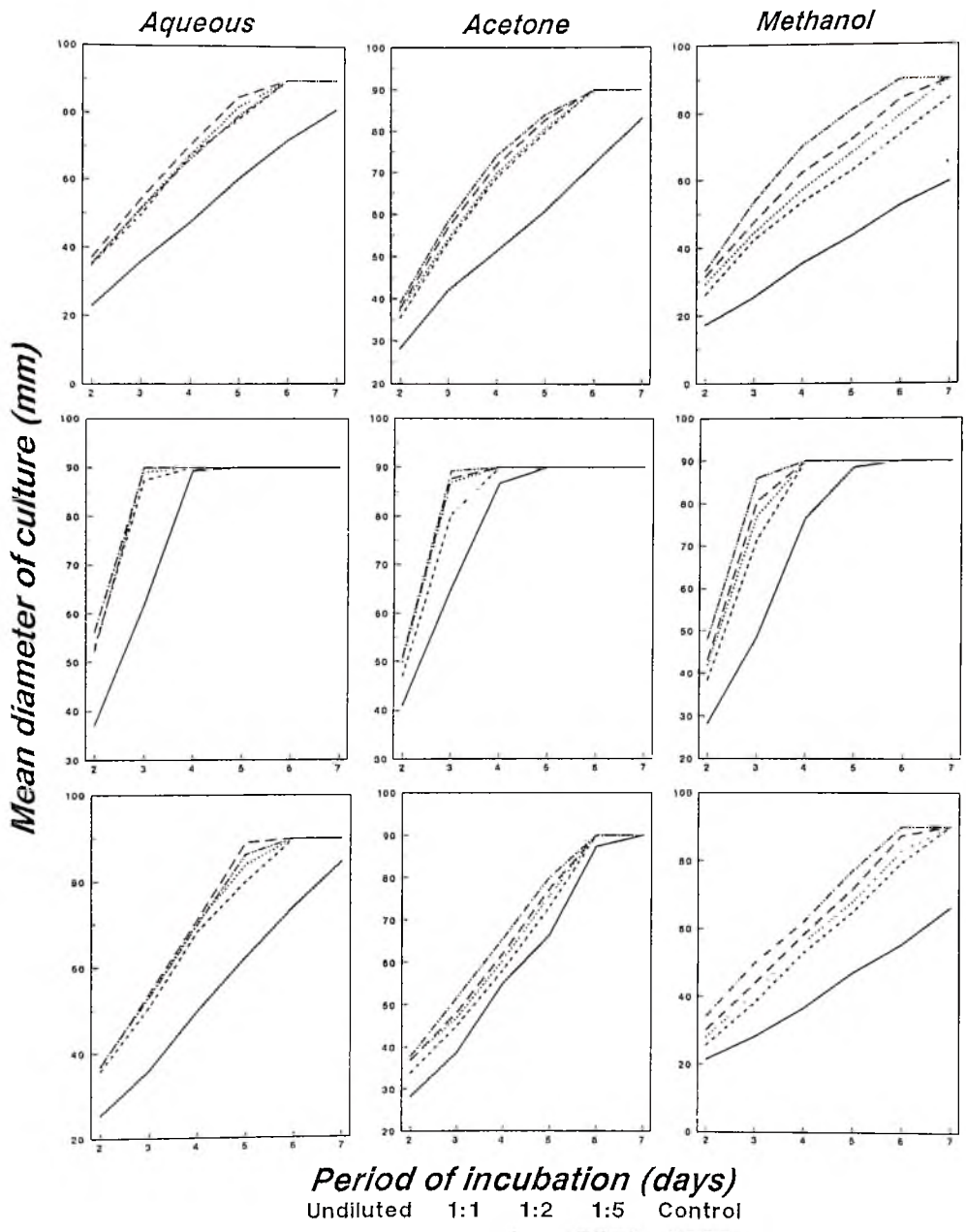
Inhibitory effect of the fruit of *K. africana* on the test fungi was variable and could be ranked as follows in decreasing order: *P. varioti* > *P. carneus* > *P. puntonii*.

Fig. 18



Radial growth of *Paecilomyces carneus*(TOP), *P.puntonii*(MIDDLE) and *P.varioti*(BOTTOM) at 28-30°C on maize dextrose agar medium (ABELEEHI) amended with aqueous, acetone or methanol extracts of the fruit of *Kigelia africana.*

Fig. 19



Radial growth of *Paecilomyces carneus* (TOP), *P.puntonii* (MIDDLE) and *P.varioti* (BOTTOM) at 28-30°C on maize dextrose agar medium (OBAATANPA) amended with aqueous, acetone or methanol extracts of the fruit of *Kigelia africana.*

K. VEGETATIVE GROWTH OF *C. LUNATA*, *F. MONILIFORME* AND *P. DIGITATUM* IN MAIZE MEAL BROTH AMENDED WITH AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE FRUIT OF *K. AFRICANA*

Growth of the test fungi in liquid medium after 8 days incubation was variable depending on the test fungus. Vegetative growth by all the test fungi in maize meal broth amended with undiluted extracts of the *K. africana* was significantly depressed by 69.0-90.0% (Tables 25 & 26). The inhibitory effect was, however, gradually removed with increasing dilution of the extracts (Tables 25 & 26). The highest depression in vegetative growth was observed on *C. lunata* incubated in maize meal broth (Obaatanpa) amended with methanol extract of the plant.

The pH of the aqueous, acetone and methanol extracts used in amending the maize meal broth were 4.8, 4.7 and 4.4, respectively.

TABLE 25

Vegetative growth of indicated fungal species in maize dextrose broth (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of the fruit of *Kigelia africana* (Dry weight of mycelium was assessed after 8 days).

Fungal species	Dilution ratio of extract (%)	Dry weight of mycelium (mean ± S.E.) in mg in the indicated extract		
		Aqueous	Acetone	Methanol
Penicillium digitatum	Undiluted	70 ± 2.14a	65 ± 1.80a	55 ± 2.28a
	1:1	165 ± 2.44b	200 ± 2.47b	150 ± 1.43b
	1:2	235 ± 1.80c	223 ± 1.55c	195 ± 2.69c
	1:5	315 ± 1.80d	240 ± 2.14d	230 ± 2.14d
	Control	293 ± 2.62e	270 ± 2.54e	305 ± 1.80e
Curvularia lunata	Undiluted	58 ± 1.55a	45 ± 1.20a	30 ± 1.42a
	1:1	145 ± 2.44b	180 ± 2.14b	133 ± 1.77b
	1:2	195 ± 2.69c	210 ± 2.14c	165 ± 2.69c
	1:5	245 ± 1.80d	245 ± 1.80d	220 ± 2.14d
	Control	263 ± 2.07e	260 ± 2.02e	245 ± 2.28e
Fusarium moniliforme	Undiluted	40 ± 1.43a	38 ± 1.55a	25 ± 1.80a
	1:1	105 ± 1.80b	100 ± 1.70b	85 ± 1.20b
	1:2	140 ± 1.43c	115 ± 2.44c	95 ± 1.22c
	1:5	145 ± 2.28c	120 ± 1.43c	105 ± 2.08d
	Control	150 ± 2.02cd	130 ± 1.43d	150 ± 2.14e

By Multiple Range Test, means recorded for each species at the same type of extract and bearing the same letters are not significantly different at $P<0.05$.

TABLE 26

Vegetative growth of indicated fungal species in maize dextrose broth (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of the fruit of *kigelia africana* (Dry weight of mycelium was assessed after 8 days).

Fungal	Dilution ratio of extract (%)	Dry weight of mycelium (mean ± S.E) in mg in the species indicated extract		
		Aqueous	Acetone	Methanol
Penicillium digitatum	Undiluted	80 ± 2.14a	65 ± 1.80a	40 ± 1.70a
	1:1	195 ± 2.69b	175 ± 1.80b	145 ± 2.28b
	1:2	230 ± 1.70c	200 ± 1.99c	190 ± 2.14c
	1:5	305 ± 2.28d	195 ± 2.28c	210 ± 2.14d
	Control	305 ± 2.28d	300 ± 2.54d	290 ± 2.02e
Curvularia lunata	Undiluted	53 ± 1.55a	40 ± 1.43a	25 ± 1.80a
	1:1	140 ± 2.32b	138 ± 2.50b	110 ± 1.43b
	1:2	155 ± 2.08c	170 ± 2.02c	125 ± 1.80c
	1:5	210 ± 1.43d	220 ± 2.02d	140 ± 1.43d
	Control	245 ± 3.51e	253 ± 2.07e	265 ± 2.08e
Fusarium moniliforme	Undiluted	35 ± 1.80a	45 ± 1.80a	20 ± 1.70a
	1:1	120 ± 2.02b	113 ± 2.50b	65 ± 1.80b
	1:2	130 ± 1.43c	115 ± 1.80b	90 ± 1.70c
	1:5	145 ± 1.80d	125 ± 1.80c	115 ± 1.80d
	Control	140 ± 1.70d	145 ± 2.28d	130 ± 2.54e

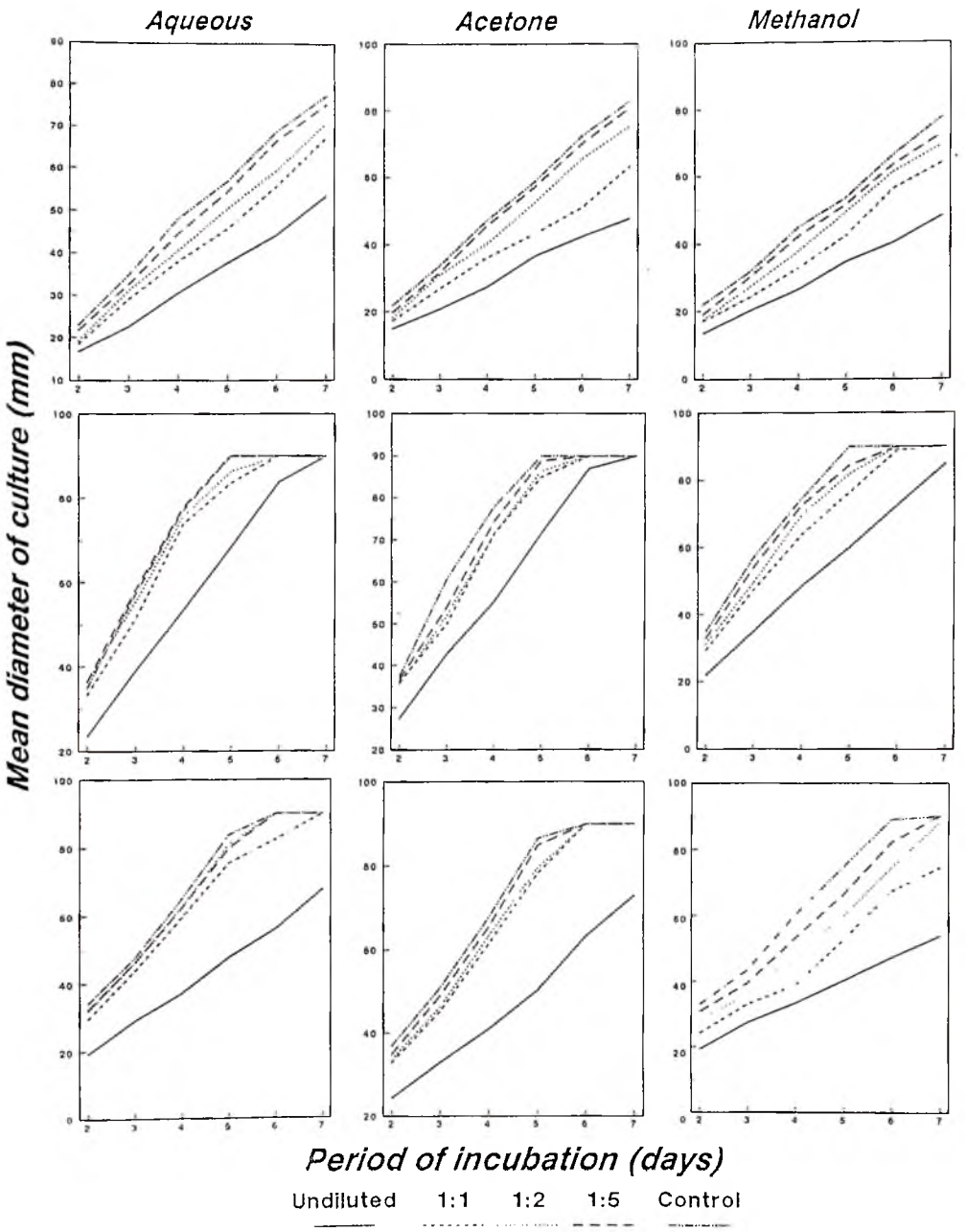
By Multiple Range Test, means recorded for each species at the same type of extract and bearing the same letters are not significantly different at $P<0.05$.

L. RADIAL GROWTH OF *C. LUNATA, F. MONILIFORME* AND *P. DIGITATUM* ON MAIZE MEAL AGAR AMENDED WITH AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE FRUIT OF *K. AFRICANA*

The aqueous, acetone and methanol extracts of the fruit of *K. africana* had variable effect on the growth of *C. lunata, F. moniliforme* and *P. digitatum* (Figs. 20 & 21). Methanol extract of *K. africana* of dilutions, 1:1, 1:2 and 1:5 $^{v}/_{v}$ used in amending maize meal broth significantly ($P < 0.05$) depressed radial growth of all the three test fungi (Figs. 20 & 21; Appendices 32 - 37; Tables 27a-27f).

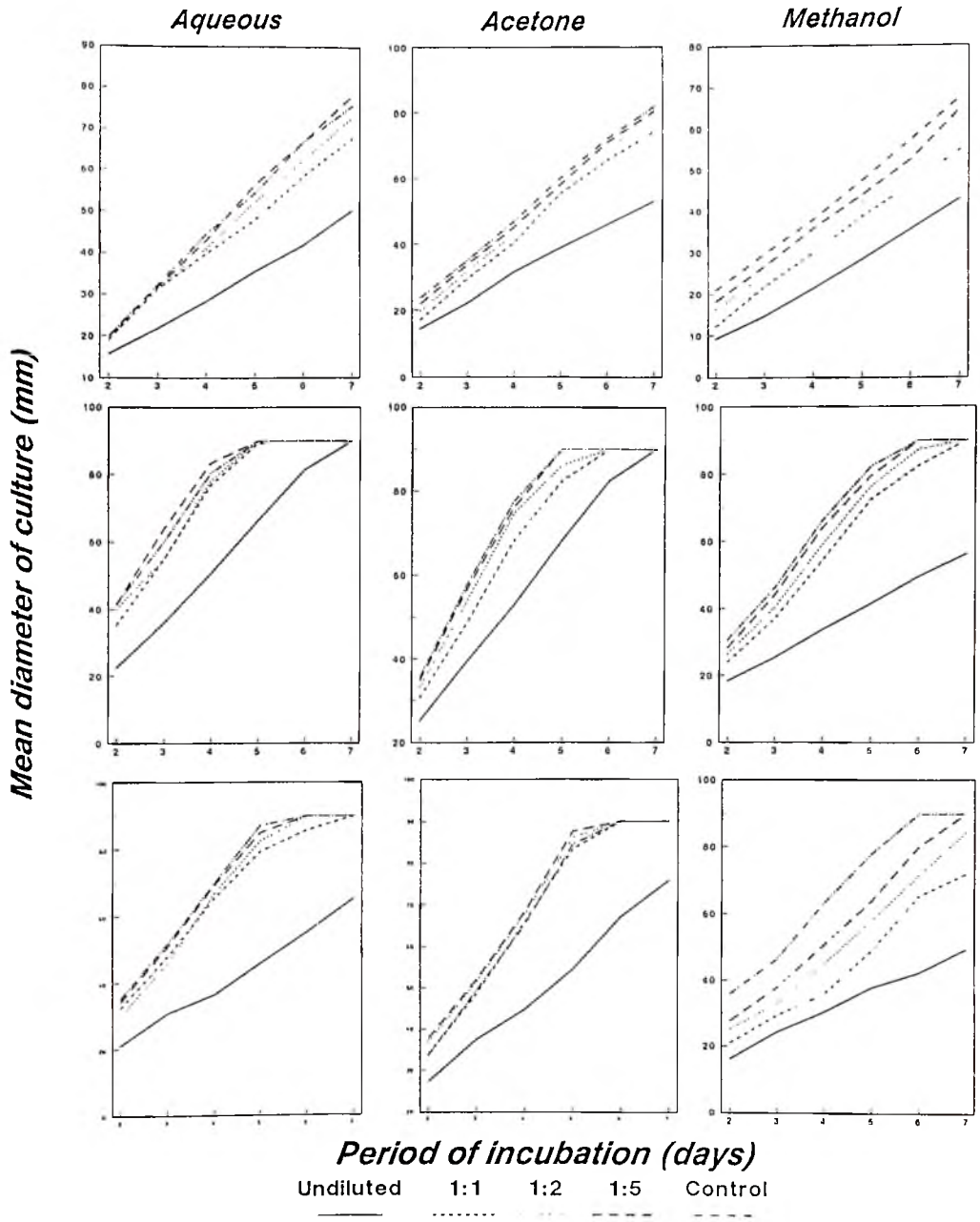
Aqueous and acetone extracts of *K. africana* were less inhibitory on the growth of the test fungi as increasing dilution rendered the extracts less potent. Statistical analyses showed that the inhibitory effects of the extracts were severer on *P. digitatum* than on *C. lunata* and *F. moniliforme* (Tables 28a - 28f).

Fig. 20



Radial growth of *Penicillium digitatum* (TOP), *Curvularia lunata* (MIDDLE) and *Fusarium moniliforme* (BOTTOM) at 28-30°C on maize dextrose agar medium (ABEELEHI) amended with aqueous, acetone or methanol extracts of the fruit *of Kigelia africana* .

Fig. 21



Radial growth of *Penicillium digitatum* (TOP), ***Curvularia lunata*** (MIDDLE) and *Fusarium moniliforme* (BOTTOM) at 28-30°C on maize dextrose agar medium (OBAATANPA) amended with aqueous, acetone or methanol extracts of the fruit of *Kigelia africana*.

TABLE 27a

Multiple range analysis showing the effect of aqueous, acetone and methanol extracts of the fruit of *K. africana* on the radial growth of *C. lunata* on maize meal agar medium (ABELEEHI).

Type of Extract	Count	Mean	Homogeneous Grouping
Aqueous	16	82.025	A
Acetone	16	82.950	B
Methanol	16	75.701	C

TABLE 27b

Multiple range analysis showing the effect of aqueous, acetone and methanol extracts of the fruit of *K. africana* on the radial growth of *F. moniliforme* on maize meal agar medium (ABELEEHI).

Type of Extract	Count	Mean	Homogeneous Grouping
Aqueous	16	71.210	A
Acetone	16	73.275	B
Methanol	16	54.911	C

TABLE 27c

Multiple range analysis showing the effect of aqueous, acetone and methanol extracts of the fruit of *K. africana* on the radial growth of *P. digitatum* on maize meal agar medium (ABELEEHI).

Type of Extract	Count	Mean	Homogeneous Grouping
Aqueous	16	47.150	A
Acetone	16	47.200	A
Methanol	16	44.525	B

Means with the same letters are not significantly different.

TABLE 27d

Multiple range analysis showing the effect of aqueous, acetone and methanol extracts of the fruit of *K. africana* on the radial growth of *C. lunata* on maize meal agar medium (OBAATANPA).

Type of Extract	Count	Mean	Homogeneous Grouping
Aqueous	16	83.900	A
Acetone	16	81.775	B
Methanol	16	67.501	C

TABLE 27e

Multiple range analysis showing the effect of aqueous, acetone and methanol extracts of the fruit of *K. africana* on the radial growth of *F. moniliforme* on maize meal agar medium (OBAATANPA).

Type of Extract	Count	Mean	Homogeneous Grouping
Aqueous	16	73.150	A
Acetone	16	78.025	B
Methanol	16	52.152	C

TABLE 27f

Multiple range analysis showing the effect of aqueous, acetone and methanol extracts of the fruit of *K. africana* on the radial growth of *P. digitatum* on maize meal agar medium (OBAATANPA).

Type of Extract	Count	Mean	Homogeneous Grouping
Aqueous	16	48.075	A
Acetone	16	51.700	B
Methanol	16	38.101	C

Means with the same letters are not significantly different.

TABLE 28a

Multiple range analysis showing the effect of AQUEOUS extract of the fruit of *K. africana* on the radial growth of *C. lunata, F. moniliforme* and *P. digitatum* on maize meal agar medium (ABELEEHI).

Fungal species	Count	Mean	Homogeneous Grouping
C. lunata	16	82.125	A
F. moniliforme	16	71.210	B
P. digitatum	16	47.150	C

TABLE 28b

Multiple range analysis showing the effect of ACETONE extract of the fruit of *K. africana* on the radial growth of *C. lunata, F. moniliforme* and *P. digitatum* on maize meal agar medium (ABELEEHI).

Fungal species	Count	Mean	Homogeneous Grouping
C. lunata	16	82.951	A
F. moniliforme	16	73.276	B
P. digitatum	16	47.213	C

TABLE 28c

Multiple range analysis showing the effect of METHANOL extract of the fruit of *K. africana* on the radial growth of *C. lunata, F. moniliforme* and *P. digitatum* on maize meal agar medium (ABELEEHI).

Fungal species	Count	Mean	Homogeneous Grouping
C. lunata	16	75.721	A
F. moniliforme	16	54.913	B
P. digitatum	16	44.529	C

Means with the same letters are not significantly different.

TABLE 28d

Multiple range analysis showing the effect of AQUEOUS extract of the fruit of *K. africana* on the radial growth of *C. lunata*, *F. moniliforme* and *P. digitatum* on maize meal agar medium (OBAATANPA).

Fungal species	Count	Mean	Homogeneous Grouping
C. lunata	16	83.923	A
F. moniliforme	16	73.152	B
P. digitatum	16	48.079	C

TABLE 28e

Multiple range analysis showing the effect of ACETONE extract of the fruit of *K. africana* on the radial growth of *C. lunata*, *F. moniliforme* and *P. digitatum* on maize meal agar medium (OBAATANPA).

Fungal species	Count	Mean	Homogeneous Grouping
C. lunata	16	81.775	A
F. moniliforme	16	78.336	B
P. digitatum	16	51.716	C

TABLE 28f

Multiple range analysis showing the effect of METHANOL extract of the fruit of *K. africana* on the radial growth of *C. lunata*, *F. moniliforme* and *P. digitatum* on maize meal agar medium (OBAATANPA).

Fungal species	Count	Mean	Homogeneous Grouping
C. lunata	16	67.533	A
F. moniliforme	16	52.156	B
P. digitatum	16	37.989	C

Means with the same letters are not significantly different.

M. VEGETATIVE GROWTH OF THREE *PAECILOMYCES* SPECIES IN MAIZE MEAL BROTH AMENDED WITH AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE LEAVES OF *K. AFRICANA*

Undiluted aqueous, acetone or methanol extracts of the leaves of *K. africana* significantly ($P \leq 0.05$) depressed the growth of all the test fungi (Tables 29 & 30). In most cases this inhibitory effect on dry matter accumulation by the fungus using different concentrations (1:1 - 1:5 $^{v}/_{v}$) was severer in the methanol extract of the plant than what existed in the aqueous and acetone extracts (Tables 29 & 30). For examples, in the case of *Paecilomyces carneus* the dry weight of mycelium obtained in maize meal medium amended with undiluted aqueous, acetone and methanol extracts of the leaves of *K. africana* were 60, 40 and 35mg, respectively. The inhibitory principle was gradually removed with increasing dilution of the respective extracts such that at 1:5 $^{v}/_{v}$ dilution the dry weight of mycelium of *P. carneus* obtained were 290g (aqueous) 265mg (acetone) and 250mg (methanol), indicating 3.3 to 10.2% depression of growth.

Aqueous, acetone and methanol extracts used in amending the maize meal broth had pH's of 4.5, 4.3 and 4.0, respectively.

TABLE 29

Vegetative growth of indicated fungal species in maize dextrose broth (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of the leaves of *Kigelia africana* (Dry weight of mycelium was assessed after 8 days).

Fungal species	Dilution ratio of extract (%)	Dry weight of mycelium (mean ± S.E.) in mg in the indicated extract		
		Aqueous	Acetone	Methanol
Paecilomyces carneus	Undiluted	60 ± 1.43a	40 ± 2.02a	35 ± 1.20a
	1:1	240 ± 3.02b	250 ± 3.26b	170 ± 2.02b
	1:2	235 ± 1.20c	260 ± 2.54c	245 ± 2.28c
	1:5	290 ± 2.32d	265 ± 1.20c	250 ± 2.14c
	Control	300 ± 2.71e	295 ± 1.80d	315 ± 2.28d
P. puntonii	Undiluted	70 ± 2.02a	40 ± 1.43a	38 ± 1.43a
	1:1	215 ± 2.28b	145 ± 1.80b	125 ± 2.28b
	1:2	230 ± 2.14c	145 ± 2.69b	170 ± 2.14c
	1:5	235 ± 2.28d	160 ± 1.43c	185 ± 2.69d
	Control	280 ± 1.43e	270 ± 2.14d	240 ± 2.54e
P varioti	Undiluted	53 ± 1.55a	30 ± 1.43a	28 ± 1.12a
	1:1	195 ± 1.80b	185 ± 2.44b	170 ± 1.88b
	1:2	220 ± 1.43c	180 ± 1.43b	175 ± 2.28b
	1:5	283 ± 2.24d	200 ± 1.07c	175 ± 1.80b
	Control	295 ± 1.20e	243 ± 2.07d	255 ± 2.28c

By Multiple Range Test, means recorded for each species at the same type of extract and bearing the same letters are not significantly different at $P<0.05$.

TABLE 30

Vegetative growth of indicated fungal species in maize dextrose broth (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of the leaves of *Kigelia africana* (Dry weight of mycelium was assessed after 8 days).

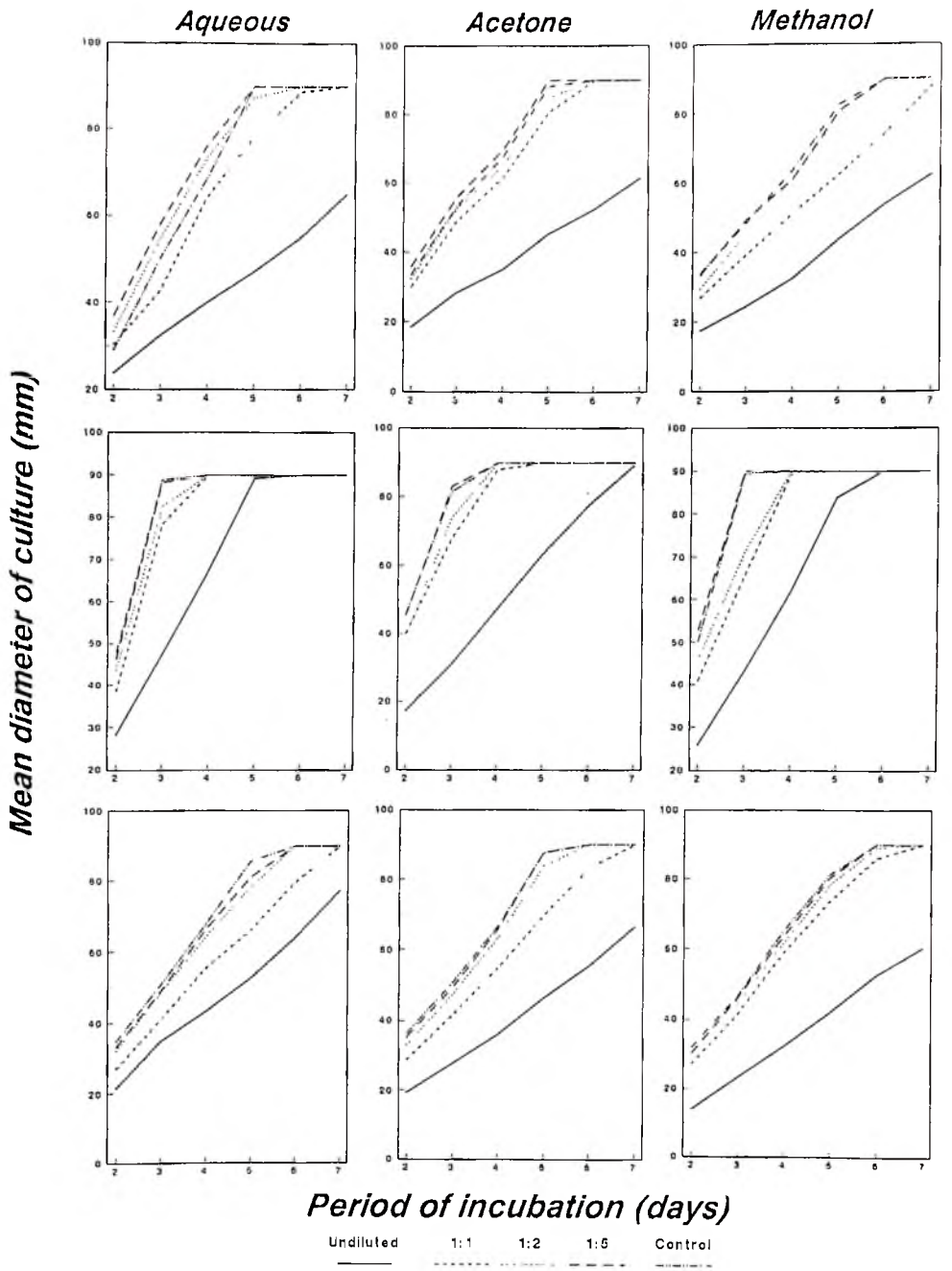
Fungal species	Dilution ratio of extract (%)	Dry weight of mycelium (mean ± S.E) in mg in the indicated extract		
		Aqueous	Acetone	Methanol
Paecilomyces carneus	Undiluted	45 ± 1.20a	45 ± 1.80a	30 ± 1.43a
	1:1	185 ± 1.80b	245 ± 1.80b	175 ± 2.44b
	1:2	235 ± 2.69c	250 ± 2.14c	220 ± 2.02c
	1:5	240 ± 2.14c	295 ± 1.20d	240 ± 2.54d
	Control	280 ± 2.14d	320 ± 1.43e	305 ± 2.79e
P. puntonii	Undiluted	70 ± 1.43a	38 ± 1.55a	33 ± 1.11a
	1:1	200 ± 2.71b	103 ± 1.94b	118 ± 1.45b
	1:2	220 ± 2.02c	120 ± 2.14c	155 ± 1.58c
	1:5	225 ± 1.80c	118 ± 1.55c	158 ± 2.18c
	Control	265 ± 1.80d	240 ± 2.02d	270 ± 2.02d
P. varioti	Undiluted	53 ± 1.12a	23 ± 1.12a	25 ± 1.80a
	1:1	155 ± 2.69b	108 ± 1.55b	145 ± 1.80b
	1:2	230 ± 2.54c	135 ± 1.80c	138 ± 2.56b
	1:5	285 ± 2.28d	150 ± 2.14d	183 ± 2.27c
	Control	255 ± 1.20e	275 ± 1.80e	230 ± 2.14d

By Multiple Range Test, means recorded for each species at the same type of extract and bearing the same letters are not significantly different at $P<0.05$.

N. RADIAL GROWTH OF THREE *PAECILOMYCES* SPP. ON MAIZE MEAL AGAR AMENDED WITH AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE LEAVES OF *K. AFRICANA*

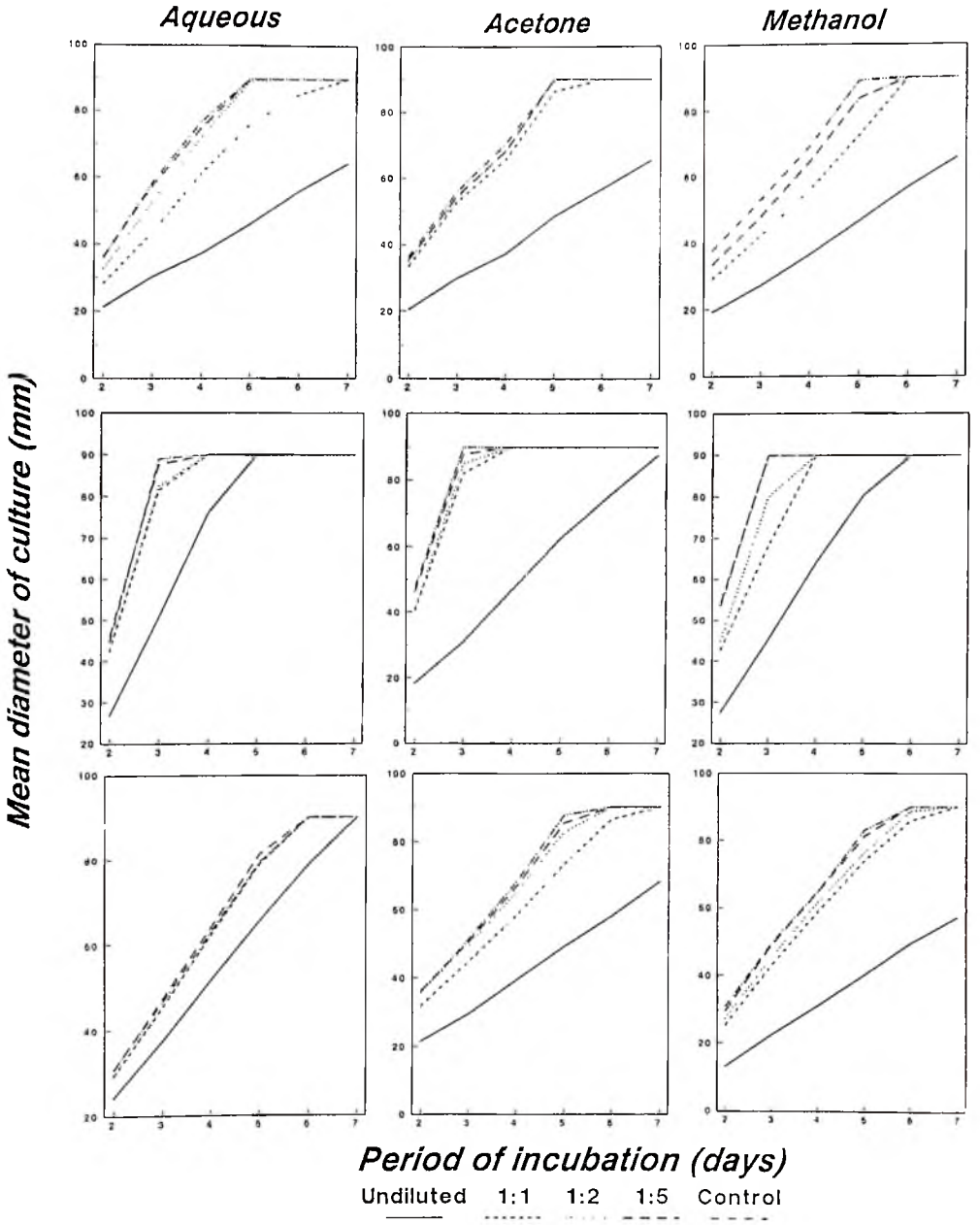
The undiluted aqueous, acetone and methanol extracts of the leaves of *K. africana* significantly ($P \leq 0.05$) impaired the radial growth of the three *Paecilomyces* species on agar medium. However, the effect was less severe on *P. puntonii* as radial growth on the agar medium amended with the undiluted extracts approximated that of the control after 4-7 days (Figs. 22 & 23; Appendices 39-43). Radial growth of *P. carneus* and *P. varioti* in the undiluted extracts significantly lagged behind that of the control. The inhibitory effect, however, was gradually removed with increasing dilution (1:1 1:5 $^{v}/_{v}$) of the extracts (Figs. 22 & 23). The inhibitory effect of methanol extract of the leaves of *K. africana* seems to be the most potent as shown by the Multiple Range Test ($P \leq 0.05$) (Tables 31a - 31f).

Fig. 22



Radial growth of *Paecilomyces carneus* (TOP), *P.puntonii* (MIDDLE) and *P.varioti* (BOTTOM) at 28-30°C on maize dextrose agar medium (ABEELEHI) amended with aqueous, acetone or methanol extracts of the leaves of *Kigelia africana.*

Fig. 23



Radial growth of *Paecilomyces carneus* (TOP), *P.puntonii* (MIDDLE) and *P.varioti* (BOTTOM) at 28-30°C on maize dextrose agar medium (OBAATANPA) amended with aqueous,acetone or methanol extracts of the leaves of *Kigelia africana.*

TABLE 31a

Multiple range analysis showing the effect of aqueous, acetone and methanol extracts of the leaves of *K. africana* on the radial growth of *P. carneus* on maize meal agar medium (ABELEEHI).

Type of extract	Count	Mean	Homogeneous Grouping
Aqueous	16	47.114	A
Acetone	16	46.450	B
Methanol	16	39.651	C

TABLE 31b

Multiple range analysis showing the effect of aqueous, acetone and methanol extract of the leaves of *K. africana* on the radial growth of *P. puntonii* on the radial growth of *P. puntonii* on maize meal agar medium (ABELEEHI).

Type of Extract	Count	Mean	Homogeneous Grouping
Aqueous	16	74.150	A
Acetone	16	67.375	B
Methanol	16	63.956	C

TABLE 31c

Multiple range analysis showing the effect of aqueous, acetone and methanol extract of the leaves of *K. africana* on the radial growth of *P. varioti* on maize meal agar medium (ABELEEHI).

Type of Extract	Count	Mean	Homogeneous Grouping
Aqueous	16	43.375	A
Acetone	16	41.475	B
Methanol	16	38.725	C

Means with the same letters are not significantly different.

TABLE 31d

Multiple range analysis showing the effect of aqueous, acetone and methanol extracts of the leaves of *K. africana* on the radial growth of *P. carneus* on maize meal agar medium (OBAATANPA).

Type of Extract	Count	Mean	Homogeneous Grouping
Aqueous	16	46.000	A
Acetone	16	47.825	B
Methanol	16	41.353	C

TABLE 31e

Multiple range analysis showing the effect of aqueous, acetone and methanol extracts of the leaves of *K. africana* on the radial growth of *P. puntonii* on maize meal agar medium (OBAATANPA).

Type of Extract	Count	Mean	Homogeneous Grouping
Aqueous	16	75.625	A
Acetone	16	71.451	B
Methanol	16	70.900	B

TABLE 31f

Multiple range analysis showing the effect of aqueous, acetone and methanol extracts of the leaves of *K. africana* on the radial growth of *P. varioti* on maize meal agar medium (OBAATANPA).

Type of Extract	Count	Mean	Homogeneous Grouping
Aqueous	16	44.025	A
Acetone	16	43.525	A
Methanol	16	39.875	B

Means with same letters are not significantly different.

0. VEGETATIVE GROWTH OF *C. LUNATA*, *F. MONILIFORME* AND *P. DIGITATUM* IN MAIZE MEAL BROTH AMENDED WITH AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE LEAVES OF *K. AFRICANA*

Results obtained were similar to the effect recorded when *Paecilomyces* species were used as test fungi. Undiluted extracts significantly ($P \leq 0.05$) depressed vegetative growth of the test fungi in liquid medium (Tables 32 & 33). However, this inhibitory effect was gradually removed with increasing dilution (1:1 - 1:5 $^{v}/_{v}$) of the extracts. Multiple Range Test showed that growth in media amended with 1:5 $^{v}/_{v}$ of the extracts approximated that of the control in some instances (Tables 32 & 33). Thus both the fruit and the leaves of *K. africana* contain some active ingredients which could offset the growth of the test fungi even at the low concentrations tested.

The pH of the acqueous, acetone and methanol extracts used were 4.5, 4.3 and 4.3, respectively.

TABLE 32

Vegetative growth of indicated fungal species in maize dextrose broth (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of the leaves of *Kigelia africana* (Dry weight of mycelium was assessed after 8 days).

Fungal species	Dilution ratio of extract (%v)	Dry weight of mycelium (mean ± S.E.) in mg in the indicated extract		
		Aqueous	Acetone	Methanol
	Undiluted	65 ± 1.80a	33 ± 1.12a	28 ± 1.55a
Penicillium	1:1	180 ± 2.02b	138 ± 1.12b	135 ± 2.28b
digitatum	1:2	195 ± 2.28c	195 ± 2.44c	230 ± 2.54c
	1:5	310 ± 2.54d	230 ± 2.54d	245 ± 2.28d
	Control	338 ± 1.12e	240 ± 2.02e	280 ± 2.47e
	Undiluted	68 ± 2.07a	35 ± 1.80a	30 ± 1.70a
Curvularia	1:1	150 ± 2.14b	110 ± 1.43b	90 ± 1.43b
lunata	1:2	215 ± 1.80c	145 ± 1.80c	125 ± 2.28c
	1:5	250 ± 1.70d	153 ± 1.79c	130 ± 2.02c
	Control	245 ± 1.80d	253 ± 2.35d	200 ± 2.02d
	Undiluted	20 ± 1.43a	20 ± 1.43a	15 ± 1.20a
Fusarium	1:1	100 ± 1.70b	80 ± 2.47b	50 ± 2.02b
moniliforme	1:2	105 ± 1.20b	85 ± 1.20b	70 ± 1.43c
	1:5	115 ± 1.80bc	105 ± 2.28c	85 ± 2.28d
	Control	133 ± 2.50c	100 ± 1.43c	125 ± 2.28e

By Multiple Range Test, means recorded for each species at the same type of extract and bearing the same letters are not significantly different at $P<0.05$.

TABLE 33

Vegetative growth of indicated fungal species in maize dextrose broth (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of the leaves of *Kigelia africana* (Dry weight of mycelium was assessed after 8 days).

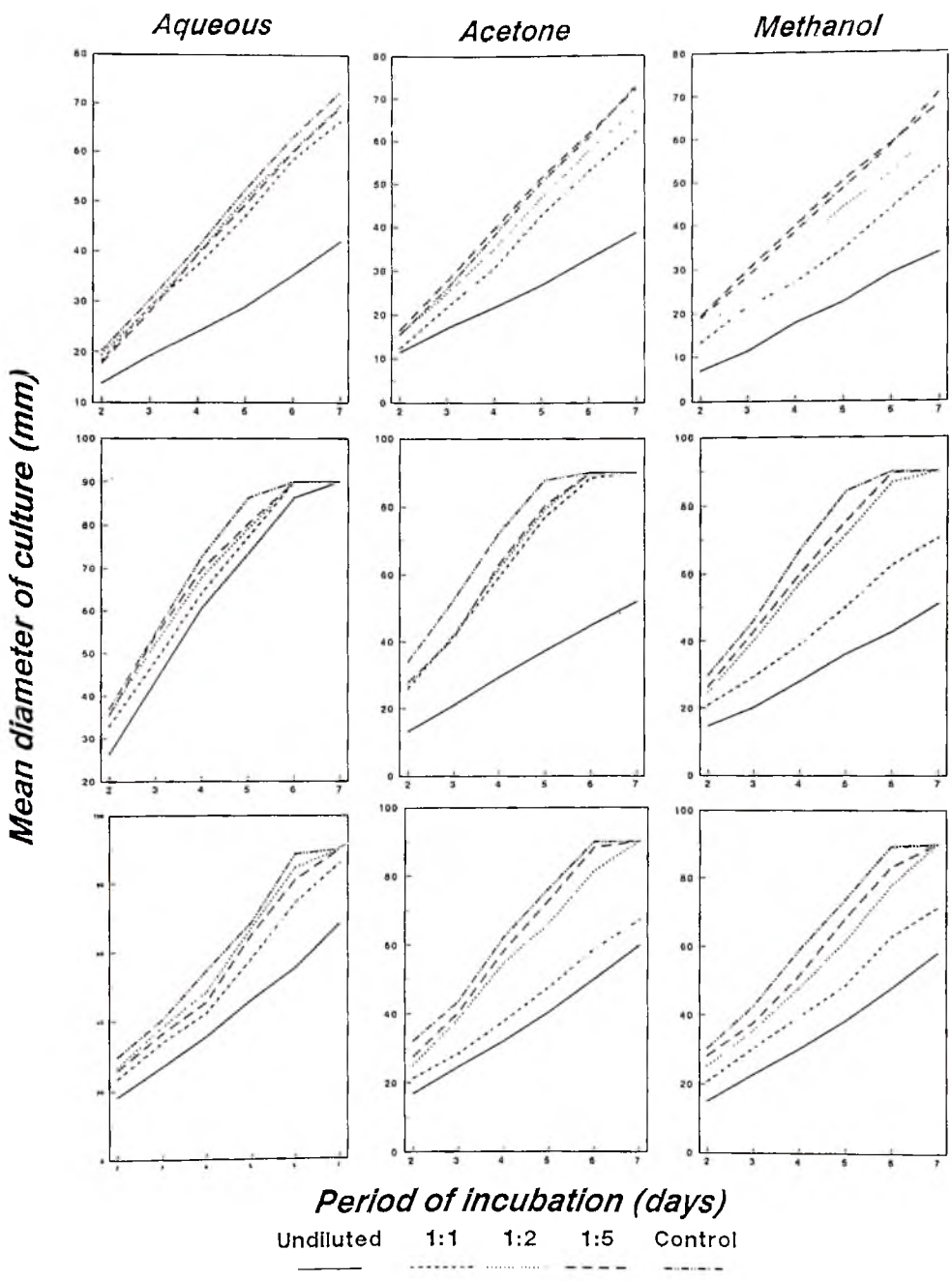
Fungal species	Dilution ratio of extract (%)	Dry weight of mycelium (mean ± S.E) in mg in the indicated extract		
		Aqueous	Acetone	Methanol
Penicillium digitatum	Undiluted	60 ± 1.43a	35 ± 1.80a	30 ± 1.43a
	1:1	170 ± 2.13b	158 ± 1.55b	110 ± 1.43b
	1:2	200 ± 2.02c	175 ± 1.80c	135 ± 1.80c
	1:5	275 ± 1.80d	205 ± 2.28d	185 ± 1.80d
	Control	278 ± 1.55d	235 ± 2.69e	260 ± 2.02e
Curvularia lunata	Undiluted	65 ± 1.80a	30 ± 1.70a	55 ± 1.80a
	1:1	135 ± 2.28b	90 ± 2.54b	85 ± 1.80b
	1:2	170 ± 1.42c	100 ± 2.02c	85 ± 2.28b
	1:5	200 ± 2.14d	110 ± 2.14d	100 ± 2.02c
	Control	225 ± 2.28e	255 ± 2.28e	195 ± 2.69d
Fusarium moniliforme	Undiluted	28 ± 1.55a	18 ± 1.12a	15 ± 1.20a
	1:1	90 ± 1.70b	65 ± 1.20b	55 ± 1.20b
	1:2	115 ± 1.80c	80 ± 1.43c	65 ± 1.80c
	1:5	125 ± 2.69d	110 ± 1.43d	95 ± 1.80d
	Control	133 ± 2.50d	115 ± 1.80d	110 ± 2.40e

By Multiple Range Test, means recorded for each species at the same type of extract and bearing the same letters are not significantly different at $P<0.05$.

P. RADIAL GROWTH OF *C. LUNATA*, *F. MONILIFORME* AND *P. DIGITATUM* ON MAIZE MEAL AGAR AMENDED WITH AQUEOUS, ACETONE OR METHANOL EXTRACT OF THE LEAVES OF *K. AFRICANA*

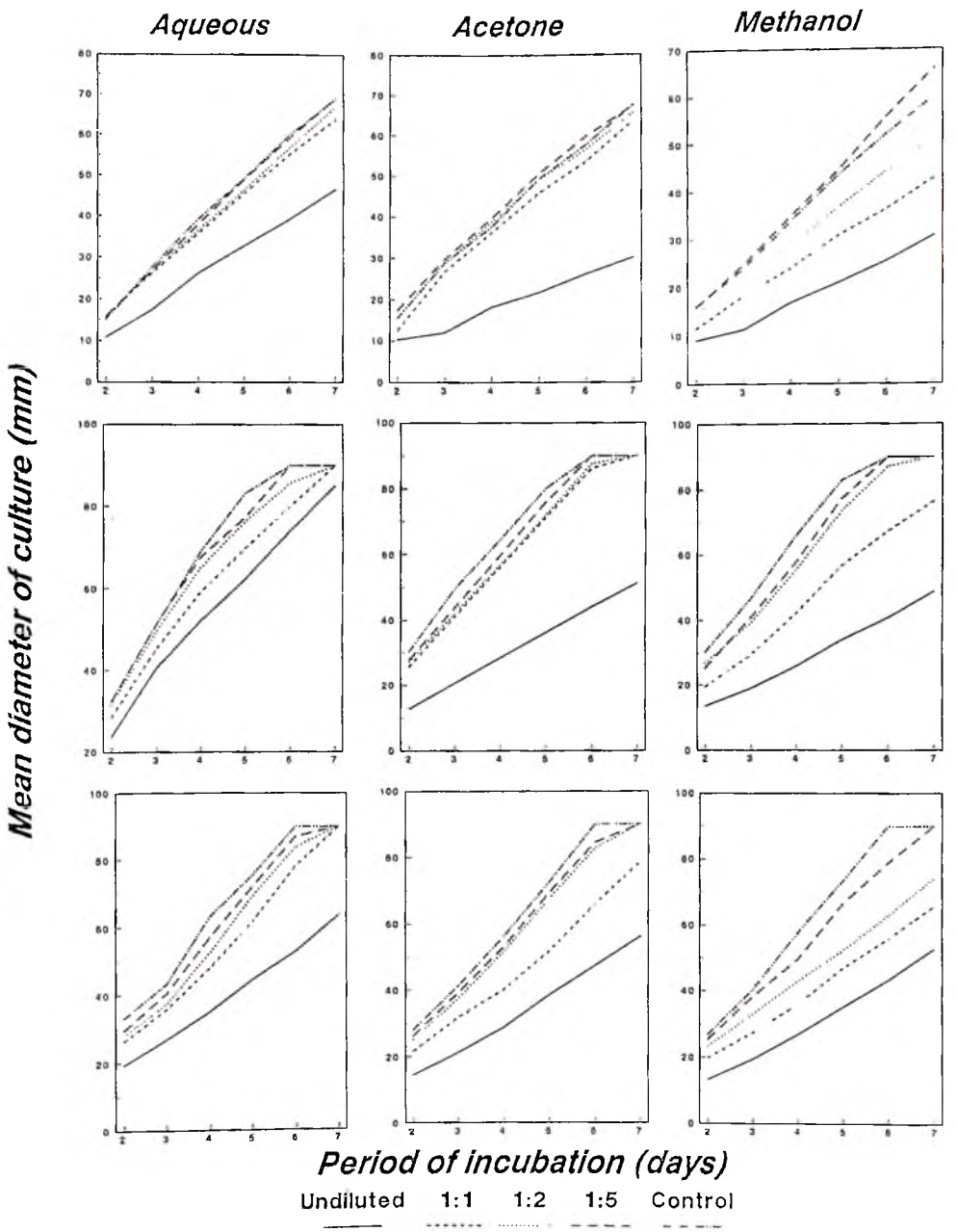
Radial growth of all the test fungi on agar media was significantly ($P \leq 0.05$) depressed by the different extracts of the leaves of *K. africana* used in amending the maize meal agar. The inhibitory effect was severer at the highest concentrations (undiluted) but decreased with increased dilution of the extracts (Figs. 24 & 25; Appendices 44 - 49). There were marked differences in the response of the three test fungi to the inhibitory principle in the plant extracts. Methanol and acetone extracts were generally more potent than water extract as illustrated by Plates 8 and 9. The potency of the inhibitory effect of the undiluted extract on radial growth of the test fungi can be ranked as follows: *P. digitatum*>*F. moniliforme*>*C. lunata*

Fig. 24



Radial growth of *Penicillium digitatum* (TOP), *Curvularia lunata* (MIDDLE) and *Fusarium moniliforme* (BOTTOM) at 28-30°C on maize dextrose agar medium (ABEELEHI) amended with aqueous, acetone or methanol extracts of the leaves of *Kigelia africana.*

Fig. 25



Radial growth of *Penicillium digitatum* (TOP), *Curvularia lunata* (MIDDLE) and *Fusarium moniliforme* (BOTTOM) at 28-30°C on maize dextrose *agar* medium (OBAATANPA) amended with aqueous, acetone or methanol extracts of the leaves of *Kigelia africana*.

Plate 8: Radial growth of *C. lunata* on Maize meal agar amended with methanol extract of leaves of *K. africana* and incubated at 28-31°C for 5 days (x½).

Top: left, undiluted extract; right, control.

Bottom: left, 1:1 $^{v}/_{v}$; middle, 1:2 $^{v}/_{v}$; right, 1:5 $^{v}/_{v}$

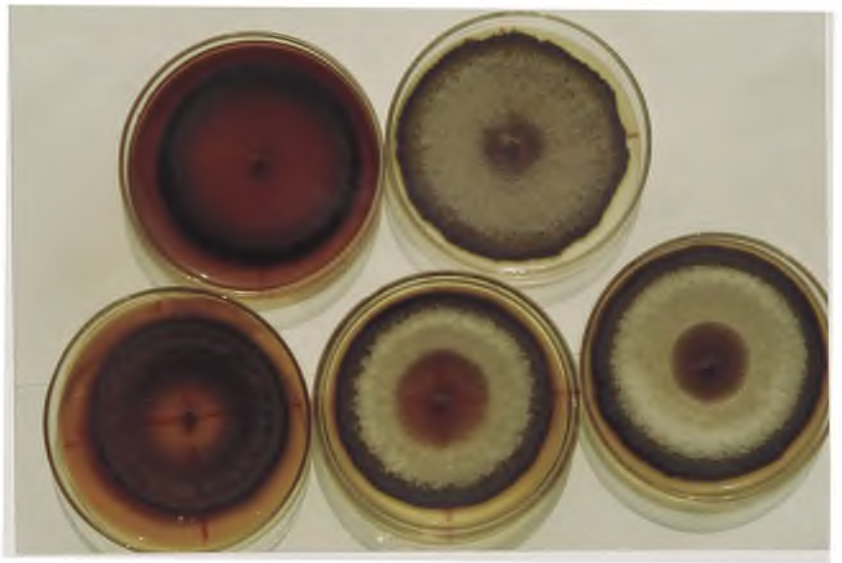


Plate 9: Radial growth of *C. lunata* on Maize meal agar amended with aqueous extract of the leaves of *K. africana* and incubated at 28-31°C for 5 days (x½).

Top: left, undiluted extract; right, control

Bottom: left, 1:1 $^{v}/_{v}$; middle, 1:2 $^{v}/_{v}$; right, 1:5 $^{v}/_{v}$
(Note the luxuriant mycelial growth in the undiluted extract).

Q. COMPARATIVE FUNGITOXICITY OF AQUEOUS, ACETONE AND METHANOL EXTRACTS OF LEAVES OF *Z. XANTHOXYLOIDES*, AND FRUIT AND LEAVES OF *K. AFRICANA* ON MYCELIAL GROWTH OF SIX TEST FUNGI

Repeat of the experiments reported in Chapters E-P by and large confirmed results obtained. Both test plants (*K. africana* and *Z. xanthoxyloides*) showed measurable fungitoxic activity (measured by % mycelial inhibition) on the growth of six test fungi, namely, *Paecilomyces carneus, P. puntonii, P. varioti, Curvularia lunata, Fusarium moniliforme* and *Penicillium lunata* which were isolated from two newly developed maize varieties, Abeleehi and Obaatanpa. The results can be summarised as follows:

1. Percentage mycelial inhibition was generally higher in the undiluted extracts as compared to what existed in the 1:1 $^{v}/_{v}$ dilution Tables 34 & 35).

2. Inhibitory activity was significantly ($P \leq 0.05$) higher in methanol extract than in aqueous or acetone extract of the test plants (Tables 34 & 35).

3. Extract of leaves of *K. africana* was more potent than test solutions obtained from its fruit and leaves of *Z. xanthoxyloides*.

4. Among the *Paecilomyces* species tested, *P. puntonii* was the most resistant to the fungitoxic principles in all the test plants allowing only 1.0 - 7.4% inhibition of mycelial growth. The remaining species, *P. carneus* and *P. varioti* could be controlled by the various extracts used in amending the growth medium.

TABLE 34

Mycelial Inhibition (% MI) by aqueous, acetone and methanol extracts of indicated plant parts of *Zanthoxylum xanthoxyloides* and *Kigelia africana* on radial growth of three *Paecilomyces* spp. at 20 - 30°C. (Medium used was Maize Dextrose Agar from "Abeleehi").

Fungal species	Plant material	Dilution ratio (%)	% Mycelial Inhibition (MI)		
			Aqueous	Acetone	Methanol
Paecilomyces carneus	*Z.xanthoxyloides* (leaves)	Undiluted	34.4	27.8	32.7
		1:1	10.7	4.3	9.0
	K.africana (fruit)	Undiluted	36.3	30.3	41.3
		1:1	16.7	3.1	18.1
	K. africana (leaves)	Undiluted	47.8	48.7	47.0
		1:1	13.0	8.8	24.7
P. puntonii	*Z. xanthoxyloides* (leaves)	Undiluted	1.0	2.8	7.4
		1:1	1.0	1.0	1.0
	K. africana (fruit)	Undiluted	3.9	4.0	9.0
		1:1	1.0	1.0	4.7
	K. africana (leaves)	Undiluted	7.8	29.5	6.9
		1:1	1.0	11.9	1.0
P. varioti	*Z. xanthoxyloides* (leaves)	Undiluted	40.9	30.6	35.4
		1:1	10.7	3.5	9.6
	K. africana (fruit)	Undiluted	24.1	19.5	30.7
		1:1	13.8	9.8	11.4
	K. africana (leaves)	Undiluted	38.6	47.3	48.4
		1:1	22.8	20.5	9.4

High MI(%) above 1.0 shows some measurable inhibition of growth of the fungus.

TABLE 35

Mycelial inhibition (%MI) by aqueous, acetone and methanol extracts of indicated plants parts of *Z.xanthoxyloides* and *K. africana* on radial growth of *Curvularia lunata*, *Fusarium moniliforme and Penicillium digitatum* at 28 - 30°C (Medium used was Maize Dextrose Agar from "Abeleehi").

Fungal species	Plant material	Dilution ratio (v/v)	% Mycelial Inhibition (MI)		
			Aqueous	Acetone	Methanol
Curvularia lunata	*Z.xanthoxyloides* (leaves)	Undiluted	15.6	44.1	43.3
		1:1	3.6	7.4	15.4
	K. africana (fruit)	Undiluted	24.1	20.6	33.3
		1:1	7.2	5.6	15.2
	K. africana (leaves)	Undiluted	15.1	57.5	56.9
		1:1	10.4	12.3	40.3
Fusarium monilforme	*Z. xanthoxyloides* (leaves)	Undiluted	39.7	34.8	41.4
		1:1	18.2	13.8	18.0
	K. africana (fruit)	Undiluted	42.3	41.8	46.1
		1:1	9.9	9.5	29.4
	K. africana (leaves)	Undiluted	32.8	47.1	47.8
		1:1	15.3	37.5	33.9
Penicillium digitatum	*Z. xanthoxyloides* (leaves)	Undiluted	39.8	35.6	34.4
		1:1	12.0	4.7	18.3
	K. africana (fruit)	Undiluted	33.6	37.6	34.9
		1:1	19.6	26.5	20.6
	K. africana (leaves)	Undiluted	44.6	46.9	53.6
		1:1	10.1	15.2	28.9

High MI(%) above 1.0 shows some measurable inhibition of growth of the fungus.

R. INFLUENCE OF AQUEOUS, ACETONE AND METHANOL EXTRACTS OF EITHER LEAVES OF *Z. XANTHOXYLOIDES*, FRUIT OR LEAVES OF *KIGELIA AFRICANA* ON SPORULATION OF THE TEST FUNGI.

Extracts from the leaves of *Z. xanthoxyloides*, and fruit and leaves of *K. africana* variably affected sporulation of the fungi.

Aqueous, acetone and methanol extract of the leaves of *Z. xanthoxyloides* completely inhibited sporulation of *P carneus* at all levels of dilutions (1:1, 1:2 and 1:5 $^{v}/_{v}$), except the aqueous extract of 1:5 $^{v}/_{v}$ dilution, where sporulation was depressed by 45.5% (Table 36). Sporulation of the rest of the test fungi was commensurate with the concentration of the extract applied such that further dilution beyond 1:1 $^{v}/_{v}$ permitted sporulation (Tables 36 & 37).

The highest concentrations of methanol and aqueous extracts from the fruit of *K. africana* completely depressed sporulation by *P. carneus* (Tables 38 & 39), while acetone extract of the same concentration depressed sporulation by 62.4%.

Extracts of the leaves of *K. africana*, also, completely depressed spore production in *P carneus* (Tables 40 & 41). Methanol extracts of the leaves of *K. africana* could depressed sporulation in *F. moniliforme* by 95.5% (undiluted) and 83.0% (in 1:1 $^{v}/_{v}$). Undiluted extract generally exerted some measurable depression on spore production by almost all the test fungi (Tables 40 & 41).

Analysis of variance showed that the effectiveness of both plants extracts on sporulation by the test fungi differ significantly (P 0.05) and can be ranked as following in descending order: leaves of *Z. xanthoxyloides*>leaves of *K. africana*>fruit of *K. africana* for *Curvularia lunata, Paecilomyces carneus* and *P. puntonii*.

The general effect on sporulation was however, different for *P. digitatum* and *F. moniliforme*. The effect could be ranked as follows (in descending order):Fruit of *K. africana*>leaves of *K. africana*>leaves of *Z. xanthoxyloides*.

TABLE 36

Effect of aqueous, acetone or methanol extracts of the leaves of *Zanthoxylum xanthoxyloides* on sporulation of the indicated fungal species on maize dextrose agar medium (ABELEEHI) at 28 - 30°C.

Fungal species	Dilution ratio of extract (%v)	No. of spores per ml (x10³)		
		Aqueous	Acetone	Methanol
Paecilomyces carneus	Undiluted			
	1:1			
	1:2			
	1:5	5.5		
	Control	10.1	3.1	11.9
Paecilomyces puntonii	Undiluted	7.4	6.0	3.6
	1:1	19.7	15.9	10.0
	1:2	44.5	13.6	20.5
	1:5	31.9	11.9	20.0
	Control	50.9	22.8	42.1
Penicillium digitatum	Undiluted	92.1	9.5	80.7
	1:1	53.7	19.7	40.4
	1:2	70.5	41.2	44.3
	1:5	74.5	58.3	65.9
	Control	82.8	57.1	70.9
Curvularia lunata	Undiluted	2.9	2.3	3.3
	1:1	2.8	5.5	3.7
	1:2	4.9	6.8	7.1
	1:5	5.2	9.1	6.7
	Control	6.7	5.2	7.5
Fusarium moniliforme	Undiluted	36.0	27.5	37.8
	1:1	75.1	50.3	58.9
	1:2	63.6	67.3	86.1
	1:5	80.1	64.0	90.5
	Control	124.4	128.9	140.8

No sporulation

TABLE 37

Effect of aqueous, acetone or methanol extracts of the leaves of *Zanthoxylum xanthoxyloides* on sporulation of the indicated fungal species on maize dextrose agar medium (OBAATANPA) at 28 - 30°C.

Fungal species	Dilution ratio of extract (%)	No. of spores per ml (x 10^3)		
		Aqueous	Acetone	Methanol
Paecilomyces carneus	Undiluted			
	1:1			
	1:2			
	1:5			
	Control	8.1	4.3	6.8
Paecilomyces puntonii	Undiluted	7.9	6.5	8.7
	1:1	16.5	12.1	13.5
	1:2	32.0	12.1	12.3
	1:5	36.0	18.0	10.3
	Control	37.2	30.8	39.3
Penicillium digitatum	Undiluted	91.9	7.3	95.9
	1:1	39.7	20.5	90.4
	1:2	98.9	66.8	36.0
	1:5	87.2	67.5	52.5
	Control	34.5	70.3	54.0
Curvularia lunata	Undiluted	2.4	2.3	2.3
	1:1	2.6	4.5	6.5
	1:2	3.2	3.7	5.1
	1:5	3.7	3.6	6.1
	Control	2.6	5.1	5.1
Fusarium moniliforme	Undiluted	36.0	28.5	53.1
	1:1	65.2	40.1	88.1
	1:2	69.6	55.5	54.5
	1:5	70.9	52.9	70.9
	Control	147.6	148.0	146.8

No sporulation

TABLE 38

Effect of acqueous, acetone or methanol extracts of the fruit of *Kigelia africana* on sporulation of the indicated fungal species on maize dextrose agar medium (ABELEEHI) at 28 - 30°C.

Fungal species	Dilution ratio of extract (%)	No. of spores per ml ($x10^3$)		
		Aqueous	Acetone	Methanol
Paecilomyces carneus	Undiluted		3.5	
	1:1	2.1	2.4	
	1:2	4.9	4.1	
	1:5	8.4	5.1	3.9
	Control	5.9	9.3	9.6
Paecilomyces puntonii	Undiluted	2.1	14.9	5.9
	1:1	12.5	26.8	25.5
	1:2	15.9	36.2	34.3
	1:5	14.5	43.3	36.7
	Control	42.0	35.6	43.2
Penicillium digitatum	Undiluted	11.7	22.8	14.0
	1:1	12.3	38.3	29.3
	1:2	19.3	63.1	54.0
	1:5	17.1	70.4	66.8
	Control	57.5	58.3	75.5
Curvularia lunata	Undiluted	3.0	3.9	3.7
	1:1	4.0	7.7	4.1
	1:2	9.3	12.0	13.6
	1:5	13.7	14.0	11.7
	Control	10.4	10.0	17.2
Fusarium moniliforme	Undiluted	7.9	24.3	9.5
	1:1	25.6	32.8	53.5
	1:2	32.1	39.7	49.5
	1:5	40.0	60.0	75.9
	Control	64.3	66.9	103.5

No sporulation

TABLE 39

Effect of aqueous, acetone or methanol extracts of the fruit of *Kigelia africana* on sporulation of the indicated fungal species on maize dextrose agar medium (OBAATANPA) at 28 - 30°C.

Fungal species	Dilution ratio of extract (%)	No. of spores per ml ($x10^3$)		
		Aqueous	Acetone	Methanol
Paecilomyces carneus	Undiluted		5.3	
	1:1	1.7	3.3	
	1:2	2.5	7.3	
	1:5	2.4	9.3	
	Control	3.1	7.2	4.5
Paecilomyces puntonii	Undiluted		17.7	2.5
	1:1	9.9	30.5	14.7
	1:2	10.4	48.4	39.6
	1:5	23.7	49.7	43.9
	Control	56.4	43.9	51.5
Pencillium digitatum	Undiluted	12.7	46.1	7.5
	1:1	19.6	56.5	13.6
	1:2	10.5	78.1	36.5
	1:5	21.7	87.2	47.5
	Control	101.5	94.4	91.1
Curvularia lunata	Undiluted	0.7	5.6	3.9
	1:1	1.2	9.9	4.9
	1:2	5.3	7.9	3.9
	1:5	7.3	14.3	7.1
	Control	4.8	8.0	9.9
Fusarium moniliforme	Undiluted	10.4	20.9	7.5
	1:1	22.1	40.3	35.9
	1:2	53.6	66.4	44.9
	1:5	42.0	72.9	61.1
	Control	118.3	144.1	155.2

No sporulation

TABLE 40

Effect of aqueous, acetone or methanol extracts of the leaves of *Kigelia africana* on sporulation of the indicated fungal species on maize dextrose agar medium (ABELEEH) at 28 - 30°C.

Fungal species	Dilution ratio of extract (v/v)	No. of spores per ml (x10³)		
		Aqueous	Acetone	Methanol
Paecilomyces carneus	Undiluted		2.4	-
	1:1		3.7	
	1:2		2.4	
	1:5		5.6	
	Control	4.7	3.2	8.3
Paecilomyces puntonii	Undiluted	7.1	5.2	4.9
	1:1	13.5	10.0	19.1
	1:2	52.3	16.8	21.7
	1:5	53.5	13.6	25.8
	Control	43.6	28.4	39.8
Penicillium digitatum	Undiluted	54.4	34.4	7.2
	1:1	49.1	46.0	14.0
	1:2	70.5	57.2	37.3
	1:5	52.7	52.8	28.9
	Control	69.7	80.4	60.0
Curvularia lunata	Undiluted	4.1	3.2	4.2
	1:1	5.6	6.7	6.3
	1:2	3.6	7.7	8.5
	1:5	8.4	6.3	8.7
	Control	5.7	8.3	11.2
Fusarium moniliforme	Undiluted	20.4	23.6	9.0
	1:1	37.3	52.4	23.5
	1:2	83.7	54.0	46.3
	1:5	75.1	52.8	48.3
	Control	128.0	118.4	144.7

No sporulation

TABLE 41

Effect of aqueous, acetone or methanol extracts of the leaves of *Kigelia africana* on sporulation of the indicated fungal species on maize dextrose agar medium (OBAATANPA) at 28 - 30°C.

Fungal species	Dilution ratio of extract (v/v)	No. of spores per ml (x10³)		
		Aqueous	Acetone	Methanol
Paecilomyces carneus	Undiluted		5.7	
	1:1		5.6	
	1:2		4.8	
	1:5	3.2	4.9	
	Control	5.6	3.3	2.9
Paecilomyces puntonii	Undiluted	5.1	4.8	3.5
	1:1	12.1	19.1	25.7
	1:2	21.2	18.4	22.0
	1:5	52.7	19.7	22.3
	Control	44.3	32.1	45.9
Penicillium digitatum	Undiluted	45.7	39.3	14.1
	1:1	39.3	54.1	25.5
	1:2	57.5	56.5	15.6
	1:5	58.4	61.7	32.1
	Control	63.9	86.8	49.2
Curvularia lunata	Undiluted	3.3	3.3	0.7
	1:1	5.3	4.0	2.9
	1:2	3.7	5.6	4.8
	1:5	4.5	5.7	3.7
	Control	5.5	8.0	7.8
Fusarium moniliforme	Undiluted	17.6	13.5	6.3
	1:1	46.5	43.9	23.6
	1:2	90.0	43.1	51.9
	1:5	84.5	47.7	43.9
	Control	147.5	127.3	138.8

No sporulation

V. DISCUSSION

Maize is an important seasonal crop in West Africa. When stored as dry grains it forms an enormous reserve of food. However, stored maize is subject to attack by a variety of insects, fungi and other biodeterioagents. Losses in storage due to insects and fungi is estimated at between 25-50% of the annual harvest (Rawnsley, 1970; Adams, 1977).

The role of fungi in quality deterioration of grains is well documented in developed countries (Bothast et al., 1975; Christensen and Kaufmann, 1965, 1969; Tuite et al., 1967) and in some African Countries (Broadbent et al., 1969; Oyeniran, 1973; Moubasher et al., 1972). Members of the genus *Aspergillus* were the most predominant followed by *Penicillium.*

The initial population of fungi in the grains from Balduzzi Warehouse was 4.8 - 5.4 $\log_{10}$ $cfug^{-1}$ but decreased by 0.4 - 1.3 log cycles after 2 months. The position from which the grains were sampled did not influence the results (Table 2). Presumably, the similar moisture contents, the source and handling history of the grains before storage could have contributed to the similarity in the results obtained from top, middle and bottom of the stacks.

Aspergillus flavus was ubiquitous and the most predominant fungal species (24.2 - 38.1%) appearing on whole grains either by the Blotter method or the decimal dilution technique followed by *Mucor haemalis* (3.4 - 21.4%) (Table 4). The method of isolation and media used may influence the species of fungi encountered. This partly explains why the use of two media and two methods of isolation enabled one isolate a wider range of fungal species. *A.sulphureus, Fusarium roseum, Penicillium citrinum, P.chrysogenum, P.glabrum, P.oxalicum, P. brevicompactum* and *Mucor haemalis* are being recorded for the first time on local maize variety and they extend the list of Danquah (1973), Odamtten and Kampelmacher (1986). The preponderance of *Aspergillus* species over other genera encountered followed by genus *Penicillium* confirms previous findings by many workers for maize in Ghana and elsewhere.

Twenty four different fungal species were isolated from the air within the Balduzzi Warehouse at Kumasi at 44 - 55% ERH and 29-32°C inspite of frequent fumigation. In many publications (Majumder et al., 1955, 1963; Raghunathan et al., 1969; Tsuruta and Ishirava, 1966; Narasimhan and Rangaswnay, 1968; Vander graft et al., 1973) effect of insecticide on some strains of fungi were strain dependent as well

as on the type of insecticide applied. It is well known that volatile substances interfere with respiratory mechanisms of spores (Hawker et al., 1952;). The cell wall composition and wall contents vary not only in species of fungi but also the stages of development such as hyphae and conidiophore etc.; mycelia are more susceptible than spores. Odamtten (1986), showed that prophylactic spraying of Supreme Warehouse at Tema with Actellic 25(R) and Phosphine Detia-x resulted in reduction of fungal colony counts and the elimination of some fungal species, but this was followed by an increase in fungal colony counts in the subsequent sampling weeks. Additional work is needed to elucidate the possible effect of the fumigants/insecticides used in the Warehouse on the airspora.

Interestingly, twelve out of the 24 fungal species encountered in the airspora also contaminated the maize grains in the Blotter test. They were *A.flavus, A.niger, A.sulphureus, A.tamarii, P.citrinum, P.chrysogenum, P.cyclopium, P.digitatum, P.glabrum, Cladosporium herbarum, Fusarium moniliforme* and *Mucor haemalis.* Thus, again *Aspergillus* and *Penicillium* species predominated over members of other genera encountered.

The species of fungi isolated from 'Abeleehi' and 'Obaatanpa' varieties varied and depended on the methods of isolation, storage humidity and type of microbiological medium used in isolating the resident fungi. Thirty (30) different fungal species were isolated from Abeleehi as compared to twenty-eight (28) from Obaatanpa variety. These species are all being recorded for the first time in these two newly improved maize varieties in Ghana. Again, *Aspergillus* species predominated over other genera encountered followed by *Penicillium. Aspergillus* and *Penicillium* species are of importance in the warmer tropics because they contain many species capable of growth and production of potent mycotoxins at low water activities (Smith and Moss, 1985).

Some fungal species of pathological importance *(Curvularia lunata, Fusarium moniliforme, Penicillium* spp, and *Paecilomyces* spp) (Neergaard, 1983) were encountered in both Abeleehi and Obaatanpa varieties that required further studies. A.flavus was isolated from both maize varieties stored at 55-95% in both open Petri dishes and those kept in woven polypropylene sachet; total number of fungal colonies in grains using the direct plating method and the total fungal population obtained by the serial dilution technique was higher in maize varieties stored exposed in Petri dishes than the same grains kept in woven polypropylene sachets (Tables 13 and 14). Presumably, woven polypropylene restricts air and moisture flow to and from within the bags. Indeed, New (1995) showed that jute-sack fabric allows greater airflow than any of the woven polypropylene (8x8, 8x7 and 8x6 mesh) under conditions simulating those in a stack of bagged grain. If movement of air through bag walls

is a factor in heat loss from bagged grain; then maize bagged in jute would lose heat to the surroundings faster than maize bagged in woven polypropylene.

Moisture sorption isotherms of Abeleehi and Obaatanpa varieties followed a sigmoid curve; an initial high rate of water absorption followed by a decrease at saturated point after which grains seem not to pick up any more moisture (Odamtten and Langerak, 1980). The equilibrium period for grains stored at 65-85% ERH was 8-12 days whereas moisture content of grains kept at 90-95% ERH continued rising (Figs 10 & 11). Analysis of variances to ascertain the influence of ERH, packaging material, incubation period and maize variety on moisture sorption as well as the interaction of these factors showed that each of these significantly ($P< 0.05$) influenced moisture sorption and desorption of the two maize varieties. Consequently grains stored in open Petri dishes significantly absorbed more moisture than same samples stored in woven polypropylene sachets. This confirms the prognosis that woven polypropylene restricts moisture transfer (New, 1995; Odamtten and Kampelmacher, 1986).

Naturally, one would expect larger number of individual fungal species to be isolated at the higher ERH's (80-95%) than at the lower ERH's (55-75%) as moisture content (m.c) of grain increased so will the availability of water for fungal growth. Thus the m.c. of Obaatanpa variety increased from an initial 10.0% to 14-17.2% after 36 days at 85-95% ERH. In the case of Abeleehi variety m.c. increased from an initial 11.0% to 13.9 - 18.1% at ERH's 85-95%. A moisture content of 12.5% at ERH < 75% is considered safe for maize storage (Muckle and Stirling, 1971). The m.c. of Abeleehi and Obaatanpa varieties stored at ERH. 55-75% had m.c. ranging from 10.2 - 12.5% and 9.2 - 12.5%, respectively, and were on the "safe" side (Tables 10 and 11) which explains why they were less susceptible to deterioration by the resident fungi.

A.flavus, A.fumigatus and *A.niger* were ubiquitous and could be isolated at all ERH's used (55-95%) whereas xerophilic species like *Aspergillus giganteus, Paecilomyces carneus, P.puntonii* and *P.varioti* were isolated at a low ERH of 55-75%. The survival of fungi in grains has recently been studied by Kesse (1995). The conidia of *Aspergillus* spp showed varied longevity. Longevity was influenced by species, relative humidity at which spores were formed by the humidity of storage and light conditions.

Fungi are largely responsible for decrease in germination capacity of seeds during storage (Neergaard, 1983; Christensen and Lopez, 1963, Fields and King, 1962). Infected peas kept at 85% ERH and 30°C

loss viability within six months when invaded by *A.flavus, A.candidus* and *A.ruber* in contrast with fungus-free seeds with 95% germination (Field and King, 1962). Sound maize, wheat and sorghum retained germination of 90-95% throughout even at a m.c. favourable for fungal growth whereas infected samples lost viability within a few weeks or months (Christensen and Lopez, 1963).

Data from this thesis show that there was no statistical difference ($P< 0.05$) between the germination of Abeleehi and Obaatanpa varieties incubated at ERH's 55-85%. However germination capacity of the grain was drastically reduced at 90-95% ERH (Fig.8). Data on the percentage germination of grains kept in woven polypropylene were similar to those exposed to the ambient ERH. The storage humidity also significantly ($P< 0.05$) influenced the length of the emerging radicles (Fig.8) such that at ERH 95% the length of the emerging radicle was reduced by 39-61% depending on the maize variety (Fig.9). Odamtten and Kampelmacher (1986) showed that both storage ERH and type of packaging material affected the germination of cowpea, groundnut, maize, millet and sorghum. The higher the storage humidity, the lower the length of the emerging radicles (Odamtten and Kampelmacher, 1986). This confirms the present findings.

Water absorption by Obaatanpa variety was significantly ($P< 0.05$) higher than Abeleehi variety placed under the same conditions (Figs. 10-13). This explains why Obaatanpa variety showed a comparatively better water absorption level than Abeleehi (Fig.1a). Similarly, local normal white maize absorbed better than stackburn local white maize (Fig.16). There was no statistical difference between the water absorption capacity of the normal yellow and stackburn yellow maize.

The degree of seed water absorption and swelling as well as the 1000 - seed weight are important physical characteristics that are used by the food processor to evaluate grain acceptability. For example, in the cocoa industry, up to 1000 beans count per kg. sample is considered 'main crop' which has low shell and high fat content; 1100 up to 1200 beans per kg is regarded as 'light crop' and has high shell and low fat content. Cocoa bean processors prefer the former category with higher fat content (Cocoa, Chocolate and Confectionery Alliance, 1968; Wood, 1973).

The 1000-seed weight of maize (Table 16) is a reflection of the density or ability to accumulate dry matter. Obaatanpa has a higher density (273.2 ± 2.0g) than Abeleehi (268.9 ± 4.2g); stackburned yellow maize (331.7 ± 5.4g); white stackburned maize (237.8 ± 1.9g) has a lower density than non-stackburn

white (275.3 ± 2.1g) (Table 16). The decrease in swelling of stackburnt white and yellow maize is a disadvantage as the ability of maize to swell when soaked is one of the desirable characteristics preferred by the food processor (Sefa-Dedeh, 1993). After soaking, swollen kernels give the impression of increase in amount of material. High density grains require fewer kernels to achieve a certain volume than low density grains. This partly explains the decrease in swelling of stackburnt yellow and white grains with lower 1000-seed weight.

Steeping of maize grains prior to milling is essential as it improves the milling properties of the maize and offers better consistency of the dough. Steeping also initiates the activities of lactic acid bacteria which act as a buffer system that keeps the steepwater around pH 4.0. Undesirable microorganisms at this pH 4.0 are inhibited (Watson, Hirata and Williams, 1955). The pH's of the steepwater of stackburnt and non-stackburned yellow maize were 4.17 and 4.22 respectively; that of non-stackburnt white maize was 4.18 (Appendix 5). The pH of steepwater of Abeleehi, Obaatanpa and stackburnt white maize were 4.53, 5.02 and 5.26 respectively.

The pH profile of wet and dry milled maize (normal and stackburnt) undergoing spontaneous fermentation was generally similar at least during the first 24-48h (Figs 6 and 7) attended by a drop in pH from 5.0-6.5 to pH 4.2 - 4.6. However with time the wet-milled maize increased in pH from 4.4 to 5.1 in 72h. Wet-milling by soaking grains as practised by the indigenous kenkey manufacturers is an essential step in dough preparation as its omission results in a kenkey product with inferior textural quality. Indeed, Nche et al. (1994) showed that dry-milled maize flours had pasting and set-back viscosities that were inferior to those of the traditionally prepared doughs from steeped maize grains. Pre-gelatinised aflata from unfermented dry-milled maize flour resulted in crumbly and friable kenkey product (Nche et al., 1994).

Over the years, several interesting and significant reviews have appeared on bio-pesticides and biofungicides (Van Latum and Gerrits, 1991). The number of literature references concerned with the subject exceed 5,000. Several thousand species of higher plants and an unknown number of fungi and lower plants have been screened (Van Latum and Gerrits, 1991).

The major pests and pathogens taking heavy toll on agricultural crops in the field and in storage are insects and fungi. The idea of controlling them by the use of chemicals is not new. However, many of the

original chemicals developed generally become injurious to the environment with non-specific activity (Cremlyn, 1978). There is now a greater awareness of the dangers of environmental pollution arising from the widespread application of chemicals; pesticides and fungicides (Carson, 1962) and candidate chemicals have to pass increasingly stringent tests on the toxicity and residue formation before they can be marketed as pesticides/fungicides in many countries. This has provided impetus in research on new biopesticides naturally derived from plant origin. Such compounds are safer and more selective in their action and do not affect non-target organisms. The need to evaluate the biological activities of extracts and phytochemical constituents (active ingredients) is not only important for the development of new therapeutic agent but also the new chemicals isolated from the plants with some biological activity become a springboard for chemists exploring plants for lead compounds to manufacture synthetic analogues from these naturally occurring compounds.

As part of an on-going research in this laboratory, over 30 local plants belonging to 20 families have been tested for their fungistatic and antibacterial activities (Ahiabu, 1985; Myles, 1986; Boateng, 1986; Sanuna, 1990; Apetorgbor, 1991; Odamtten, 1992; Owusu-Boiatey, 1992). In Chapters E-R of this thesis, aqueous, acetone and methanol extracts of *Zanthoxylum xanthoxyloides* and *Kigelia africana* were tested for their fungistatic effect on fungi isolated from Abeleehi and Obaatanpa maize varieties namely *Paecilomyes carneus, P.puntonii, P.varioti, Curvularia lunata, Fusarium moniliforme* and *Penicillium digitatum.*

Aqueous, acetone and methanol extracts of the leaves of Z.xanthoxyloides variably depressed vegetative growth of all test fungi in liquid medium and radial growth on agar amended with varying concentrations of the extracts. Depression of growth was severer at the higher concentrations (Undiluted - 1:1 v/v) and the inhibitory principle was gradually removed with increasing dilution of the extract (Figs. 14-25; Tables 21-33). Methanol extract of the leaves of *Z.xanthoxyloides* was the most effective on the three *Paecilomyces* species followed by acetone and water extracts in decreasing order. There were some exceptions, however, as there was no statistical difference ($P < 0.05$) between the efficacy of the acetone and aqueous extract of the leaves of *Z.xanthoxyloides* on the vegetative growth of *C. lunata, F.moniliforme* and *P.digitatum.* Odebiyi and Soforowa (1979) have isolated benzoic acid

derivatives, alkaloids including furoquinoline, L-benzyltetrahydroisoquinolines, orthocoupled, aporphines, amides, bi-cyclic coumarins, furanocoumarins and pyranocoumarins, liquans and cinnamic acid derivatives. Torto et al. (1969) and Ayitey-Smith (1989) added skinmianine, chelerythrine, dihydrochelerythrine, artarine (9-ethoxychelarythrine) to the list of active ingredients from *Z.xanthoxyloides.* These compounds may have contributed to the fungistatic effect of the leaf extracts of *Z.xanthoxyloides* on the test fungi. However, the yield of the active ingredients may depend on the extracting solvent used. This partly explains why the efficacy of the extracts in depressing vegetative growth varied depending on the solvent used in extracting the active ingredients. Other workers, example, Sabir et al. (1987) found that ethanol extracts of the leaves, stems and seeds of *Ardisia solanacea* was the most potent against most of the Gram positive and Gram negative bacteria they used when compared to the hexane, chloroform and methanol extracts of the same plant parts. Chloroform extract of *Myrsine africana* was more potent on test pathogenic bacteria than the ethanolic extracts (Tahir et al. 1988). *Aspergillus niger* and *Candida albicans* were effectively controlled by chloroform extracts of 34 plants tested by Almagboul et al. (1988) but not the aqueous and methanolic extracts of the same plants. Results in this thesis extends the list of fungi reported by Apetorgbor (1991) and Owusu-Boaitey (1992) whose vegetative and reproductive phases of their life cycles are adversely affected by extracts of *Z.xanthoxyloides.*

K.africana is used extensively in traditional medicinal practice (Sharma et al. 1993; Houghton et. al 1993; Irvine, 1961; Anonymous, 1959, 1986). Flavonoids have been isolated from the leaves and fruits (El-Sayyad, 1982; Govindachari, 1971) sterols, coumarins and napthaquinones, naphthaquinoids from roots (Inoue et al. 1981; Joshi et al. 1982), iridoids, speciosides I (El-Naggar et al. 1980), verminoside II and minecoside III (Sticher et al., 1979) from root bark.

Results from chapter E-P showed that leaf extracts of *K.africana* was the most potent against the vegetative growth of *Paecilomyces carneus, P.varioti, C.lunata, F.moniliforme* and *Penicillium digitatum* (Figs. 22-25, Tables 34 & 35) compared to extracts from its own fruit and the leaves of *Z.xanthoxyloides.* Effect on vegetative growth of *P.puntonii* was less severe allowing only 1.0 - 7.4% inhibition of mycelial growth (Figs. 14-25; Tables 17-33). Presumably some of the active ingredients in the leaves and fruits of *K.africana* mentioned above might have contributed to the fungistatic effect observed 'in vitro'.

In the concluding Chapter of this thesis the effect of the extracts of the leaves of *Z.xanthoxyloides* and the leaves and fruits of *K.africana* were tested for their effects on the sporulation of *P.carneus, P.puntonii, C.lunata, F.moniliforme and P.digitatum*. The highest concentration of the extracts significantly ($P<0.05$) and variably suppressed sporulation of the test fungi. This inhibitory effect was gradually removed with increasing dilution (Tables 36-41). The severity of the inhibition of sporulation can be ranked as follows for *C.lunata, P.carneus and P.puntonii* in descending order:

Leaves of *Z.xanthoxyloides* > leaves of *K.africana* > fruit of *K.africana*.

In the case of *P.digitatum* and *F.moniliforme* the trend was different as indicated in descending order: Fruit of *K.africana* > leaves of *K.africana* > leaves of *Z.xanthoxyloides*.

There was another interesting variation. Leave extracts (aqueous, acetone and methanol) completely inhibited sporulation of *P.carneus* at all levels of dilution tested (undiluted, 1:1, 1:2, 1:5v/v) except the aqueous extract at 1:5v/v dilution where sporulation was depressed by 45.5% (Table 36).

Thus, the efficacy of the plant extracts in preventing/depressing both vegetative growth and sporulation depends on (a) the solvents used in the extraction of the active ingredients (b) the plant part used and (c) the concentration of the extract applied.

A fortuitous condition is created in which the active ingredient not only depress vegetative growth of the fungi at high concentrations but also drastically reduce or prevent sporulation and could serve as effective biocontrol agents. However, only 50g samples have been used in the screening tests reported in this thesis. If indeed the weight of the test sample is increased to 1kg or more, it is anticipated that the yield of the active ingredients could be improved proportionately. In future studies, the sample weight could be increased and a broader spectrum of polar and non-polar solvents used to see if the yield and efficacy of the anticipated active ingredients could be increased. There were differences in the ability of the fruit and leaf extracts of *K.africana* in depressing both vegetative and sporulation of the test fungi. Future studies could be extended to include the root bark, stem bark and flowers of *K.africana* - a promising plant for biocontrol of plant pathogenic fungi resident in maize.

The practical conclusion from these findings is that the newly developed maize varieties 'Abeleehi' and 'Obaatanpa' harbour potential pathogenic fungi belonging to different genera. *P.carneus, P.pantonii, P.varioti, C.lunata, F.moniliforme* and *Penicillium digitatum* were selected for further studies. The

two plants used *Z.xanthoxyloides* and *K.africana* are biocontrol agents containing active constituents that showed variable phytoxicity against the selected test fungi.

The use of plants with toxic or repellant action against pests and pathogens is a common protection practice in traditional agricultural system in developing countries. Traditional practices of admixture of grains with natural plant products is used primarily with the view of curtailing insect infestation. However, these practices are not very widespread and their efficacy have not been exhaustively investigated. No attempt has been made to use natural plant products as admixtures of grains to prevent fungal proliferation during storage.

There are two possible ways in which *Z.xanthoxyloides* and/or *K.africana* (fruit/leaves) can be used in biocontrol of plant pathogenic fungi. The plant part with toxic repellant can be used in powdered form as admixture of grains in storage, seed dressing with chemical fungicides before storage or sowing has been a long-standing practice in plant pathology (Nene, 1971). This method can find application here using the pulverised plant parts of *K.africana* or *Z.xanthoxyloides*. Secondly, active ingredients of plants when isolated and formulated into a natural fungicides can be used as prophylactic aerial spray or soil drench in instances where the crop in the field is infected by the test fungi listed above. However, plant biotoxins are natural toxins that need to be scrutinized carefully because possible harm may result from over exposure to some of such substances just as it is with certain synthetic chemicals. They cannot therefore be applied indiscriminately. With the help of research under controlled circumstances, criteria and guidelines can be developed under which biofungicides whose efficacy have been proven in this thesis can be promoted further and at some time their application be rendered environmentally friendly. If this is eventually achieved, this thesis would serve as a springboard and the basis for future application of findings for better storage, growth and higher yield of maize grains in this country.

VI. SUMMARY

1. Twenty four different species of fungal airspora were isolated from the Ghana Food Distribution Corporation warehouse at Balduzzi, Kumasi. *Aspergillus flavus* was the most predominant *Asperigillus* species isolated throughout the two months' storage and constituting 41.7 - 44.0% of the total species recorded. *Mucor haemalis* constituted 4.0-20.5% of the total mycoflora.
2. *Aspergillus* species (*A. clavatus, A. flavus, A. fumigatus, A. niger, A. ochraceus, A. parasitins, A. sulphureus* and *A. tamarii*) were more predominant followed by *Penicillum* species (*P chrysogenum P. citrinum, P. cyclopium, P. digitatum* and *P. expansum*).

3.(a) The initial population of fungi recorded in the grains was 4.8-5.4 Log_{10}cfu/g and this decreased by 0.4-1.3log cycles after 2 months.

(b) There was no statistical difference between data collected from the top, middle and bottom of the stackbags in the Warehouse.

4. The species diversity in the grains obtained by the decimal serial dilution technique varied from what existed in the direct plating method. In spite of this variation, *A. flavus* was the most predomimant species (24.2-38.1%) isolated, followed by *M. haemalis* (3.4-21.4%).
5. The advantage of using a wider range of media for the isolation of fungi was that it enabled one to isolate a wider range of fungal genera and species.
6. The species of fungi that were encountered in Abeleehi and Obaatanpa maize varieties depended on the method of isolation, storage equilibrium relative humidity and the type of isolation medium used. The packaging material also influence the profile of fungi encountered.

(a) Using direct plating method, *A. flavus* was found to be ubiquitous in both Abeleehi and Obaatanpa varieties stored at ERH's 65-95%.

(b) *Fusarium moniliforme* was isolated at all ERH's 65-95% and *Penicillium* sp.1 was not encountered in Obaatanpa grain stored at ERH's 55-95%.

(c) Xerophilic species like *A. giganteus*, occurred at low ERH's of 55-65% in Abeleehi while *Paecilomyces puntonii* and *P. carneus* were isolated at 55-65% ERH in both Abeelehi and Obaatanpa varieties.

(d) *Penicillium digitatum* was not isolated from Abeleehi at all ERH's tested (55-95%) but was encountered at 90% ERH in Obaatanpa variety.

(e) Population (Total no/plate) of fungi was higher in maize grains stored 'exposed' in Petri dishes than same samples kept in woven polypropylene sachets.

7. All the maize varieties showed the characteristic sigmoid water absorption pattern of macromolecules. The newly improved maize variety, Obaatanpa exhibited comparatively better water absorption level than Abeleehi. Similarly, the local normal white maize absorbed better than the stackburned local white maize.

8. Generally, seed dimension of the maize varieties variably increased with soaking time.

9(a) After 24h of soaking, there was no statistical difference ($P \geq 0.05$) between the seed length of Abeleehi and Obaatanpa.

(b) Seed length of normal white maize was 2-3% more than that of stackburned white maize; swelling of normal yellow maize initially lagged behind that of stackburned samples but this was reversed after 24h resulting in 1-2% increase in seed length over that of the stackburned yellow maize.

(c) Similar trends were observed for seed width and seed thickness.

10(a) The pH profile of the steep water of yellow maize grains (stackburned and non-stackburned) were very close throughout the steeping time of 30h.

(b) pH of steepwater of non-stackburned local white maize was more acidic (pH 4.2-4.3) than stackburned grains of the same variety (pH 5.1-5.2).

(c) The pH steepwater of Abeleehi dropped from 5.9-4.6 after 10-30h soaking as compared to pH 5.0-5.2 for Obaatanpa during the same period.

11. The pH profile of wet and dry-milled maize (stackburned and no-stackburned) undergoing spontaneous fermentation was smimilar at least during the first 24-48h attended by a drop in pH from 5.0-6.5 to pH 4.2-4.6

12. Grains of Obaatanpa variety had a higher average 1000-seed weight (273.2g) than Abeleehi (268.9g), while stackburned yellow and white maize had lower average 1000-seed weight compared to their correspon ding non-stackburned grains.

13. The moisture content of normal grains (12.0-13.5%) did not differ significantly from the stackburned samples (13-13.5%) of the same grains.

14. There was no statistical difference (Analysis of variance $P \geq 0.05$) between the germination of Abeleehi

grains incubated at ERH's 55-85%. However, seed germination was drastically reduced at 90 and 95% ERH.

15. Percentage germination of grains stored in woven polypropylene sachets were similar to same varieties exposed in Petri dishes to the simulated ambient conditions.

16. Storage ERH's influence the development of radicles. The higher the incubation humidity, the shorter the length of the emerging radicle such that at 95% ERH radicle length was reduced by 39-61% depending on the maize variety.

17. There was a significant difference (students t-test $P \leq 0.05$) between the higher radicle length recorded in grains of both Abeleehi and Obaatanpa stored in woven polypropylene sachets than same grains kept exposed in Petri dishes under the same condition.

18(a) The packaging material and the incubation period influenced the moisture sorption and desorption of Abeleehi and Obaatanpa.

(b) Grains stored at 65-85% ERH equilibrated in 8-12 days.

(c) Moisture content of Abeleehi and Obaatanpa grains kept at 90-95% ERH continued rising; the moisture content of grains incubated at 55% ERH decreased within the same period.

(d) Analysis of variance to ascertain the influence of ERH, packaging material (P), incubation period (I) and maize variety (V) on moisture sorption as well as the interaction of these factors showed that P, I and V significantly ($P \leq 0.05$) influenced moisture sorption of the two maize varieties (Abeleehi and Obaatanpa).

(e) Grains kept in open Petri dishes significantly ($P \leq 0.05$) absorbed and desorbed moisture to a greater extent than some varieties stored in woven polypropylene sachets.

19. Moisture sorption by Obaatanpa variety was significantly ($P \leq 0.05$) higher than Abeleehi variety placed under the same condition.

20(a) Antifungal potential of two local Ghanaian plants, namely, *Kigelia africana* and *Zanthoxylum xanthoxyloides* were tested against *Paecilomyces carneus, P. puntonii, P varioti, Curvularia lunata, Fusarium moniliforme* and *Penicillium digitatum*.

(b) Aqueous, acetone and methanolic extracts of the leaves of *Z. xanthoxyloides* depressed vegetative growth by dry matter accumulation of *Paecilomyces carneus, P. puntonii* and *P. varioti.*

25. The efficacy of the inhibitory effect of the aqueous, acetone and methanolic extracts of the leave of *Z. xanthoxyloides* on the test fungi can be ranked as follows (in decreasing order):

P. digitatum>*F. moniliforme*>*C. lunata*

26(a) Aqueous, acetone and methanolic extracts of the fruit of *K. africana* variably depressed vegetative growth of *P. carneus, P. puntonii* and *P. varioti*.

(b) Depression of growth (77.0-88.0%) of all test fungi was observed at the highest concentration (undiluted) used. The inhibitory effect was, however, gradually removed with increasing dilution of the extracts.

(c) The inhibitory effect of the methanolic extract of the fruit of *K. africana* was the severest as compared to the aqueous or the acetone extracts of the same plant.

27(a) Radial growth on maize meal agar of *P. carneus, P. puntonii* and *P. varioti* was exponential during the early stages of incubation on agar medium amended with 1:1-1:5 $^{v}/_{v}$ dilution of extract of fruit of *K. africana*.

(b) *P. puntonii* grew faster even in the medium of highest concentration of the plant extract and covered the entire plate in 4-5 days.

28. The methanol extract of the plant (fruit of *K. africana*) significantly ($P \leq 0.05$) inhibited the radial growth of *P. carneus, P. puntonii* and *P. varioti* than the aqueous and acetone extract of the same plant part.

29. Inhibitory effect of the fruit of *K. africana* on the test fungi can be ranked as follows (in decreasing order):

P. varioti<*P. carneus*<*P.puntonii*.

30(a) Vegetative growth in liquid medium of *C. lunata, F. moniliforme* and *P. digitatum* in maize meal broth amended with undiluted extracts of the fruit of *K. africana* was depressed by 69.0 - 90.0% depending on the fungus.

(b) The highest depression in vegetative growth was observed in *C. lunata*.

31. Undiluted aqueous, acetone and methanol extracts of the leaves of *K. africana* significantly depressed growth in liquid medium and on agar of the three *Paecilomyces* species. Methanol extract was most potent and the effect was less severe on *P. puntonii*.

32. Both fruit and leaves of *K. africana* contain active ingredients which could depress vegetative growth

of *C. lunata, F. moniliforme* and *P. digitatum* in liquid medium and on agar.

33. Generally, efficacy of all the extracts in depressing growth of the test fungi can be ranked as follows: methanol>acetone>aqueous.

34. Extracts from *K. africana* and *Z. xanthoxyloides* showed measurable fungitoxic activity on the growth of the six test fungi, namely, *P. carneus, P. puntonii, P. varioti, C. lunata, F. moniliforme* and *P. digitatum*.

35. Among the fungal species tested, *P. puntonii* was the most resistant to the fungitoxic principles in all the test plants allowing only 1.0-7.4% inhibition of mycelial growth.

36(a) Extracts from all test plants completely inhibited sporulation of *P. carneus* at the highest concentrations.

36(b) The effectiveness of test plants extracts on sporulation by all the test fungi differed significantly ($P \geq 0.05$) and can be ranked as follows in descending order: leaves of *Z. xanthoxyloides*>*leaves*>*K. africana*>fruit of *K. africana*.

APPENDIX 1

Percentage increase in water uptake by the indicated varieties at 30°C (Data presented in Fig.1)

Soaking Time (Hr)	% WATER ABSORBTION OF MAIZE VARIETIES					
	ABI	OBA	WStacb	WnStacb	YStacb	YnStacb
1	12.4	13.1	15.1	17.6	20.0	19.5
2	18.9	20.0	23.1	23.4	26.4	26.7
4	25.8	27.8	29.4	30.3	32.7	33.3
6	31.3	34.9	33.4	34.6	36.4	35.8
8	34.8	38.4	35.9	37.6	38.8	39.0
10	36.0	41.6	36.6	39.3	40.8	41.3
15	39.6	44.6	38.4	41.8	43.3	43.3
20	41.3	47.3	39.2	42.5	44.6	44.8
24	42.3	49.2	40.1	43.7	46.2	46.6
30	42.9	49.7	40.5	45.5	48.0	48.3

ABI: Abeleehi
OBA: Obaatanpa
WStacb: Local White Maize(Stackburned)
WnStacb: Local White Maize(Non-Stackburned)
YStacb: Yellow Maize (Stackburned)
YnStacb: Yellow Maize (Non-Stackburned)

APPENDIX 2

Change in seed length of the indicated maize varieties during soaking at 30°C (Data presented in Fig.2)

Soaking Time (Hr)	% INCREASE IN SEED LENGTH					
	ABI	OBA	WStacb	WnStacb	YStacb	YnStacb
1	6.4	4.1	0.2	0.2	2.2	0.7
2	1.0	5.0	0.4	0.6	5.4	1.1
4	4.3	5.6	1.5	2.2	6.8	2.2
6	10.8	8.0	1.9	2.9	6.0	2.8
8	12.9	10.2	2.3	4 3	6.0	2.9
10	8.9	12.7	2.7	8.6	12.1	3 4
15	15.1	14.9	7.5	10.8	9.6	11.9
20	15.4	15.7	11.0	12.7	10.5	14.5
24	15.7	15.9	12.3	13.4	14.0	15.0
30	16.2	16.8	12.7	14.1	14.4	15.3

ABI: Abeleehi
OBA: Obaatanpa
WStacb: Local White Maize(Stackburned)
WnStacb: Local White Maize(Non-Stackburned)
YStacb: Yellow Maize (Stackburned)
YnStacb: Yellow Maize (Non-Stackburned)

APPENDIX 3

Change in seed width of maize varieties soaked at 30°C for the indicated periods (Data presented in Fig.3)

Soaking Time (Hr)	% INCREASE IN SEED WIDTH					
	ABI	OBA	WStacb	WnStacb	YStacb	YnStacb
1	2.1	5.3	1.3	0.4	0.5	0.9
2	0.8	5.9	2.3	6.7	1.4	2.0
4	4.3	7.6	0.6	7.8	3.5	4.1
6	7.0	10.7	1.6	8.5	3.0	5.9
8	9.8	10.9	2.7	9.0	4.5	8.0
10	10.5	12.7	5.5	8.7	5.1	8.4
15	13.2	14.1	8.0	9.6	8.5	9.7
20	12.4	14.3	8.7	10.9	8.8	10.3
24	15.0	14.4	9.1	11.2	9.6	11.7
30	15.1	14.5	9.4	11.4	11.1	13.2

ABI: Abeleehi
OBA: Obaatanpa
WStacb: Local White Maize(Stackburned)
WnStacb: Local White Maize(Non-Stackburned)
YStacb: Yellow Maize (Stackburned)
YnStacb: Yellow Maize (Non-Stackburned)

APPENDIX 4

Change in seed thickness of maize varieties soaked at 30°C for the indicated periods (Data presented in Fig.4)

Soaking Time (Hr)	% INCREASE IN SEED THICKNESS					
	ABI	OBA	WStacb	WnStacb	YStacb	YnStacb
1	2.0	3.9	1.1	1.6	1.6	1.1
2	8.8	4.1	2.9	3.8	4.0	3.0
4	10.1	11.9	5.4	6.1	7.3	6.4
6	7.3	10.7	7.0	2.1	8.2	7.3
8	13.4	8.4	8.8	7.5	13.1	8.4
10	13.6	15.0	8.3	13.8	10.3	14.4
15	15.9	15.8	10.8	15.8	14.5	16.0
20	16.7	16.3	12.2	16.5	14.1	15.5
24	17.1	16.7	13.5	17.5	14.8	15.8
30	16.9	17.0	13.3	18.0	15.2	16.2

ABI: Abeleehi
OBA: Obaatanpa
WStacb: Local White Maize(Stackburned)
WnStacb: Local White Maize(Non-Stackburned)
YStacb: Yellow Maize (Stackburned)
YnStacb: Yellow Maize (Non-Stackburned)

APPENDIX 5

Change in pH of steep water during soaking of whole maize kernel at 30°C for the indicated periods (Data presented in Fig.5)

Soaking Time (Hr)	pH OF DIFFERENT STEEP WATER OF					
	ABI	OBA	WStacb	WnStacb	YStacb	YnStacb
0	5.61	5.61	5.61	5.61	5.61	5.61
10	5.96	5.02	5.10	4.30	4.46	4.24
15	4.65	5.08	5.00	4.17	4.31	4.19
20	4.53	5.02	5.26	4.18	4.22	4.17
24	4.56	5.18	5.18	4.25	4.27	4.18
30	4.61	5.20	5.20	4.27	4.29	4.20

ABI: Abeleehi
OBA: Obaatanpa
WStacb: Local White Maize(Stackburned)
WnStacb: Local White Maize(Non-Stackburned)
YStacb: Yellow Maize (Stackburned)
YnStacb: Yellow Maize (Non-Stackburned)

APPENDIX 6

Change in pH of wet and dry-milled maize during fermentation at 30°C.(Data presented in Figs. 6 and 7)

Treatment	Maize Samples	pH at the indicated fermentation periods(hr)			
		0	24	48	72
WET-MILLED	ABI	6.58	4 76	4.71	4.68
	OBA	6.84	4.81	4.72	4.71
	WStacb	5.77	4.75	4.67	4.91
	WnStacb	5.86	4.63	4.68	4.73
	YStacb	4.98	4.36	5.00	5.13
	YnStacb	5.09	4.38	5.01	5.55
DRY-MILLED	ABI	6.61	4.09	4.12	4.46
	OBA	6.80	4.32	4.30	5.92
	WStacb	5.88	4.19	4.26	5.11
	WnStacb	6.74	4.28	4.21	4.77
	YStacb	5.84	4.20	4.13	4.39
	YnStacb	5.95	4.33	4.14	4.23

ABI: Abeleehi
OBA: Obaatanpa
WStacb: Local White Maize(Stackburned)
WnStacb: Local White Maize(Non-Stackburned)
YStacb: Yellow Maize (Stackburned)
YnStacb: Yellow Maize (Non-Stackburned)

APPENDIX 7

Seed germination capacity of Abeleehi and Obaatanpa varieties stored in either exposed or woven polypropylene satchets at ERH 55-95% for 36 days at 28-31°C.

ERH (%)	Seed germination (%) after 5 days				Radicle length (mm) after 5 days			
	ABI (Exposed)	ABI (W.p)	OBA (Exposed)	OBA (W.p)	ABI (Exposed)	ABI (W.p)	OBA (Exposed)	OBA (W.p)
CONTROL	98	98	100	100	97±1.7	97±1.7	95±1.5	95±1.5
55	94	98	94	100	76±1.6	91±1.7	82±1.6	89±1.6
65	98	96	98	94	82±1.6	80±1.5	79±1.6	87±1.7
75	92	98	98	98	71±1.6	72±1.7	73±1.6	84±1.4
85	88	96	96	96	76±1.6	78±1.9	73±1.5	87±1.4
90	64	62	94	96	51±1.7	65±2.0	69±1.5	72±1.4
95	6	12	20	24	35±1.2	34±0.4	49±1.3	57±1.5

APPENDIX 8

Changes in weight of maize grains (ABELEEHI) kept at varying equilibrium relative humidities (%) at 29±2°C

INCUBATION TIME (days)	PACKAGING USED	WEIGHT OF MAIZE SAMPLES(g) (MEAN±S.E)					
		55%	65%	75%	85%	90%	95%
0	Exposed	50.13±0.30	50.05±0.24	50.05±0.24	50.05±0.16	50.08±0.17	50.05±0.24
	W.p	50.05±0.24	50.08±0.17	50.08±0.17	50.05±0.20	50.03±0.17	50.05±0.24
4	Exposed	49.97±0.14	50.43±0.60	50.55±0.27	51.15±0.30	51.49±0.26	51.98±0.31
	W.p	49.98±0.31	50.10±0.24	50.40±0.21	50.85±0.20	51.15±0.25	51.58±0.35
8	Exposed	49.92±0.23	50.57±0.57	50.67±0.32	51.50±0.32	52.13±0.24	53.00±0.34
	W.p	49.93±0.22	50.10±0.20	50.55±0.28	51.23±0.23	51.70±0.16	52.60±0.17
12	Exposed	49.86±0.17	50.60±0.56	50.70±0.31	51.58±0.30	52.21±0.17	53.50±0.38
	W.p	49.83±0.36	50.11±0.22	50.63±0.33	51.32±0.26	51.86±0.24	53.10±0.22
24	Exposed	49.84±0.14	50.68±0.62	50.70±0.32	51.57±0.30	52.23±0.26	53.53±0.34
	W.p	49.82±0.37	50.13±0.17	50.61±0.34	51.31±0.26	51.86±0.25	53.10±0.25
36	Exposed	49.83±0.15	50.68±0.62	50.71±0.32	51.62±0.32	52.25±0.30	53.55±0.34
	W.p	49.82±0.35	50.15±0.17	50.63±0.34	51.32±0.26	51.86±0.26	53.15±0.16

Exposed: Maize samples exposed in Petri dishes
W.p : Maize samples bagged in woven polypropylene sachets.

APPENDIX 9

Changes in weight of maize grains (OBAATANPA) kept at varying equilibrium relative humidities (%) at 29±2°C

INCUBATION TIME (days)	PACKAGING USED	WEIGHT OF MAIZE SAMPLES(g) (MEAN±S.E)					
		55%	65%	75%	85%	90%	95%
0	Exposed	50.05±0.17	50.08±0.26	50.05±0.14	50.00±0.00	50.05±0.16	50.08±0.15
	W.p	50.00±0.00	50.08±0.25	50.05±0.15	50.08±0.20	50.03±0.13	50.05±0.19
4	Exposed	50.03±0.17	50.30±0.25	50.70±0.14	51.25±0.16	51.53±0.15	52.05±0.21
	W.p	49.98±0.20	50.35±0.16	50.68±0.05	51.15±0.16	51.43±0.19	51.83±0.30
8	Exposed	50.03±0.29	50.37±0.15	50.87±0.14	51.60±0.26	52.27±0.19	53.33±0.26
	W.p	49.98±0.15	50.46±0.14	50.88±0.31	51.68±0.13	52.00±0.22	53.23±0.22
12	Exposed	50.00±0.25	50.44±0.12	50.87±0.12	51.70±0.20	52.40±0.17	53.90±0.25
	W.p	49.97±0.17	50.53±0.18	50.93±0.13	51.73±0.11	52.17±0.24	53.77±0.21
24	Exposed	49.99±0.15	50.44±0.15	50.86±0.12	51.71±0.18	52.41±0.19	54.08±0.20
	W.p	49.96±0.17	50.58±0.14	50.95±0.12	51.74±0.09	52.19±0.22	54.00±0.22
36	Exposed	49.99±0.12	50.43±0.14	50.86±0.09	51.72±0.16	52.39±0.16	54.20±0.30
	W.p	49.96±0.16	50.57±0.09	50.94±0.14	51.74±0.13	52.19±0.22	54.10±0.21

Exposed: Maize samples exposed in Petri dishes
W.p : Maize samples bagged in woven polypropylene sachets.

APPENDIX 10

Moisture content of ABELEEHI variety kept at varying equilibrium relative humidities (%) at 28-31°C for 36 days. (Data presented in Fig.10)

INCUBATION TIME (days)	PACKAGING USED	MOISTURE CONTENT (%)					
		55%	65%	75%	85%	90%	95%
0	Exposed	11.0	11.0	11.0	11.0	11.0	11.0
	W.p	11.0	11.0	11.0	11.0	11.0	11.0
4	Exposed	10.8	11.2	12.0	13.0	14.0	15.0
	W.p	10.7	11.0	11.5	12.6	13.5	13.5
8	Exposed	10.5	11.5	12.3	13.5	14.5	17.0
	W.p	10.5	11.0	11.7	13.0	14.0	15.5
12	Exposed	10.3	11.9	12.5	13.8	15.4	17.8
	W.p	10.4	11.1	11.8	13.2	14.6	16.8
24	Exposed	10.1	12.0	12.4	13.8	15.2	18.0
	W.p	10.4	11.2	11.8	13.2	14.4	16.9
36	Exposed	10.2	11.9	12.5	13.9	15.5	18.2
	W.p	10.3	11.2	11.9	13.1	14.5	16.2

APPENDIX 11

Moisture content of OBAATANPA variety kept at varying equilibrium relative humidities (%) at 28-31°C for 36 days. (Data presented in Fig.11)

INCUBATION TIME (days)	PACKAGING USED	MOISTURE CONTENT (%)					
		55%	65%	75%	85%	90%	95%
0	Exposed	10.0	10.0	10.0	10.0	10.0	10.0
	W.p	10.0	10.0	10.0	10.0	10.0	10.0
4	Exposed	9.8	10.5	11.0	12.1	12.4	14.0
	W.p	9.8	10.8	11.0	12.0	12.2	13.5
8	Exposed	9.5	10.8	11.9	13.5	14.0	15.5
	W.p	9.7	11.0	11.9	13.4	13.6	15.5
12	Exposed	9.3	11.0	12.0	14.0	14.6	16.3
	W.p	9.5	11 5	12.3	13.5	13.9	15.8
24	Exposed	9.3	11.0	11.7	13.8	14.7	17.2
	W.p	9.5	11.8	12.4	13.3	14.7	16.9
36	Exposed	9.2	11.1	11.9	14.0	14.9	17.1
	W.p	9.4	11.8	12.5	13.4	14.0	16.8

APPENDIX 12

Percentage weight increase of maize grains (ABELEEHI) kept at the indicated equilibrium relative humidities (%) at 28-31°C for 36 days. (Data presented in Fig. 12)

INCUBATION TIME (days)	PACKAGING USED	CHANGE IN WEIGHT (%)					
		55%	65%	75%	85%	90%	95%
0	Exposed	0	0	0	0	0	0
	W.p	0	0	0	0	0	0
4	Exposed	-0.30	0.75	1.00	2.20	2.80	3.85
	W.p	-0.16	0.05	0.65	1.60	2.24	3.05
8	Exposed	-0.42	1.03	1.23	2.90	4.04	5.89
	W.p	-0.24	0.05	1.05	2.36	3.34	5.09
12	Exposed	-0.53	1.10	1.30	3.10	4.31	6.89
	W.p	-0.45	0.07	1.11	2.53	3.67	6.09
24	Exposed	-0.57	1.19	1.29	3.03	4.30	6.95
	W.p	-0.46	0.10	1.07	2.52	3.67	6.13
36	Exposed	-0.59	1.18	1.31	3.14	4.33	6.99
	W.p	-0.47	0.15	1.10	2.54	3.66	6.20

APPENDIX 13

Percentage weight increase of maize grains (OBAATANPA) kept at the indicated equilibrium relative humidities (%) at 28-31°C for 36 days. (Data presented in Fig.13)

INCUBATION TIME (days)	PACKAGING USED	CHANGE IN WEIGHT (%)					
		55%	65%	75%	85%	90%	95%
0	Exposed	0	0	0	0	0	0
	W.p	0	0	0	0	0	0
4	Exposed	-0.04	0.45	1.30	2.50	2.95	3.94
	W.p	-0.05	0.54	1.25	2.15	2.78	3.55
8	Exposed	-0.05	0.58	1.63	3.20	4.43	6.51
	W.p	-0.05	0.78	1.70	3.20	3.94	6.40
12	Exposed	-0.10	0.72	1.63	3.40	4.70	7.64
	W.p	-0.07	0.90	1.76	3.31	4.23	7.43
24	Exposed	-0.12	0.72	1.62	3.42	4.71	8.00
	W.p	-0.08	1.01	1.79	3.33	4.32	7.89
36	Exposed	-0.12	0.71	1.62	3.44	4.68	8.23
	W.p	-0.08	0.98	1.78	3.33	4.32	8.09

APPENDIX 14

Radial growth of *Paecilomyces carneus* at 28 - 30°C on maize dextrose agar (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Zanthoxylum xanthoxyloides*.

(Data provided in Fig.14)

Type of Extract	Dilution of Extract (%)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	19.8 ± 0.7	32.5 ± 1.1	46.3 ± 1.1	58.0 ± 0.9a	70.0 ± 0.9	79.5 ± 1.1
	1:1	25.3 ± 1.1	43.8 ± 1.3	61.5 ± 1.1	79.0 ± 0.8b	90.0 ± 0.0	
	1:2	28.8 ± 1.2	48.3 ± 1.0	69.0 ± 1.2	87.0 ± 0.9c	90.0 ± 0.0	
	1:5	31.3 ± 1.0	49.5 ± 1.1	71.5 ± 1.1	89.5 ± 0.8d	90.0 ± 0.0	
	Control	29.3 ± 0.8	50.0 ± 0.9	68.5 ± 1.3	88.5 ± 0.8d	90.0 ± 0.0	
Acetone	Undiluted	20.5 ± 1.1	30.5 ± 1.1	42.8 ± 0.7	54.0 ± 1.3a	66.8 ± 0.9	75.0 ± 0.9
	1:1	28.0 ± 0.9	47.8 ± 1.0	63.8 ± 1.1	80.0 ± 0.0b	90.0 ± 0.0	
	1:2	32.0 ± 0.9	52.0 ± 1.0	70.5 ± 1.3	88.8 ± 1.2c	90.0 ± 0.0	
	1:5	34.0 ± 1.2	55.8 ± 0.7	74.8 ± 1.1	89.0 ± 0.9d	90.0 ± 0.0	
	Control	29.0 ± 1.0	45.8 ± 1.0	64.5 ± 1.1	84.8 ± 1.1e	90.0 ± 0.0	
Methanol	Undiluted	21.0 ± 0.8	30.3 ± 1.0	40.0 ± 0.9	51.0 ± 1.2a	60.0 ± 0.9	71.8 ± 0.9
	1:1	29.0 ± 0.9	39.5 ± 0.8	56.8 ± 1.0	69.0 ± 0.9b	89.5 ± 0.8	90.0 ± 0.0
	1:2	30.0 ± 0.9	42.3 ± 0.7	59.0 ± 0.9	71.5 ± 0.8c	90.0 ± 0.0	
	1:5	30.3 ± 0.7	43.8 ± 0.7	61.5 ± 0.8	74.3 ± 0.7d	90.0 ± 0.0	
	Control	30.8 ± 1.0	44.8 ± 1.0	63.3 ± 1.0	75.8 ± 1.0d	90.0 ± 0.0	

Readings discontinued

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 15

Radial growth of *Paecilomyces puntonii* at 28 - 30°C on maize dextrose agar (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Zanthoxylum xanthoxyloides*.

(Data provided in Fig.14.)

Type of Extract	Dilution of Extract (%)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	27.3 ± 1.1	49.5 ± 0.8a	76.3 ± 1.0	90.0 ± 0.0		
	1:1	35.8 ± 1.0	81.3 ± 1.3b	90.0 ± 0.0			
	1:2	38.8 ± 1.2	84.3 ± 1.0c	90.0 ± 0.0			
	1:5	40.0 ± 0.9	86.5 ± 0.8d	90.0 ± 0.0			
	Control	41.8 ± 1.7	88.3 ± 1.4e	90.0 ± 0.0			
Acetone	Undiluted	30.3 ± 1.0	44.0 ± 0.9a	69.8 ± 0.7	87.5 ± 0.8	90.0 ± 0.0	
	1:1	45.5 ± 1.1	82.3 ± 1.3b	90.0 ± 0.0			
	1:2	48.5 ± 1.1	83.0 ± 1.4b	90.0 ± 0.0			
	1:5	50.5 ± 1.1	87.8 ± 1.0c	90.0 ± 0.0			
	Control	53.0 ± 0.9	90.0 ± 0.0d				
Methanol	Undiluted	21.7 ± 0.8	43.8 ± 1.3a	61.9 ± 1.3	83.3 ± 1.0	90.0 ± 0.9	
	1:1	32.3 ± 0.8	77.5 ± 0.8b	90.0 ± 0.0			
	1:2	33.8 ± 1.4	83.8 ± 1.2c	90.0 ± 0.0			
	1:5	35.0 ± 1.3	85.3 ± 1.2c	90.0 ± 0.0			
	Control	40.8 ± 1.4	89.5 ± 1.0d	90.0 ± 0.0			

Readings discontinued

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at P<0.05.

APPENDIX 16

Radial growth of *Paecilomyces varioti* at 28 - 30°C on maize dextrose agar (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Zanthoxylum xanthoxyloides*.

(Data provided in Fig.14)

Type of Extract	Dilution of Extract (%)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	23.8 ± 0.7	32.5 ± 1.1	43.0 ± 1.5	51.3 ± 1.0a	66.5 ± 1.1	76.3 ± 1.3
	1:1	29.3 ± 1.0	43.8 ± 1.2	61.5 ± 1.1	77.5 ± 1.1b	89.3 ± 1.0	90.0 ± 0.0
	1:2	31.3 ± 0.7	46.0 ± 0.0	65.5 ± 1.1	79.8 ± 0.7c	90.0 ± 0.0	
	1:5	32.0 ± 0.9	46.5 ± 1.1	67.0 ± 0.9	84.0 ± 1.1d	90.0 ± 0.0	
	Control	31.0 ± 0.9	51.0 ± 0.9	68.0 ± 1.1	86.8 ± 1.1e	90.0 ± 0.0	
Acetone	Undiluted	19.4 ± 0.8	31.3 ± 1.0	38.8 ± 0.9	49.3 ± 0.8a	61.5 ± 1.1	71.9 ± 1.2
	1:1	32.3 ± 1.5	41.0 ± 1.4	50.8 ± 1.5	68.5 ± 1.3b	81.0 ± 1.2	89.3 ± 1.0
	1:2	32.0 ± 1.3	39.8 ± 1.1	51.8 ± 1.1	69.3 ± 1.2b	83.3 ± 1.1	90.0 ± 0.0
	1:5	32.3 ± 1.4	41.5 ± 1.1	57.5 ± 1.3	72.5 ± 1.6c	87.3 ± 1.5	90.0 ± 0.0
	Control	33.3 ± 1.4	41.5 ± 1.4	56.5 ± 1.5	71.0 ± 1.8d	87.0 ± 1.4	90.0 ± 0.0
Methanol	Undiluted	22.0 ± 0.9	31.5 ± 1.0	44.3 ± 1.0	52.0 ± 0.9a	61.5 ± 1.1	75.0 ± 0.9
	1:1	28.0 ± 0.9	43.3 ± 1.0	61.5 ± 0.8	72.8 ± 0.7b	82.0 ± 0.9	90.0 ± 0.0
	1:2	31.3 ± 1.0	45.0 ± 0.9	64.8 ± 0.7	74.8 ± 1.0c	85.3 ± 0.7	90.0 ± 0.0
	1:5	32.5 ± 0.8	47.0 ± 0.9	66.5 ± 0.8	77.5 ± 1.3d	88.5 ± 1.3	90.0 ± 0.0
	Control	34.0 ± 0.9	49.5 ± 1.1	69.5 ± 0.8	80.5 ± 1.1e	90.0 ± 0.9	

Readings discontinued.

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at P<0.0.5.

APPENDIX 17

Radial growth of *Paecilomyces carneus* at 28 - 30°C on maize dextrose agar (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Zanthoxylum xanthoxyloides*.

(Data provided in Fig.15)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	23.0 ± 0.9	35.5 ± 1.0	50.0 ± 0.9	61.3 ± 1.1a	73.3 ± 1.0	82.8 ± 0.7
	1:1	28.5 ± 0.8	46.0 ± 0.9	65.8 ± 0.7	83.5 ± 0.8b	90.0 ± 0.0	
	1:2	29.3 ± 0.7	46.8 ± 1.0	66.5 ± 0.8	86.0 ± 0.9c	90.0 ± 0.0	
	1:5	29.5 ± 0.8	47.5 ± 0.8	66.0 ± 0.9	89.3 ± 1.0d	90.0 ± 0.0	
	Control	29.9 ± 0.9	46.4 ± 1.0	65.8 ± 1.1	84.8 ± 1.0e	90.0 ± 0.0	
Acetone	Undiluted	17.8 ± 1.0	27.8 ± 1.1	39.5 ± 1.1	52.3 ± 1.3a	63.8 ± 1.3	75.2 ± 0.9
	1:1	29.8 ± 0.7	49.5 ± 1.1	68.0 ± 1.4	81.8 ± 1.3b	90.0 ± 0.0	
	1:2	35.3 ± 0.7	55.7 ± 0.9	74.8 ± 0.7	90.0 ± 0.0c		
	1:5	35.3 ± 0.7	56.2 ± 0.7	75.3 ± 1.3	90.0 ± 0.0c		
	Control	32.5 ± 0.7	53.2 ± 1.1	73.0 ± 1.3	89.5 ± 0.8c	90.0 ± 0.0	
Methanol	Undiluted	22.5 ± 0.8	33.0 ± 0.9	45.3 ± 0.7	55.5 ± 0.8a	63.8 ± 1.0	80.3 ± 1.2
	1:1	27.5 ± 1.1	39.3 ± 1.2	57.5 ± 1.1	67.0 ± 0.9b	81.5 ± 1.4	90.0 ± 0.0
	1:2	30.0 ± 0.0	43.8 ± 0.7	61.8 ± 0.7	73.8 ± 0.7c	86.8 ± 1.0	90.0 ± 0.0
	1:5	30.5 ± 0.8	44.5 ± 0.8	61.5 ± 0.8	75.5 ± 0.8d	89.3 ± 1.0	90.0 ± 0.0
	Control	29.0 ± 0.0	42.8 ± 0.7	60.0 ± 0.0	72.0 ± 0.0c	88.5 ± 1.0	90.0 ± 0.0

Readings discontinued.

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 18

Radial growth of *Paecilomyces puntonii* at 28 - 30°C on maize dextrose agar (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Zanthoxylum xanthoxyloides*.

(Data provided in Fig.15)

Type of Extract	Dilution of Extract (%)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	27.5 ± 1.1	46.3 ± 1.5a	73.0 ± 1.5	90.0 ± 0.0		
	1:1	39.5 ± 1.8	84.8 ± 0.7b	90.0 ± 0.0			
	1:2	40.0 ± 1.5	80.0 ± 0.0c	90.0 ± 0.0			
	1:5	41.5 ± 1.4	87.8 ± 1.0d	90.0 ± 0.0			
	Control	49.5 ± 0.8	85.5 ± 0.8e	90.0 ± 0.0			
Acetone	Undiluted	27.8 ± 1.0	44.5 ± 1.5a	62.3 ± 1.6			
	1:1	47.3 ± 1.6	87.0 ± 0.9b	90.0 ± 0.0			
	1:2	50.3 ± 1.9	90.0 ± 0.0c				
	1:5	55.3 ± 1.9	90.0 ± 0.0c				
	Control	49.8 ± 1.2	90.0 ± 0.0c				
Methanol	Undiluted	22.3 ± 1.1	46.8 ± 1.1a	59.0 ± 0.7	79.3 ± 1.0	88.5 ± 0.8	90.0 ± 0.0
	1:1	46.0 ± 1.4	79.8 ± 1.3b	90.0 ± 0.0			
	1:2	50.5 ± 1.1	84.8 ± 1.7c	90.0 ± 0.0			
	1:5	48.3 ± 0.9	80.5 ± 1.0d	90.0 ± 0.0			
	Control	57.5 ± 1.1	90.0 ± 0.0e				

Readings discontinued.

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at P 0.05.

APPENDIX 19

Radial growth of *Paecilomyces varioti* at 28 - 30°C on maize dextrose agar (OBAA'TANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Zanthoxylum xanthoxyloides*.

(Data provided in Fig.15)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	22.5 ± 1.1	34.3 ± 1.0a	46.5 ± 1.1	55.5 ± 1.1	70.5 ± 1.1	80.8 ± 1.1
	1:1	31.3 ± 0.1	48.5 ± 0.8b	64.8 ± 1.0	80.3 ± 0.7	90.0 ± 0.0	
	1:2	31.3 ± 0.7	48.5 ± 1.1b	66.8 ± 0.7	83.0 ± 0.9	90.0 ± 0.0	
	1:5	31.8 ± 0.7	48.8 ± 0.7b	67.0 ± 0.9	85.3 ± 1.0	90.0 ± 0.0	
	Control	31.0 ± 0.9	48.8 ± 1.3b	70.5 ± 1.3	89.5 ± 0.8	90.0 ± 0.0	
Acetone	Undiluted	19.0 ± 0.0	30.8 ± 0.9a	39.3 ± 1.0	50.5 ± 0.8	62.5 ± 0.8	73.0 ± 0.9
	1:1	26.0 ± 1.7	42.3 ± 1.8b	55.5 ± 1.9	72.0 ± 2.0	82.5 ± 1.6	89.5 ± 1.0
	1:2	25.3 ± 1.1	42.5 ± 1.1b	55.8 ± 1.4	74.8 ± 1.0	85.0 ± 1.2	90.0 ± 0.0
	1:5	27.3 ± 1.9	43.0 ± 1.8b	57.8 ± 1.3	77.0 ± 1.4	87.8 ± 1.3	90.0 ± 0.0
	Control	28.3 ± 0.7	44.0 ± 0.0bc	59.3 ± 1.4	78.8 ± 1.0	89.3 ± 1.0	90.0 ± 0.0
Methanol	Undiluted	24.0 ± 0.0	34.3 ± 0.0a	47.8 ± 0.7	55.5 ± 0.7	65.5 ± 1.1	79.5 ± 1.1
	1:1	29.3 ± 1.0	44.0 ± 1.2b	61.0 ± 1.2	72.0 ± 1.5	84.5 ± 1.0	90.0 ± 0.0
	1:2	31.5 ± 0.8	45.3 ± 1.0b	63.0 ± 1.1	75.0 ± 1.1	89.3 ± 1.0	90.0 ± 0.0
	1:5	33.3 ± 0.7	47.3 ± 0.7c	67.5 ± 1.1	77.8 ± 0.9	89.5 ± 0.8	90.0 ± 0.0
	Control	30.3 ± 0.7	45.0 ± 1.1b	66.0 ± 0.9	77.5 ± 1.1	90.0 ± 0.0	

Readings discontinued

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 20

Radial growth of *Penicillium digitatum* at 28 - 30°C on maize dextrose agar (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Zanthoxylum xanthoxyloides*.

(Data provided in Fig.16)

Type of Extract	Dilution of Extract (%)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	11.0 ± 0.9	17.0 ± 0.9	24.0 ± 0.9	30.0 ± 0.9a	36.5 ± 1.4	41.5 ± 1.1
	1:1	13.5 ± 0.8	26.3 ± 1.0	37.3 ± 1.1	43.8 ± 1.3b	52.0 ± 1.0	62.5 ± 1.1
	1:2	15.0 ± 1.1	29.0 ± 0.9	38.5 ± 0.8	45.8 ± 1.0c	55.3 ± 1.0	63.5 ± 1.3
	1:5	16.5 ± 0.8	30.5 ± 1.0	39.0 ± 0.9	47.8 ± 1.0d	57.5 ± 0.8	66.0 ± 1.1
	Control	15.8 ± 1.0	27.5 ± 0.8	40.8 ± 1.0	49.8 ± 1.0e	61.0 ± 0.9	68.5 ± 1.1
Acetone	Undiluted	13.5 ± 0.9	19.6 ± 1.1	25.8 ± 0.8	34.0 ± 0.9a	40.5 ± 0.7	48.9 ± 1.1
	1:1	17.3 ± 1.3	29.5 ± 1.0	39.5 ± 0.8	50.3 ± 1.1b	60.8 ± 1.0	72.0 ± 1.1
	1:2	18.0 ± 0.9	30.5 ± 0.8	41.8 ± 1.0	51.3 ± 1.0c	62.0 ± 0.9	74.5 ± 0.8
	1:5	18.0 ± 0.9	33.8 ± 1.0	44.8 ± 0.7	55.8 ± 1.1d	66.8 ± 0.7	77.3 ± 1.0
	Control	16.0 ± 0.9	30.0 ± 0.0	40.8 ± 1.0	52.8 ± 1.2e	64.5 ± 1.0	75.8 ± 1.0
Methanol	Undiluted	12.3 ± 1.0	18.0 ± 0.9	24.3 ± 1.0	30.5 ± 0.7a	36.0 ± 0.9a	43.0 ± 0.9
	1:1	13.8 ± 0.7	24.3 ± 0.7	29.5 ± 1.1	38.0 ± 1.2b	47.5 ± 1.1	59.3 ± 0.9
	1:2	17.3 ± 1.0	26.5 ± 0.8	32.5 ± 0.8	41.5 ± 1.1c	54.8 ± 1.0	64.0 ± 0.9
	1:5	17.0 ± 0.8	25.8 ± 0.7	35.0 ± 0.9	44.0 ± 0.9d	56.8 ± 1.0	66.8 ± 1.0
	Control	17.8 ± 1.0	27.0 ± 0.9	36.5 ± 1.1	46.5 ± 0.7e	60.0 ± 0.9	69.5 ± 1.0

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 21

Radial growth of *Curvularia lunata* at 28 - 30°C on maize dextrose agar (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Zanthoxylum xanthoxyloides*.

(Data provided in Fig.16)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	22.0 ± 1.5	43.3 ± 1.0	60.3 ± 1.2	76.0 ± 1.1a	90.0 ± 0.0	
	1:1	30.3 ± 0.7	49.8 ± 1.3	68.3 ± 1.0	86.8 ± 1.5b		
	1:2	31.3 ± 1.2	53.8 ± 1.0	73.8 ± 1.1	90.0 ± 0.0c		
	1:5	33.5 ± 1.1	57.3 ± 1.0	79.3 ± 1.0	90.0 ± 0.0c		
	Control	34.0 ± 1.2	54.8 ± 1.5	76.5 ± 1.1	90.0 ± 0.0c		
Acetone	Undiluted	14.9 ± 1.3	25.3 ± 1.2	37.5 ± 1.1	50.3 ± 1.2a	61.8 ± 1.4	74.3 ± 1.3
	1:1	31.3 ± 0.7	53.0 ± 0.0	70.8 ± 1.1	83.3 ± 1.3b	89.3 ± 1.0	90.0 ± 0.0
	1:2	33.0 ± 0.9	55.8 ± 1.0	74.0 ± 1.1	88.5 ± 1.3c	90.0 ± 0.0	
	1:5	34.8 ± 1.0	56.3 ± 0.7	73.8 ± 1.2	89.0 ± 1.1c	90.0 ± 0.0	
	Control	36.0 ± 1.1	59.5 ± 1.1	77.5 ± 1.1	90.0 ± 0.0c		
Methanol	Undiluted	19.3 ± 1.0	27.8 ± 1.0	38.3 ± 1.3	46.8 ± 1.0a	54.8 ± 1.1	69.0 ± 1.2
	1:1	24.5 ± 0.8	36.5 ± 0.8	54.5 ± 0.8	69.8 ± 0.7b	88.0 ± 0.9	90.0 ± 0.0
	1:2	25.5 ± 0.8	37.5 ± 0.8	56.3 ± 0.7	72.8 ± 1.0c	90.0 ± 0.0	
	1:5	28.0 ± 0.9	39.5 ± 1.1	62.0 ± 0.9	78.0 ± 1.4d	90.0 ± 0.0	
	Control	29.5 ± 0.8	44.0 ± 0.9	65.0 ± 0.9	82.5 ± 1.1e	90.0 ± 0.0	

Readings discontinued.

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 22

Radial growth of *Fusarium moniliforme* at 28 - 30°C on maize dextrose agar (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Zanthoxylum xanthoxyloides*.

(Data provided in Fig. 16)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	17.5 ± 1.1	26.3 ± 0.7	35.5 ± 0.8	44.8 ± 1.0a	56.0 ± 0.9	67.0 ± 1.2
	1:1	23.3 ± 1.0	34.0 ± 0.9	48.3 ± 1.2	60.8 ± 1.4b	71.0 ± 0.9	87.0 ± 0.9
	1:2	30.0 ± 1.1	37.0 ± 0.9	53.3 ± 1.1	65.8 ± 1.0c	82.8 ± 1.1	90.0 ± 0.0
	1:5	28.8 ± 1.0	36.3 ± 0.8	51.8 ± 1.1	66.3 ± 0.7c	83.3 ± 0.7	90.0 ± 0.0
	Control	33.0 ± 0.9	42.3 ± 1.0	56.5 ± 1.1	74.3 ± 1.0d	89.3 ± 1.0	90.0 ± 0.0
Acetone	Undiluted	17.8 ± 1.0	26.5 ± 0.8	36.3 ± 1.2	46.0 ± 0.9a	56.3 ± 0.7	68.8 ± 1.0
	1:1	22.0 ± 0.9	32.0 ± 0.9	47.8 ± 1.0	60.8 ± 1.0b	80.5 ± 0.7	90.0 ± 0.0
	1:2	24.5 ± 0.8	34.8 ± 1.0	49.8 ± 1.0	65.5 ± 0.8c	84.5 ± 1.0	90.0 ± 0.0
	1:5	28.5 ± 1.1	38.0 ± 0.9	53.0 ± 0.9	67.8 ± 0.9d	88.5 ± 0.7	90.0 ± 0.0
	Control	28.5 ± 1.1	40.5 ± 0.8	55.5 ± 1.0	70.5 ± 0.7e	89.8 ± 0.7	90.0 ± 0.0
Methanol	Undiluted	14.8 ± 1.0	23.0 ± 0.9	33.3 ± 1.2	41.3 ± 1.4a	47.5 ± 1.1	53.0 ± 0.9
	1:1	18.8 ± 1.0	28.8 ± 1.0	44.3 ± 1.0	57.8 ± 1.0b	67.0 ± 1.4	78.3 ± 1.0
	1:2	21.8 ± 1.0	31.8 ± 1.0	47.0 ± 1.1	61.8 ± 1.1c	70.5 ± 0.7	82.5 ± 0.8
	1:5	25.3 ± 1.0	35.0 ± 0.9	50.0 ± 0.9	64.8 ± 1.0d	75.3 ± 1.1	86.5 ± 0.8
	Control	33.5 ± 1.1	40.8 ± 0.9	54.5 ± 1.4	70.5 ± 1.1e	83.5 ± 1.1	90.0 ± 0.0

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 23

Radial growth of *Penicillium digitatum* at 28 - 30°C on maize dextrose agar (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Zanthoxylum xanthoxyloides*.

(Data provided in Fig.17)

Type of Extract	Dilution of Extract (%)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	11.8 ± 1.0	19.0 ± 1.1	26.0 ± 0.9	33.3 ± 1.3a	37.8 ± 1.1	42.5 ± 1.1
	1:1	15.0 ± 1.1	24.0 ± 0.9	35.8 ± 1.0	44.0 ± 0.9b	55.8 ± 0.7	64.3 ± 1.3
	1:2	15.5 ± 1.0	26.0 ± 0.0	37.3 ± 1.0	48.0 ± 1.2c	57.5 ± 1.0	66.3 ± 1.1
	1:5	17.0 ± 0.9	27.5 ± 1.1	38.0 ± 0.9	49.3 ± 1.0d	58.8 ± 0.7	68.5 ± 0.8
	Control	15.8 ± 1.0	25.5 ± 1.1	38.5 ± 1.4	49.8 ± 1.1d	59.0 ± 0.9	69.3 ± 1.0
Acetone	Undiluted	12.8 ± 0.7	19.5 ± 0.8	26.3 ± 1.0	34.3 ± 0.7a	42.0 ± 0.9	51.3 ± 0.7
	1:1	16.3 ± 1.0	26.8 ± 0.7	33.5 ± 1.0	44.8 ± 1.2b	54.8 ± 1.4	64.5 ± 1.5
	1:2	16.3 ± 1.3	27.3 ± 0.7	35.5 ± 0.8	46.8 ± 1.0c	55.8 ± 1.4	64.8 ± 1.5
	1:5	15.8 ± 0.7	26.5 ± 0.8	34.0 ± 1.1	47.3 ± 1.2d	58.0 ± 0.9	67.0 ± 1.4
	Control	17.8 ± 0.7	28.5 ± 0.8	37.3 ± 1.0	49.8 ± 0.7e	60.3 ± 1.0	69.3 ± 1.1
Methanol	Undiluted	11.3 ± 1.0	17.3 ± 0.7	23.8 ± 0.7	29.5 ± 0.8a	35.5 ± 0.8	41.8 ± 1.1
	1:1	14.3 ± 0.7	22.8 ± 1.0	31.8 ± 1.1	41.5 ± 1.3b	52.5 ± 0.8	63.3 ± 1.0
	1:2	16.0 ± 1.1	24.3 ± 0.7	34.8 ± 1.0	44.0 ± 0.9c	57.3 ± 1.0	67.0 ± 1:1
	1:5	17.0 ± 0.9	26.0 ± 0.9	37.3 ± 0.7	46.3 ± 1.2d	57.8 ± 0.9	68.0 ± 0.9
	Control	15.3 ± 0.7	25.3 ± 0.7	36.0 ± 1.1	46.3 ± 0.7d	59.8 ± 0.7	69.8 ± 1.3

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 24

Radial growth of *Curvularia lunata* at 28 - 30°C on maize dextrose agar (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Zanthoxylum Xanthoxyloides*.

(Data provided in Fig.17)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	24.0 ± 0.0	40.5 ± 0.8	58.5 ± 0.8	75.0 ± 0.9a	88.3 ± 0.7	
	1:1	32.0 ± 0.9	51.5 ± 0.8	68.5 ± 1.0	84.5 ± 0.8b	90.0 ± 0.0	
	1:2	33.5 ± 0.8	51.3 ± 1.0	69.4 ± 0.9	89.5 ± 1.1c	90.0 ± 0.0	
	1:5	32.8 ± 1.3	53.5 ± 1.0	73.5 ± 1.3	90.0 ± 0.0c		
	Control	32.0 ± 0.9	54.0 ± 1.1	75.8 ± 0.7	90.0 ± 0.0c		
Acetone	Undiluted	14.0 ± 1.2	25.0 ± 1.3	38.3 ± 1.5	54.0 ± 1.4a	69.5 ± 1.5	85.0 ± 1.1
	1:1	24.3 ± 1.3	43.3 ± 1.0	57.5 ± 1.0	72.8 ± 1.0b	83.0 ±1.20	90.0 ± 0.0
	1:2	24.5 ± 1.4	42.5 ± 1.4	56.0 ± 1.4	72.8 ± 1.4b	84.0 ± 1.4	90.0 ± 0.0
	1:5	25.3 ± 1.8	45.3 ± 1.6	62.5 ± 2.1	78.0 ± 1.4c	88.5 ± 1.1	90.0 ± 0.0
	Control	29.3 ± 1.5	48.0 ± 1.6	66.5 ± 1.1	83.8 ± 1.0d	90.0 ± 0.0	
Methanol	Undiluted	20.0 ± 1.1	28.8 ± 1.0	40.8 ± 0.7	48.5 ± 0.8a	57.0 ± 0.9	72.5 ± 0.8
	1:1	24.5 ± 0.8	38.5 ± 1.0	57.5 ± 1.1	72.8 ± 1.2b	89.3 ± 1.0	90.0 ± 0.0
	1:2	25.3 ± 0.7	38.5 ± 1.1	59.3 ± 0.7	74.3 ± 0.7b	90.0 ± 0.0	
	1:5	26.8 ± 1.0	42.5 ± 1.4	65.0 ± 0.9	79.0 ± 0.9c	90.0 ± 0.0	
	Control	28.3 ± 0.7	42.8 ± 1.1	65.3 ± 1.4	79.8 ± 1.6c	90.0 ± 0.0	

Readings discontinued.

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$

APPENDIX 25

Radial growth of *Fusarium moniliforme* at 28 - 30°C on maize dextrose agar (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Zanthoxylum xanthoxyloides*.

(Data provided in Fig.17)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	19.0 ± 0.0	27.3 ± 0.7	39.5 ± 0.8	47.5 ± 1.1a	59.5 ± 1.1	72.5 ± 0.8
	1:1	20.0 ± 0.0	32.5 ± 0.8	49.5 ± 0.8	59.0 ± 1.1b	74.3 ± 0.7	90.0 ± 0.0
	1:2	24.8 ± 0.7	35.8 ± 0.8	52.3 ± 0.7	62.5 ± 0.8c	80.0 ± 0.9	90.0 ± 0.0
	1:5	25.8 ± 0.7	38.3 ± 0.7	53.8 ± 0.7	64.8 ± 0.7d	84.3 ± 0.7	90.0 ± 0.0
	Control	29.5 ± 0.8	40.0 ± 0.0	57.3 ± 0.7	69.8 ± 1.0e	87.5 ± 1.1	90.0 ± 0.0
Acetone	Undiluted	15.5 ± 0.8	23.5 ± 0.8	31.5 ± 0.8	38.8 ± 0.8a	45.3 ± 0.7	54.0 ± 1.1
	1:1	23.0 ± 1.2	31.3 ± 0.9	46.0 ± 0.9	57.5 ± 1.1b	73.3 ± 1.0	88.0 ± 0.9
	1:2	25.8 ± 1.0	35.0 ± 0.9	53.5 ± 0.8	65.3 ± 0.9c	84.3 ± 0.7	90.0 ± 0.0
	1:5	29.5 ± 0.8	40.5 ± 1.1	58.0 ± 0.9	71.8 ± 1.3d	86.0 ± 1.2	90.0 ± 0.0
	Control	30.8 ± 1.1	40.0 ± 0.9	58.8 ± 1.1	73.3 ± 1.0d	88.8 ± 1.2	90.0 ± 0.0
Methanol	Undiluted	14.5 ± 1.1	22.5 ± 1.1	30.5 ± 1.1	39.0 ± 1.1a	48.5 ± 0.8	59.8 ± 1.1
	1:1	22.3 ± 1.0	31.3 ± 1.2	45.5 ± 0.8	77.8 ± 1.2b	77.8 ± 1.2	89.3 ± 1.0
	1:2	25.0 ± 0.9	34.5 ± 1.1	49.0 ± 0.9	67.8 ± 1.2c	79.5 ± 0.8	90.0 ± 0.0
	1:5	30.0 ± 1.3	37.5 ± 1.1	51.5 ± 1.4	67.5 ± 1.1c	80.5 ± 1.1	90.0 ± 0.0
	Control	32.8 ± 1.1	39.5 ± 1.1	52.3 ± 1.4	71.5 ± 1.1d	83.3 ± 1.3	90.0 ± 0.0

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 26

Radial growth of *Paecilomyces carneus* at 28 - 30°C on maize dextrose agar (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of fruit of *Kigelia africana*.

(Data provided in Fig.18)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	21.5 ± 0.8	31.5 ± 0.8	42.5 ± 1.1	53.5 ± 1.1a	65.5 ± 1.1	77.3 ± 1.0
	1:1	28.3 ± 0.7	42.0 ± 0.0	59.3 ± 0.7	70.0 ± 1.4b	82.3 ± 1.3	90.0 ±0.0
	1:2	30.0 ± 0.9	45.3 ± 1.1	63.0 ± 0.9	73.5 ± 1.1c	86.5 ± 1.3	90.0 ±0.0
	1:5	34.0 ± 1.4	48.5 ± 1.1	67.3 ± 1.3	78.5 ± 1.3d	90.0 ± 0.0	
	Control	37.5 ± 1.1	57.0 ± 1.4	70.8 ± 1.0	84.0 ± 1.4e	90.0 ± 0.0	
Acetone	Undiluted	26.3 ± 1.0	38.8 ± 0.7	45.5 ± 0.8	56.0 ± 1.1a	69.0 ± 0.9	79.3 ± 1.1
	1:1	34.0 ± 1.1	52.8 ± 1.3	64.8 ± 1.0	77.8 ± 1.1b	88.8 ± 1.1	90.0 ± 0.0
	1:2	38.8 ± 1.0	58.3 ± 1.3	73.8 ± 1.5	84.0 ± 0.9c	90.0 ± 0.0	
	1:5	39.0 ± 1.1	58.5 ± 1.0	74.5 ± 1.3	85.5 ± 1.1d	90.0 ± 0.0	
	Control	34.5 ± 0.8	55.0 ± 0.9	67.8 ± 1.0	80.3 ± 1.4e	90.0 ± 0.0	
Methanol	Undiluted	21.3 ± 1.0	32.3 ± 0.7	40.0 ± 0.9	48.0 ± 1.0a	57.5 ± 1.1	66.5 ± 0.8
	1:1	29.8 ± 1.0	45.5 ± 1.0	56.0 ± 0.9	67.0 ± 1.0b	77.5 ± 1.1	88.0 ± 0.9
	1:2	32.5 ± 1.1	48.3 ± 1.0	61.5 ± 1.1	71.8 ± 1.0c	82.3 ± 0.0	90.0 ± 0.0
	1:5	34.0 ± 1.0	51.0 ± 0.9	65.3 ± 75.0	75.0 ± 1.1d	87.4 ± 0.9	90.0 ± 0.0
	Control	38.0 ± 0.9	56.3 ± 1.0	71.8 ± 1.2	81.8 ± 1.0e	90.0 ± 0.0	

Readings discontinued

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 27

Radial growth of *Paecilomyces puntonii* at 28 - 30°C on maize dextrose agar (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of fruit of *Kigelia africana*.

(Data provided in Fig.18)

Type of Extract	Dilution of Extract (%)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	34.3 ± 1.3	59.8 ± 1.1a	86.7 ± 1.0	90.0 ± 0.0		
	1:1	50.3 ± 1.0	84.0 ± 0.9b	90.0 ± 0.0			
	1:2	52.8 ± 1.0	86.3 ± 1.0c	90.0 ± 0.0			
	1:5	57.3 ± 1.0	89.3 ± 1.0d	90.0 ± 0.0			
	Control	49.0 ± 1.5	85.5 ± 0.8c	90.0 ± 0.0			
Acetone	Undiluted	38.5 ± 0.8	62.0 ± 1.2a	88.5 ± 0.8	90.0 ± 0.0		
	1:1	47.3 ± 0.7	82.5 ± 1.1b	90.0 ± 0.0			
	1:2	48.5 ± 0.8	85.8 ± 1.0c	90.0 ± 0.0			
	1:5	50.0 ± 1.2	89.5 ± 1.0d	90.0 ± 0.0			
	Control	52.8 ± 1.3	90.0 ± 0.0d				
Methanol	Undiluted	31.3 ± 1.0	53.5 ± 0.8a	81.0 ± 0.9	90.0 ± 0.0		
	1:1	41.5 ± 1.1	74.5 ± 1.0b	90.0 ± 0.0			
	1:2	44.8 ± 0.7	76.8 ± 1.0c	90.0 ± 0.0			
	1:5	46.3 ± 0.8	81.5 ± 1.1d	90.0 ± 0.0			
	Control	50.5 ± 1.1	89.3 ± 1.0e	90.0 ± 0.0			

Readings discontinued

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 28

Radial growth of *Paecilomyces variotii* at 28 - 30°C on maize dextrose agar (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of fruit of *Kigelia africana*.

(Data provided in Fig.18)

Type of Extract	Dilution of Extract (%)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	27.3 ± 1.2	38.5 ± 0.8	53.8 ± 1.1	66.0 ± 0.9a	77.5 ± 1.1	88.5 ± 1.4
	1:1	31.0 ± 1.2	47.5 ± 0.8	63.8 ± 1.1	75.0 ± 1.2b	88.0 ± 0.9	90.0 ± 0.0
	1:2	33.3 ± 1.0	50.5 ± 1.1	66.5 ± 1.5	86.0 ± 1.5c	90.0 ± 0.0	
	1:5	38.3 ± 1.0	54.5 ± 1.1	72.5 ± 1.1	88.8 ± 0.7d	90.0 ± 0.0	
	Control	35.0 ± 0.9	52.0 ± 0.9	70.3 ± 1.0	87.0 ± 0.9e	90.0 ± 0.0	
Acetone	Undiluted	30.3 ± 0.7	41.0 ± 0.9	57.0 ± 0.9	68.3 ± 1.1a	78.0 ± 1.5	88.3 ± 1.4
	1:1	34.0 ± 0.9	48.0 ± 0.9	62.5 ± 0.8	76.5 ± 1.0b	88.0 ± 0.9	90.0 ± 0.0
	1:2	36.3 ± 0.7	50.5 ± 1.0	63.0 ± 0.9	78.0 ± 1.3c	89.3 ± 0.9	90.0 ± 0.0
	1:5	38.0 ± 0.0	51.5 ± 1.0	64.8 ± 1.0	80.8 ± 1.3d	90.0 ± 0.0	
	Control	38.8 ± 1.1	53.8 ± 1.4	69.3 ± 0.7	84.8 ± 0.7e	90.0 ± 0.0	
Methanol	Undiluted	25.0 ± 0.0	36.0 ± 0.0	48.3 ± 1.0	57.5 ± 0.8a	67.0 ± 1.2	77.0 ± 1.0
	1:1	29.3 ± 1.1	40.5 ± 1.1	61.5 ± 1.1	73.5 ± 1.3b	83.0 ± 1.0	90.0 ± 0.0
	1:2	31.0 ± 1.0	43.3 ± 1.0	63.3 ± 1.1	75.8 ± 1.1c	86.8 ± 1.0	90.0 ± 0.0
	1:5	34.5 ± 1.1	46.0 ± 0.9	64.8 ± 1.0	78.8 ± 1.1d	90.0 ± 0.0	
	Control	36.0 ± 1.4	48.8 ± 1.1	67.3 ± 1.1	83.0 ± 0.0e	90.0 ± 0.0	

Readings discontinued

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 29

Radial growth of *Paecilomyces carneus* at 28 - 30°C on maize dextrose agar (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of fruit of *Kigelia africana*.

(Data provided in Fig.19)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	23.0 ± 1.1	36.0 ± 0.9	47.5 ± 1.1	60.5 ± 1.0a	72.3 ± 1.1	81.5 ± 0.8
	1:1	35.0 ± 0.0	49.8 ± 1.2	67.5 ± 0.8	78.5 ± 1.1b	90.0 ± 0.0	
	1:2	35.5 ± 0.8	51.8 ± 0.7	67.5 ±0.8	82.0 ± 0.9c	90.0 ± 0.0	
	1:5	37.3 ± 1.1	54.3 ± 1.6	70.5 ± 1.1	85.0 ± 0.8d	90.0 ± 0.0	
	Control	35.3 ± 1.0	51.5 ± 1.1	66.3 ± 0.7	79.5 ± 0.9b	90.0 ± 0.0	
Acetone	Undiluted	28.3 ± 1.2	42.0 ± 1.2	51.3 ± 1.3	60.8 ± 1.1a	72.0 ± 1.1	83.3. ± 1.3
	1:1	35.5 ± 0.8	53.3 ± 0.7	68.8 ± 0.7	79.8 ± 0.7b	90.0 ± 0.0	
	1:2	37.3 ± 1.0	54.0 ± 0.9	69.8 ± 1.0	80.5 ± 1.1b	90.0 ± 0.0	
	1:5	37.8 ± 1.0	56.8 ± 1.2	71.8 ± 1.0	82.8 ± 1.0c	90.0 ± 0.0	
	Control	39.0 ± 0.9	58.3 ± 1.0	74.0 ± 1.2	84.0 ± 0.9d	90.0 ± 0.0	
Methanol	Undiluted	17.3 ± 0.7	25.5 ± 1.1	35.5 ± 1.1	43.3 ± 1.0a	52.5 ± 1.1	59.5 ± 1.1
	1:1	26.5 ± 0.8	42.3 ± 0.8	53.5 ± 1.1	62.5 ± 1.1b	73.5 ± 1.1	84.5 ± 1.1
	1:2	29.5 ± 1.1	44.5 ± 1.1	57.0 ± 0.9	67.8 ± 1.0c	79.5 ± 1.1	90.0 ± 0.0
	1:5	31.8 ± 1.2	47.5 ± 1.1	62.3 ± 1.0	71.8 ± 1.1d	84.3 ± 1.0	90.0 ± 0.0
	Control	33.5 ± 1.1	53.5 ± 1.0	70.0 ± 0.9	80.8 ± 1.1e	90.0 ± 0.0	

Readings discontinued

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 30

Radial growth of *Paecilomyces puntonii* at 28 - 30°C on maize dextrose agar (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of fruit of *Kigelia africana*.

(Data provided in Fig.19)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	37.0 ± 0.9	61.8 ± 1.4a	89.3 ± 1.0	90.0 ± 0.0		
	1:1	53.3 ± 1.0	87.3 ± 1.0b	90.0 ± 0.0			
	1:2	56.5 ± 1.9	89.0 ± 0.9c	90.0 ± 0.0			
	1:5	56.3 ± 1.0	90.0 ± 0.0c				
	Control	52.3 ± 1.0	90.0 ± 0.0c				
Acetone	Undiluted	41.0 ± 0.9	64.8 ± 1.0a	86.8 ± 1.0	90.0 ± 0.0		
	1:1	47.0 ± 1.1	80.3 ± 0.7b	90.0 ± 0.0			
	1:2	50.0 ± 0.0	87.0 ± 0.0c	90.0 ± 0.0			
	1:5	50.8 ± 1.0	87.8 ± 1.0c	90.0 ± 0.0			
	Control	51.3 ± 0.7	89.3 ± 1.0c	90.0 ± 0.0			
Methanol	Undiluted	28.3 ± 1.0	48.5 ± 1.1a	76.5 ± 1.1	88.5 ± 0.8	90.0 ± 0.0	
	1:1	38.5 ± 1.1	71.5 ± 1.1b	90.0 ± 0.0			
	1:2	42.0 ± 0.9	77.0 ± 1.1c	90.0 ± 0.0			
	1:5	43.3 ± 0.7	80.5 ± 1.4d	90.0 ± 0.0			
	Control	48.3 ± 1.0	86.0 ± 1.0e	90.0 ± 0.0			

Readings discontinued

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 31

Radial growth of *Paecilomyces varioti* at 28 - 30°C on maize dextrose agar (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of fruit of *Kigelia africana*.

(Data provided in Fig.19)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	25.3 ± 0.7	36.0 ± 0.9	49.8 ± 1.1	62.3 ± 0.7a	74.0 ± 1.5	84.5 ± 1.0
	1:1	35.8 ± 1.2	50.8 ± 1.0	68.3 ± 1.4	80.0 ± 1.3b	90.0 ± 0.0	
	1:2	37.3 ± 1.0	53.5 ± 0.8	70.3 ± 0.7	84.0 ± 0.9c	90.0 ± 0.0	
	1:5	36.8 ± 0.7	54.0 ± 1.1	71.0 ± 1.1	89.0 ± 0.9d	90.0 ± 0.0	
	Control	37.0 ± 1.3	53.0 ± 1.1	69.8 ± 1.2	86.3 ± 1.0e	90.0 ± 0.0	
Acetone	Undiluted	28.3 ± 1.0	38.5 ± 1.1	55.0 ± 0.9	66.5 ± 1.1a	87.3 ± 1.2	90.0 ± 0.0
	1:1	34.0 ± 0.9	45.0 ± 0.9	58.0 ± 0.9	73.0 ± 0.9b	90.0 ± 0.0	
	1:2	37.0 ± 0.9	46.8 ± 1.0	60.5 ± 0.8	75.8 ± 0.7c	90.0 ± 0.0	
	1:5	36.8 ± 1.0	48.0 ± 0.9	62.0 ± 0.9	77.3 ± 1.0d	90.0 ± 0.0	
	Control	37.8 ± 1.2	51.5 ± 1.1	65.5 ± 1.1	80.0 ± 0.9e	90.0 ± 0.0	
Methanol	Undiluted	21.5 ± 0.8	28.3 ± 1.0	36.8 ± 1.0	47.0 ± 1.4a	55.5 ± 1.1	66.3 ± 1.1
	1:1	25.8 ± 1.0	38.3 ± 1.0	53.0 ± 0.9	64.8 ± 1.0b	79.5 ± 1.1	90.0 ± 0.0
	1:2	28.3 ± 1.0	41.0 ± 0.9	56.0 ± 0.9	67.8 ± 1.0c	83.0 ± 1.4	90.0 ± 0.0
	1:5	30.3 ± 0.7	44.0 ± 0.9	58.3 ± 1.0	71.5 ± 1.1d	87.5 ± 1.1	90.0 ± 0.0
	Control	34.3 ± 1.1	49.8 ± 1.0	62.0 ± 0.9	77.0 ± 0.9e	90.0 ± 0.0	90.0 ± 0.0

Readings discontinued

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 32

Radial growth of *Penicillium digitatum* at 28 - 30°C on maize dextrose agar (ABELEEH) amended with varying dilutions of either aqueous, acetone or methanol extracts of fruit of *Kigelia africana*.

(Data provided in Fig.20)

Type of Extract	Dilution of Extract (%)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	16.8 ± 0.7	22.5 ± 0.8	30.5 ± 1.4	37.8 ± 1.0a	44.3 ± 0.7	53.5 ± 1.1
	1:1	18.5 ± 1.0	29.0 ± 0.0	38.0 ± 0.0	45.8 ± 0.7b	55.8 ± 1.0	67.5 ± 1.1
	1:2	19.3 ± 1.0	31.0 ± 1.1	40.5 ± 1.5	50.5 ± 1.1c	59.5 ± 1.1	71.0 ± 1.4
	1:5	21.8 ± 1.0	32.5 ± 0.8	44.5 ± 1.1	54.5 ± 0.8d	66.8 ± 1.0	75.5 ± 1.1
	Control	23.0 ± 0.9	34.8 ± 0.7	48.0 ± 0.9	57.0 ± 0.9e	69.0 ± 0.9	77.5 ± 1.1
Acetone	Undiluted	15.0 ± 0.0	20.8 ± 0.8	27.3 ± 0.7	36.5 ± 0.8a	42.3 ± 1.4	47.5 ± 1.1
	1.1	17.3 ± 0.7	26.8 ± 1.0	36.0 ± 0.9	43.0 ± 0.9b	50.8 ± 0.8	63.0 ± 0.9
	1:2	18.3 ± 0.7	30.8 ± 1.0	40.0 ± 0.9	52.3 ± 1.3c	65.5 ± 1.1	75.3 ± 1.0
	1:5	19.8 ± 1.0	31.8 ± 1.0	45.3 ± 1.5	57.0 ± 1.1d	70.0 ± 0.9	80.8 ± 1.0
	Control	21.8 ± 1.0	33.8 ± 1.0	47.0 ± 1.4	58.5 ± 0.8e	72.5 ± 1.1	82.8 ± 1.3
Methanol	Undiluted	13.5 ± 0.8	20.3 ± 1.0	26.5 ± 1.1	34.8 ± 1.0a	40.5 ± 1.1	48.3 ± 1.0
	1:1	17.0 ± 0.9	24.5 ± 1.1	33.0 ± 1.0	42.5 ± 1.4b	56.3 ± 0.7	64.0 ± 1.0
	1:2	17.5 ± 0.9	27.5 ± 0.8	38.0 ± 0.9	49.3 ± 1.1c	61.3 ± 1.2	69.3 ± 1.0
	1:5	19.0 ± 0.9	30.5 ± 0.8	42.3 ± 1.3	51.5 ± 1.1d	63.5 ± 1.1	72.8 ± 1.0
	Control	22.0 ± 1.2	32.0 ± 1.0	45.0 ± 1.0	53.5 ± 1.1e	66.5 ± 1.1	77.8 ± 1.1

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 33

Radial growth of *Curvularia lunata* at 28 - 30°C on maize dextrose agar (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of fruit of *Kigelia africana*.

(Data provided in Fig.20)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	23.5 ± 1.1	39.0 ± 0.9	53.5 ± 1.1	68.3 ± 1.0a	83.8 ± 1.1	90.0 ± 0.0
	1:1	33.3 ± 1.0	51.3 ± 1.0	73.8 ± 1.0	83.5 ± 0.8b	90.0 ± 0.0	
	1:2	36.3 ± 0.7	55.5 ± 1.1	75.5 ± 0.8	86.3 ± 1.0c	90.0 ± 0.0	
	1:5	36.5 ± 0.8	58.3 ± 0.7	77.8 ± 1.0	90.0 ± 0.0d		
	Control	35.0 ± 0.9	57.3 ± 07	77.0 ± 0.0	90.0 ± 0.0d		
Acetone	Undiluted	27.5 ± 0.8	42.8 ± 0.7	55.3 ± 0.7	71.5 ± 1.3a	87.0 ± 1.2	90.0 ± 0.0
	1:1	36.0 ± 0.0	50.0 ± 0.0	71.3 ± 0.7	85.0 ± 0.0b	90.0 ± 0.0	
	1:2	35.8 ± 1.2	52.0 ± 1.4	71.3 ± 1.1	86.5 ± 0.8b	90.0 ± 0.0	
	1:5	36.8 ± 1.0	54.0 ± 0.9	74.3 ± 1.0	88.8 ± 0.7c	90.0 ± 0.0	
	Control	37.5 ± 0.8	60.8 ± 1.0	77.8 ± 1.3	90.0 ± 0.0c		
Methanol	Undiluted	21.8 ± 1.0	35.0 ± 0.9	48.5 ± 1.1	60.0 ± 1.4a	72.5 ± 1.1	85.0 ± 0.9
	1:1	29.5 ± 0.8	47.3 ± 1.0	63.8 ± 1.0	76.3 ± 0.7b	89.0 ± 0.9	90.0 ± 0.0
	1:2	31.3 ± 1.0	49.5 ± 1.1	69.5 ± 1.0	82.0 ± 1.4c	90.0 ± 0.0	
	1:5	33.0 ± 1.2	54.0 ± 1.0	72.5 ± 1.1	84.5 ± 1.1d	90.0 ± 0.0	
	Control	35.0 ± 1.1	57.0 ± 0.9	74.5 ± 1.1	90.0 ± 0.0e		

Readings discontinued.

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 34

Radial growth of *Fusarium moniliforme* at 28 - 30°C on maize dextrose agar (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of fruit of *Kigelia africana*.

(Data provided in Fig.20)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	19.3 ± 0.7	29.3 ± 0.7	37.3 ± 1.0	48.3 ± 0.9a	56.3 ± 0.7	68.0 ± 0.9
	1:1	29.8 ± 1.0	44.0 ± 1.2	59.8 ± 1.0	75.5 ± 1.1b	82.5 ± 1.0	90.0 ± 0.0
	1:2	32.0 ± 0.9	46.5 ± 0.8	62.8 ± 1.0	81.0 ± 0.9c	90.0 ± 0.0	
	1:5	32.5 ± 1.0	46.5 ± 1.0	62.5 ± 1.0	80.0 ± 0.9d	90.0 ± 0.0	
	Control	34.3 ± 1.0	48.0 ± 0.9	65.3 ± 1.2	83.8 ± 1.0e	90.0 ± 0.0	
Acetone	Undiluted	24.3 ± 1.0	33.0 ± 1.4	41.0 ± 0.9	50.3 ± 1.0a	63.3 ± 1.0	73.0 ± 0.9
	1:1	33.0 ± 1.2	45.3 ± 0.7	61.5 ± 1.3	78.3 ± 0.7b	90.0 ± 0.0	
	1:2	33.8 ± 0.7	46.3 ± 1.0	63.5 ± 1.1	79.5 ± 0.8c	90.0 ± 0.0	
	1:5	35.0 ± 0.0	49.0 ± 0.0	65.5 ± 0.8	85.0 ± 0.9d	90.0 ± 0.0	
	Control	37.0 ± 0.9	51.0 ± 0.9	67.8 ± 1.0	86.5 ± 0.8e	90.0 ± 0.0	
Methanol	Undiluted	19.3 ± 1.0	27.5 ± 0.8	33.3 ± 1.3	40.3 ± 1.2a	47.3 ± 1.1	53.8 ± 1.0
	1:1	24.3 ± 1.0	33.0 ± 1.1	38.8 ± 1.0	52.8 ± 1.0b	67.5 ± 0.8	74.5 ± 1.1
	1:2	28.3 ± 1.0	36.0 ± 0.9	48.0 ± 0.9	60.0 ± 1.4c	74.5 ± 1.1	88.0 ± 1.0
	1:5	30.8 ± 1.0	39.5 ± 0.8	53.3 ± 1.1	66.5 ± 1.1d	82.3 ± 1.3	90.0 ± 0.0
	Control	33.0 ± 0.9	43.5 ± 1.1	60.3 ± 1.0	74.8 ± 1.2e	89.0 ± 0.9	90.0 ± 0.0

Readings discontinued

Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 35

Radial growth of *Penicillium digitatum* at 28 - 30°C on maize dextrose agar (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of fruit of *Kigelia africana*.

(Data provided in Fig.21)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	15.8 ± 1.0	21.8 ± 0.7	28.3 ± 0.7	35.5 ± 0.8a	42.0 ± 1.4	50.3 ± 1.0
	1:1	19.3 ± 1.3	31.2 ± 0.7	39.8 ± 1.3	48.0 ± 0.9b	58.5 ± 1.1	68.0 ± 1.4
	1:2	19.3 ± 1.4	31.5 ± 1.1	41.0 ± 1.0	52.3 ± 1.3c	62.5 ± 1.1	73.0 ± 0.9
	1:5	20.0 ± 0.0	31.8 ± 1.1	43.0 ± 0.9	56.5 ± 1.1d	67.0 ± 1.4	78.3 ± 1.0
	Control	20.0 ± 0.0	32.3 ± 1.0	44.5 ± 1.0	54.5 ± 0.7e	66.8 ± 1.0	75.8 ± 1.1
Acetone	Undiluted	14.5 ± 0.8	22.3 ± 1.0	31.5 ± 1.1	39.0 ± 0.9a	45.8 ± 1.0	53.0 ± 0.9
	1:1	17.3 ± 0.7	29.5 ± 1.1	40.3 ± 0.7	53.3 ± 1.5b	65.5 ± 1.1	74.3 ± 1.0
	1:2	19.8 ± 0.7	31.8 ± 1.0	43.0 ± 0.9	56.5 ± 0.8c	69.0 ± 0.9	78.0 ± 0.9
	1:5	22.0 ± 0.9	33.8 ± 1.0	45.0 ± 0.9	58.0 ± 0.9d	71.0 ± 0.9	80.5 ± 1.0
	Control	23.8 ± 0.7	35.0 ± 0.9	46.8 ± 1.0	60.0 ± 0.9e	72.0 ± 1.4	82.3 ± 1.0
Methanol	Undiluted	9.3 ± 0.7	14.8 ± 1.0	21.5 ± 1.1	28.3 ± 1.0a	35.5 ± 0.8	43.0 ± 0.9
	1:1	12.3 ± 0.8	22.0 ± 0.9	30.0 ± 0.9	38.5 ± 1.1b	46.3 ± 1.1	54.8 ± 1.1
	1:2	16.5 ± 1.0	24.8 ± 1.0	33.8 ± 1.0	41.8 ± 1.5c	49.5 ± 1.1	60.8 ± 1.3
	1:5	18.3 ± 1.0	26.8 ± 1.0	35.8 ± 1.0	43.8 ± 1.2d	52.5 ± 1.1	64.8 ± 1.1
	Control	21.0 ± 0.9	29.8 ± 0.7	38.0 ± 0.9	47.3 ± 1.0e	57.3 ± 1.0	67.5 ± 1.1

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 36

Radial growth of *Curvularia lunata* at 28 - 30°C on maize dextrose agar (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of fruit of *Kigelia africana*.

(Data provided in Fig.21)

Type of Extract	Dilution of Extract (%)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	22.5 ± 0.8	36.0 ± 1.4	50.5 ± 1.5	66.3 ± 1.2a	81.5 ± 1.3	90.0 ± 0.0
	1:1	35.5 ± 0.8	54.8 ± 1.3	76.8 ± 1.0	89.3 ± 1.0b	90.0 ± 0.0	
	1:2	40.0 ± 0.0	54.8 ± 1.0	78.0 ± 0.9	90.0 ± 0.0b		
	1:5	41.5 ± 1.9	63.8 ± 1.3	83.3 ± 2.0	90.0 ± 0.0b		
	Control	41.5 ± 1.3	60.0 ± 0.9	80.3 ± 1.0	90.0 ± 0.0b		
Acetone	Undiluted	25.3 ± 0.7	39.5 ± 0.8	53.0 ± 0.9	68.3 ± 1.0a	68.3 ± 1.4	90.0 ± 0.0
	1:1	30.8 ± 1.0	49.0 ± 0.9	68.5 ± 1.1	82.5 ± 1.1b	90.0 ± 0.0	
	1:2	33.3 ± 1.1	54.0 ± 0.9	75.0 ± 0.9	86.3 ± 0.7c	90.0 ± 0.0	
	1:5	35.0 ± 0.9	57.0 ± 0.9	76.3 ± 1.0	90.0 ± 0.0d		
	Control	35.8 ± 1.0	58.0 ± 0.9	77.8 ± 0.7	90.0 ± 0.0d		
Methanol	Undiluted	18.5 ± 1.1	25.5 ± 0.1	34.0 ± 0.9	41.5 ± 1.1a	49.5 ± 1.1	56.3 ± 1.0
	1:1	24.0 ± 0.9	37.3 ± 0.7	54.5 ± 1.1	72.5 ± 1.1b	82.5 ± 1.1	90.0 ± 0.0
	1:2	26.5 ± 0.8	40.5 ± 1.1	59.3 ± 1.1	76.5 ± 1.1c	87.3 ± 1.0	90.0 ± 0.0
	1:5	28.5 ± 0.8	44.3 ± 1.1	64.3 ± 1.0	79.5 ± 1.1d	90.0 ± 0.0	
	Control	30.8 ± 1.0	46.3 ± 1.1	66.5 ± 0.8	82.3 ± 1.1e	90.0 ± 0.0	

Readings discontinued

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 37

Radial growth of *Fusarium moniliforme* at 28 - 30°C on maize dextrose agar (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of fruit of *Kigelia africana*.

(Data provided in Fig.21)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	21.0 ± 1.4	30.8 ± 1.1	36.5 ± 1.1	45.8 ± 1.4a	55.3 ± 1.2	65.3 ± 0.7
	1:1	32.5 ± 1.0	48.0 ± 0.9	65.5 ± 1.1	79.3 ± 1.1b	85.8 ± 1.3	90.0 ± 0.0
	1:2	30.3 ± 1.2	45.8 ± 1.0	67.0 ± 0.9	82.5 ± 0.8c	90.0 ± 0.0	
	1:5	34.5 ± 1.1	51.0 ± 1.1	69.2 ± 1.1	85.0 ± 0.9d	90.0 ± 0.0	
	Control	35.3 ± 0.7	51.8 ± 1.1	70.0 ± 0.9	87.3 ± 1.0e	90.0 ± 0.0	
Acetone	Undiluted	27.3 ± 1.0	37.5 ± 1.1	44.8 ± 1.1	54.5 ± 1.1a	67.3 ± 0.7	76.0 ± 1.2
	1:1	34.0 ± 0.9	48.5 ± 0.8	66.0 ± 0.9	83.5 ± 0.7b	90.0 ± 0.0	
	1:2	37.0 ± 0.9	51.3 ± 1.0	67.8 ± 0.7	86.3 ± 0.7c	90.0 ± 0.0	
	1:5	37.8 ± 1.0	51.8 ± 1.1	68.5 ± 1.0	87.8 ± 1.0d	90.0 ± 0.0	
	Control	33.8 ± 1.0	49.3 ± 0.7	65.3 ± 1.0	84.5 ± 1.1e	90.0 ± 0.0	
Methanol	Undiluted	16.3 ± 1.0	24.3 ± 0.7	30.5 ± 1.1	37.8 ± 0.8a	42.3 ± 1.0	49.5 ± 1.1
	1:1	21.0 ± 0.9	29.3 ± 1.3	35.8 ± 1.0	49.0 ± 0.8b	65.3 ± 1.1	72.0 ± 0.9
	1:2	25.3 ± 1.0	33.0 ± 0.9	45.0 ± 0.9	58.0 ± 1.1c	71.5 ± 1.1	84.5 ± 1.1
	1:5	27.8 ± 1.0	37.8 ± 1.2	50.8 ± 1.2	63.8 ± 1.2d	80.0 ± 1.6	90.0 ± 0.0
	Control	36.0 ± 0.9	46.5 ± 1.1	63.3 ± 1.0	77.8 ± 1.2e	90.0 ± 0.0	

Readings discontinued

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 38

Radial growth of *Paecilomyces carneus* at 28 - 30°C on maize dextrose agar (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Kigelia africana*.

(Data provided in Fig.22)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	23.8 ± 1.0	32.5 ± 0.8	40.0 ± 0.9	47.0 ± 1.2a	54.8 ± 1.0	65.0 ± 0.9
	1:1	30.3 ± 1.0	42.8 ± 1.2	64.3 ± 0.7	78.3 ± 1.0b	88.8 ± 1.0	90.0 ± 0.0
	1:2	33.3 ± 1.1	54.8 ± 1.0	73.5 ± 1.1	87.5 ± 1.1c	90.0 ± 0.0	
	1:5	37.0 ± 0.9	58.3 ± 1.0	76.3 ± 0.7	90.0 ± 0.0d		
	Control	29.0 ± 0.9	50.3 ± 1.1	68.8 ± 1.3	90.0 ± 0.0d		
Acetone	Undiluted	18.5 ± 1.1	28.5 ± 1.1	35.0 ± 0.9	45.3 ± 1.2a	52.5 ± 1.2	61.7 ± 1.2
	1:1	30.0 ± 1.2	49.0 ± 0.9	61.5 ± 1.1	5 ± 1.1b	90.0 ± 0.0	
	1:2	32.3 ± 0.7	52.5 ± 0.9	65.0 ± 0.9	85.8 ± 1.0c	90.0 ± 0.0	
	1:5	35.8 ± 1.1	55.8 ± 0.9	69.5 ± 0.8	90.0 ± 0.0d		
	Control	33.5 ± 1.2	53.3 ± 1.0	67.5 ± 0.8	88.3 ± 1.0d	90.0 ± 0.0	
Methanol	Undiluted	17.5 ± 0.8	24.5 ± 0.8	32.4 ± 0.7	43.8 ± 1.0a	53.8 ± 0.7	62.3 ± 0.7
	1:1	27.0 ± 0.9	39.3 ± 0.7	51.0 ± 0.0	62.3 ± 1.3b	74.5 ± 0.8	88.0 ± 0.9
	1:2	29.5 ± 0.8	45.5 ± 0.8	61.3 ± 1.1	79.3 ± 1.0c	90.0 ± 0.0	
	1:5	33.3 ± 1.0	49.3 ± 0.7	61.0 ± 1.1	80.0 ± 1.0c	90.0 ± 0.0	
	Control	34.0 ± 0.0	48.5 ± 0.8	63.5 ± 0.8	82.7 ± 1.2d	90.0 ± 0.0	

Readings discontinued

By Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 39

Radial growth of *Paecilomyces puntonii* at 28 - 30°C on maize dextrose agar (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Kigelia africana*.

(Data provided in Fig.22)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	28.2 ± 1.1	47.3 ± 1.2a	67.3 ± 1.0	89.3 ± 1.0	90.0 ± 0.0	
	1:1	38.5 ± 0.8	78.5 ± 0.8b	90.0 ± 0.0			
	1:2	43.8 ± 0.7	82.5 ± 1.0c	90.0 ± 0.0			
	1:5	46.3 ± 1.0	88.3 ± 1.1d	90.0 ± 0.0			
	Control	47.8 ± 1.0	88.8 ± 0.7d	90.0 ± 0.0			
Acetone	Undiluted	17.3 ± 1.0	30.8 ± 1.0a	47.3 ± 1.2	63.4 ± 1.4	77.5 ± 1.3	89.3 ± 1.0
	1:1	40.0 ± 0.9	68.0 ± 1.0b	88.0 ± 1.4	90.0 ± 0.0		
	1:2	39.3 ± 1.0	74.0 ± 0.9c	90.0 ± 0.0			
	1:5	45.3 ± 1.9	83.0 ± 1.8d	90.0 ± 0.0			
	Control	45.8 ± 1.4	81.5 ± 1.1d	90.0 ± 0.0			
Methanol	Undiluted	25.8 ± 0.7	43.0 ± 0.9a	61.8 ± 1.0	83.8 ± 1.0	90.0 ± 0.0	
	1:1	41.0 ± 0.9	65.5 ± 0.7b	89.3 ± 1.0	90.0 ± 0.0		
	1:2	45.8 ± 0.7	71.0 ± 0.9c	90.0 ± 0.0			
	1:5	52.8 ± 1.0	90.0 ± 0.0d				
	Control	50.3 ± 1.0	89.3 ± 1.0d	90.0 ± 0.0			

Readings discontinued

By the Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 40

Radial growth of *Paecilomyces varioti* at 28 - 30°C on maize dextrose agar (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Kigelia africana*.

(Data provided in Fig.22)

Type of Extract	Dilution of Extract (%)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	21.5 ± 1.1	35.0 ± 0.9	43.3 ± 1.1	52.5 ± 1.1a	64.0 ± 1.4	77.0 ± 1.3
	1:1	27.0 ± 0.9	41.0 ± 0.9	55.5 ± 1.1	66.0 ± 0.9b	79.5 ± 0.8	90.0 ± 0.0
	1:2	32.3 ± 1.0	48.5 ± 1.1	64.3 ± 1.2	78.3 ± 1.0c	90.0 ± 0.0	
	1:5	33.3 ± 1.0	49.0 ± 0.9	66.3 ± 1.0	81.0 ± 1.4d	90.0 ± 0.0	
	Control	35.0 ± 0.9	50.8 ± 1.1	67.8 ± 1.2	85.5 ± 1.1e	90.0 ± 0.0	
Acetone	Undiluted	19.5 ± 0.8	27.8 ± 1.0	36.0 ± 0.9	46.3 ± 0.7a	55.5 ± 0.8	66.5 ± 0.8
	1:1	28.8 ± 0.7	41.5 ± 0.8	54.8 ± 0.7	69.8 ± 0.7b	83.5 ± 0.8	90.0 ± 0.0
	1:2	33.0 ± 0.0	47.3 ± 0.7	63.5 ± 0.7	84.0 ± 0.9c	90.0 ± 0.0	
	1:5	35.5 ± 0.8	49.3 ± 1.0	65.8 ± 1.0	87.8 ± 1.0d	90.0 ± 0.0	
	Control	36.3 ± 0.7	50.5 ± 0.8	66.8 ± 1.0	87.8 ± 1.2d	90.0 ± 0.0	
Methanol	Undiluted	14.0 ± 1.5	23.3 ± 1.6	32.3 ± 1.6	42.0 ± 1.5a	52.5 ± 1.5	60.5 ± 1.9
	1:1	27.3 ± 0.7	41.3 ± 0.7	59.0 ± 0.9	73.8 ± 0.7b	86.0 ± 1.2	90.0 ± 0.0
	1:2	28.3 ± 1.0	44.5 ± 0.8	61.8 ± 0.7	78.5 ± 1.0c	89.0 ± 0.9	90.0 ± 0.0
	1:5	30.3 ± 0.7	45.8 ± 0.7	63.8 ± 0.7	80.5 ± 0.8cd	90.0 ± 0.0	
	Control	32.0 ± 0.9	46.5 ± 1.1	65.3 ± 0.7	81.5 ± 1.1d	90.0 ± 0.0	

Readings discontinued.

By the Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 41

Radial growth of *Paecilimyces carneus* at 28 - 30°C on maize dextrose agar (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Kigelia africana*.

(Data provided in Fig.23)

Type of Extract	Dilution of Extract (%)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	21.3 ± 1.2	30.3 ± 0.7	37.5 ± 0.8	46.3 ± 1.0a	56.0 ± 0.9	64.5 ± 1.0
	1:1	28.3 ± 1.0	43.7 ± 1.2	61.3 ± 1.2	76.3 ± 0.9b	85.3 ± 1.0	90.0 ± 0.0
	1:2	32.8 ± 0.7	52.5 ± 1.1	72.5 ± 0.8	89.3 ± 1.0c	90.0 ± 0.0	
	1:5	36.0 ± 0.9	57.5 ± 1.1	75.0 ± 1.1	90.0 ± 0.0c		
	Control	36.3 ± 1.0	58.5 ± 0.7	77.0 ± 0.9	90.0 ± 0.0c		
Acetone	Undiluted	20.5 ± 0.8	30.0 ± 0.9	37.3 ± 1.2	48.5 ± 0.8a	56.8 ± 0.8	65.5 ± 1.1
	1:1	33.5 ± 0.8	52.8 ± 1.0	65.5 ± 1.0	86.3 ± 0.7b		
	1:2	35.0 ± 0.0	54.0 ± 0.9	68.3 ± 0.7	90.0 ± 0.0c		
	1:5	35.5 ± 0.8	54.5 ± 0.7	68.0 ± 0.0	90.0 ± 0.0c		
	Control	36.5 ± 0.8	55.8 ± 1.0	70.3 ± 1.1	90.0 ± 0.0c		
Methanol	Undiluted	19.3 ± 0.7	27.3 ± 0.7	36.5 ± 0.8	46.5 ± 0.8a	56.8 ± 0.8	65.8 ± 0.8
	1:1	29.3 ± 0.7	42.3 ± 0.7	55.8 ± 0.8	72.5 ± 0.8b	90.0 ± 0.0	
	1:2	33.5 ± 0.8	47.8 ± 0.7	64.3 ± 0.7	83.8 ± 1.0c	90.0 ± 0.0	
	1:5	33.5 ± 0.8	48.0 ± 0.0	64.3 ± 0.7	83.8 ± 0.8c	90.0 ± 0.0	
	Control	37.8 ± 1.0	53.0 ± 1.4	69.0 ± 0.9	89.5 ± 0.8d	90.0 ± 0.0	

Readings discontinued.

By the Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 42

Radial growth of *Paecilomyces puntonii* at 28 - 30°C on maize dextrose agar (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *kigelia africana*.

(Data provided in Fig.23)

Type of Extract	Dilution of Extract (%)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	26.8 ± 1.1	50.8 ± 0.9a	76.2 ± 1.2	90.0. ± 0.0		
	1:1	42.5 ± 1.2	81.5 ± 1.1b	90.0 ± 0.0			
	1:2	43.2 ± 1.2	82.5 ± 1.6b	90.0 ± 0.0			
	1:5	46.2 ± 1.1	87.7 ± 1.5c	90.0 ± 0.0	-		
	Control	44.8 ± 1.3	89.3 ± 0.9c	90.0 ± 0.0			
Acetone	Undiluted	18.4 ± 1.1	31.0 ± 0.9a	46.8 ± 0.0	62.5 ± 1.2	75.2 ± 1.1	87.3 ± 0.9
	1:1	40.5 ± 0.8	82.0 ± 1.4b	90.0 ± 0.0			
	1:2	41.5 ± 1.3	85.0 ± 1.1c	90.0 ± 0.0			
	1:5	46.3 ± 1.0	87.8 ± 1.0d	90.0 ± 0.0			
	Control	47.8 ± 0.7	90.0 ± 0.0d				
Methanol	Undiluted	27.5 ± 0.8	45.3 ± 0.7a	64.0 ± 0.9	80.3 ± 0.7	90.0 ± 0.0	
	1:1	42.8 ± 1.1	68.3 ± 1.1b	90.0 ± 0.0			
	1:2	45.0 ± 0.9	80.0 ± 1.3c	90.0 ± 0.0			
	1:5	54.3 ± 1.4	90.0 ± 0.0d				
	Control	53.5 ± 0.8	90.0 ± 0.0d				

Readings discontinued

By the Multiple Range Test, means at the same extract type bearing same letters are not significantly different at $P<0.05$.

APPENDIX 43

Radial growth of *Paecilomyces varioti* at 28 - 30°C on maize dextrose agar (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *kigelia africana*.

(Data provided in Fig.23)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	24.2 ± 1.1	37.5 ± 0.7	51.8 ± 0.9	65.5 ± 0.8a	78.8 ± 0.7	90.0 ± 0.0
	1:1	29.3 ± 0.9	45.3 ± 0.9	62.3 ± 0.7	78.8 ± 1.0b	90.0 ± 0.0	
	1:2	29.2 ± 0.9	45.8 ± 0.9	62.3 ± 0.9	78.8 ± 1.1b	90.0 ± 0.0	
	1:5	30.5 ± 1.1	47.5 ± 1.1	64.0 ± 1.0	81.3 ± 1.5c	90.0 ± 0.0	
	Control	30.8 ± 0.9	46.7 ± 1.2	63.2 ± 1.2	79.5 ± 1.3c	90.0 ± 0.0	
Acetone	Undiluted	21.5 ± 0.8	29.5 ± 0.8	39.3 ± 0.8	49.0 ± 0.0a	58.0 ± 0.9	68.3 ± 1.0
	1:1	31.8 ± 0.7	44.8 ± 0.8	58.0 ± 0.0	73.3 ± 0.7b	86.5 ± 0.8	90.0 ± 0.0
	1:2	36.0 ± 0.0	49.5 ± 0.8	65.0 ± 0.0	82.8 ± 1.2c	90.0 ± 0.0	
	1:5	36.3 ± 0.7	50.3 ± 0.7	66.5 ± 1.0	85.3 ± 0.7d	90.0 ± 0.0	
	Control	36.0 ± 0.0	51.0 ± 0.0	67.8 ± 1.0	87.8 ± 1.3e	90.0 ± 0.0	
Methanol	Undiluted	13.1 ± 1.3	22.4 ± 1.4	31.2 ± 1.3	40.3 ± 1.1a	49.6 ± 1.0	57.4 ± 1.4
	1:1	25.5 ± 0.8	43.0 ± 0.7	59.0 ± 0.0	74.0 ± 1.1b	86.0 ± 0.9	90.0 ± 0.0
	1:2	27.3 ± 0.7	45.3 ± 1.0	61.8 ± 1.0	76.5 ± 1.3c	88.8 ± 1.0	90.0 ± 0.0
	1:5	29.5 ± 0.8	48.8 ± 0.7	64.8 ± 0.7	81.3 ± 0.7d	90.0 ± 0.0	
	Control	30.8 ± 1.0	49.5 ± 1.0	65.0 ± 0.9	83.0 ± 0.9e	90.0 ± 0.0	

Readings discontinued.

By the Multiple Range Test, means at the same extract type bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 44

Radial growth of *Penicillium digitatum* at 28 - 30°C on maize dextrose agar (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Kigelia africana*.

(Data provided in Fig.24)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	13.8 ± 1.1	19.3 ± 1.0	24.0 ± 1.2	29.0 ± 0.9a	35.3 ± 1.2	42.0 ± 1.5
	1:1	18.3 ± 1.0	29.0 ± 1.0	37.3 ± 1.1	47.0 ± 0.9b	58.5 ± 1.1	66.5 ± 0.8
	1:2	19.5 ± 1.1	28.8 ± 0.7	39.7 ± 1.1	50.5 ± 1.4c	60.3 ± 0.7	69.8 ± 1.0
	1:5	17.8 ± 1.0	28.0 ± 0.0	39.5 ± 0.8	49.3 ± 1.0bc	60.0 ± 0.9	69.3 ± 1.0
	Control	20.3 ± 1.0	30.3 ± 1.1	41.0 ± 1.5	52.3 ± 1.2c	63.0 ± 1.3	72.6 ± 1.1
Acetone	Undiluted	11.5 ± 0.8	17.0 ± 0.9	21.8 ± 1.0	26.8 ± 0.7a	33.0 ± 0.9	38.8 ± 0.7
	1:1	12.3 ± 0.7	21.8 ± 1.2	30.8 ± 1.3	42.8 ± 1.3b	53.0 ± 1.2	62.3 ± 1.0
	1:2	15.5 ± 1.3	25.0 ± 0.9	35.3 ± 1.5	46.8 ± 1.4c	57.8 ± 1.2	67.5 ± 1.5
	1:5	16.5 ± 0.8	27.8 ± 1.0	39.8 ± 0.7	51.5 ± 1.1d	61.8 ± 0.7	72.8 ± 1.0
	Control	15.5 ± 0.5	26.0 ± 1.0	38.3 ± 0.7	50.5 ± 0.8d	61.0 ± 0.9	73.0 ± 0.9
Methanol	Undiluted	7.0 ± 0.9	11.3 ± 1.0	17.8 ± 1.0	22.5 ± 0.8a	29.0 ± 0.9	33.8 ± 1.0
	1:1	13.3 ± 0.7	21.5 ± 1.1	27.0 ± 0.9	34.5 ± 0.8b	43.8 ± 0.7	53.3 ± 1.0
	1:2	15.8 ± 1.0	24.3 ± 1.0	34.8 ± 0.7	44.0 ± 1.1c	52.0 ± 0.8	62.8 ± 1.0
	1:5	19.3 ± 0.7	30.0 ± 0.9	39.8 ± 0.7	50.3 ± 0.7d	59.0 ± 0.9	68.0 ± 0.9
	Control	18.8 ± 0.7	28.5 ± 0.8	38.5 ± 0.8	48.5 ± 1.0d	58.5 ± 0.8	70.8 ± 1.0

By Multiple Test means at the same type of extract bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 45

Radial growth of *Curvularia lunata* at 28 - 30°C on maize dextrose agar (ABELEEH) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Kigelia africana*.

(Data provided in Fig.24)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	26.3 ± 1.0	43.5 ± 1.0	60.8 ± 1.2	73.3 ± 1.0a	86.3 ± 1.0	90.0 ± 0.0
	1:1	33.0 ± 1.5	48.3 ± 1.0	64.3 ± 1.2	77.3 ± 1.3b	90.0 ± 0.0	
	1:2	35.5 ± 1.1	52.5 ± 0.8	68.0 ± 0.9	79.3 ± 1.2bc	90.0 ± 0.0	
	1:5	35.5 ± 0.8	54.3 ± 0.7	69.8 ± 1.3	80.3 ± 1.0c	90.0 ± 0.0	
	Control	37.0 ± 0.9	55.0 ± 1.1	72.8 ± 0.7	86.3 ± 0.7d	90.0 ± 0.0	
Acetone	Undiluted	13.3 ± 1.2	21.0 ± 1.4	29.3 ± 1.4	37.3 ± 1.6a	44.8 ± 1.6	52.0 ± 1.6
	1:1	26.0 ± 1.2	41.8 ± 1.2	59.3 ± 1.2	77.0 ± 1.4b	88.5 ± 1.1	90.0 ± 0.0
	1:2	26.8 ± 0.7	42.3 ± 1.8	61.8 ± 1.5	79.3 ± 1.1bc	90.0 ± 0.0	
	1:5	27.8 ± 0.8	41.0 ± 1.7	63.0 ± 1.2	80.3 ± 1.3c	90.0 ± 0.0	
	Control	34.0 ± 0.0	52.5 ± 0.8	72.3 ± 1.2	87.8 ± 1.3d	90.0 ± 0.0	
Methanol	Undiluted	14.8 ± 0.7	20.3 ± 0.7	28.0 ± 0.7	36.3 ± 0.7a	42.8 ± 0.7	51.0 ± 0.9
	1:1	21.0 ± 0.9	29.3 ± 1.0	39.0 ± 0.9	50.3 ± 1.0b	62.5 ± 0.8	70.5 ± 0.8
	1:2	24.8 ± 0.7	40.3 ± 0.7	57.3 ± 0.7	71.5 ± 0.8c	86.8 ± 1.0	90.0 ± 0.0
	1:5	26.5 ± 0.8	43.0 ± 0.9	60.0 ± 1.1	75.5 ± 0.8d	89.5 ± 0.8	90.0 ± 0.0
	Control	29.8 ± 1.0	46.3 ± 1.0	67.0 ± 0.9	84.3 ± 1.0e	90.0 ± 0.0	

By Multiple Range Test, means at the same type of extract bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 46

Radial growth of *Fusarium moniliforme* at 28 - 30°C on maize dextrose agar (ABELEEHI) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *Kigelia africana*.

(Data provided in Fig.24)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	18.3 ± 1.0	26.8 ± 1.0	35.5 ± 1.1	46.0 ± 0.9a	55.3 ± 0.7	68.0 ± 0.9
	1:1	23.5 ± 1.0	33.8 ± 1.0	42.3 ± 1.3	58.0 ± 0.9b	74.3 ± 1.0	86.0 ± 0.9
	1:2	27.0 ± 0.9	38.3 ± 1.0	48.3 ± 1.0	67.0 ± 0.9cd	84.5 ± 1.1	90.0 ± 0.0
	1:5	26.0 ± 1.1	36.5 ± 0.8	45.5 ± 0.8	65.0 ± 0.9c	81.0 ± 1.2	90.0 ± 0.0
	Control	29.8 ± 0.7	40.5 ± 0.8	54.5 ± 0.8	68.5 ± 1.1d	88.5 ± 1.1	90.0 ± 0.0
Acetone	Undiluted	17.0 ± 0.9	24.8 ± 0.7	32.3 ± 1.0	40.5 ± 1.0a	50.0 ± 0.9	59.8 ± 0.7
	1:1	21.5 ± 0.8	28.5 ± 0.8	38.0 ± 0.9	47.8 ± 0.9b	58.8 ± 1.0	67.0 ± 0.0
	1:2	25.3 ± 0.9	38.5 ± 1.1	55.0 ± 0.9	66.3 ± 0.8c	81.5 ± 1.4	90.0 ± 0.0
	1:5	27.8 ± 0.9	40.4 ± 0.7	58.5 ± 0.8	73.0 ± 0.9d	88.3 ± 1.0	90.0 ± 0.0
	Control	32.3 ± 1.0	43.5 ± 1.0	62.5 ± 1.0	76.5 ± 1.0e	90.0 ± 0.0	
Methanol	Undiluted	15.0 ± 0.9	22.8 ± 1.0	30.3 ± 1.0	38.5 ± 1.0a	48.0 ± 0.9	58.3 ± 1.0
	1:1	20.8 ± 1.0	30.5 ± 0.8	39.5 ± 1.1	48.8 ± 1.3b	63.0 ± 0.9	71.5 ± 1.1
	1:2	25.3 ± 0.7	35.5 ± 0.8	48.0 ± 0.9	61.5 ± 1.0c	77.8 ± 1.0	90.0 ± 0.0
	1:5	28.3 ± 0.7	37.8 ± 0.7	51.5 ± 1.1	68.3 ± 0.7d	83.3 ± 1.0	90.0 ± 0.0
	Control	30.5 ± 0.8	42.5 ± 0.8	59.0 ± 0.9	73.8 ± 1.2e	89.3 ± 1.0	90.0 ± 0.0

Readings discontinued

By Multiple Range Test, means at the same type of extract bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 47

Radial growth of *Penicillium digitatum* at 28 - 30°C on maize dextrose agar (OBAATANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *kigelia africana*.

(Data provided in Fig.25)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	10.8 ± 1.0	17.5 ± 1.5	26.2 ± 1.3	32.8 ± 1.2a	39.3 ± 1.0	46.7 ± 1.0
	1:1	15.8 ± 1.0	26.3 ± 1.1	35.8 ± 1.0	45.7 ± 1.4b	55.3 ± 1.3	64.0 ± 0.9
	1:2	15.2 ± 1.0	26.7 ± 1.4	36.7 ± 1.1	46.5 ± 1.4b	56.8 ± 1.5	67.0 ± 1.1
	1:5	16.0 ± 0.0	27.0 ± 1.0	38.0 ± 1.3	49.0 ± 1.3c	59.3 ± 1.4	69.2 ± 1.2
	Control	15.3 ± 0.7	27.7 ± 0.7	39.3 ± 0.7	49.3 ± 0.9c	60.0 ± 0.8	69.0 ± 0.9
Acetone	Undiluted	10.3 ± 0.9	12.1 ± 1.1	18.2 ± 1.2	21.8 ± 0.8a	26.2 ± 1.0	30.3 ± 0.0
	1:1	12.5 ± 0.8	26.8 ± 1.0	36.3 ± 1.0	46.0 ± 0.9b	53.8 ± 0.7	63.8 ± 1.0
	1:2	15.8 ± 1.0	28.8 ± 1.0	39.0 ± 0.9	49.3 ± 1.2c	56.8 ± 1.1	65.8 ± 1.0
	1:5	17.5 ± 0.8	29.8 ± 1.0	39.8 ± 1.0	50.8 ± 0.7c	60.8 ± 0.9	67.5 ± 0.8
	Control	15.5 ± 0.8	28.8 ± 0.7	37.8 ± 0.7	49.5 ± 0.8c	58.0 ± 1.2	67.8 ± 1.0
Methanol	Undiluted	9.0 ± 1.1	11.3 ± 1.2	16.8 ± 1.0	21.0 ± 1.1a	25.5 ± 1.1	30.8 ± 1.0
	1:1	11.5 ± 0.8	18.3 ± 0.8	24.0 ± 0.9	30.0 ± 1.0b	36.3 ± 1.0	42.8 ± 1.2
	1:2	14.8 ± 0.7	22.0 ± 0.9	28.8 ± 1.0	36.8 ± 1.0c	44.3 ± 0.7	51.3 ± 1.0
	1:5	16.0 ± 0.9	24.8 ± 0.7	34.8 ± 0.7	44.5 ± 1.0d	55.8 ± 0.7	66.0 ± 0.9
	Control	16.0 ± 1.1	24.0 ± 1.1	33.8 ± 1.0	43.5 ± 1.3d	52.0 ± 0.9	60.8 ± 1.0

By Multiple Range Test, means at the same type of extract bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 48

Radial growth of *Curvularia lunata* at 28 - 30°C on maize dextrose agar (OBATAANPA) amended with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *kigelia africana*.

(Data provided in Fig.25)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	23.8 ± 1.1	40.5 ± 0.7	52.2 ± 1.4	62.3 ± 0.9a	74.0 ± 0.9	85.0 ± 1.2
	1:1	28.5 ± 0.9	45.3 ± 0.9	59.2 ± 1.2	69.8 ± 1.6b	80.0 ± 1.7	90.0 ± 0.0
	1:2	31.5 ± 0.7	49.7 ± 0.7	65.2 ± 0.9	76.3 ± 1.2c	85.7 ± 1.1	90.0 ± 0.0
	1:5	32.5 ± 0.7	51.5 ± 1.1	67.8 ± 1.6	77.3 ± 1.0c	90.0 ± 0.0	
	Control	32.3 ± 0.7	51.3 ± 0.7	69.2 ± 0.9	83.3 ± 0.7d	90.0 ± 0.0	
Acetone	Undiluted	12.8 ± 1.4	20.7 ± 1.2	28.5 ± 0.8	36.2 ± 1.1a	44.0 ± 0.9	51.2 ± 1.0
	1:1	25.8 ± 1.3	41.1 ± 0.9	56.3 ± 1.1	71.3 ± 1.2b	86.2 ± 0.8	90.0 ± 0.0
	1:2	27.1 ± 0.9	42.0 ± 0.8	56.8 ± 1.0	72.0 ± 1.1b	86.7 ± 0.8	90.0 ± 0.0
	1:5	27.8 ± 0.8	43.7 ± 0.9	59.7 ± 1.0	75.9 ± 1.4c	90.0 ± 0.0	
	Control	30.3 ± 1.0	49.6 ± 0.9	64.6 ± 1.1	80.2 ± 1.3d	90.0 ± 0.0	
Methanol	Undiluted	13.5 ± 0.8	19.0 ± 0.9	25.8 ± 1.0	34.0 ± 0.9[a]	40.8 ± 1.0	48.8 ± 1.0
	1:1	19.5 ± 0.8	29.3 ± 1.0	42.3 ± 1.3	56.8 ± 1.1[b]	67.3 ± 1.0	76.5 ± 1.1
	1:2	26.8 ± 1.0	39.3 ± 0.7	55.5 ± 0.8	73.5 ± 1.1c	87.0 ± 0.9	90.0 ± 0.0
	1:5	25.3 ± 1.0	41.0 ± 1.2	57.8 ± 1.1	77.3 ± 1.3c	90.0 ± 0.0	
	Control	30.3 ± 1.3	46.8 ± 1.2	66.0 ± 0.9	82.8 ± 1.0d	90.0 ± 0.0	

Readings discontinuted

By Multiple Range Test means at the same type of extract bearing the same letters are not significantly different at $P<0.05$.

APPENDIX 49

Radial growth of *Fusarium moniliforme* at 28 - 30°C on maize dextrose agar (OBAATANPA) amende with varying dilutions of either aqueous, acetone or methanol extracts of leaves of *kigelia africana*.

(Data provided in Fig. 25)

Type of Extract	Dilution of Extract (%v)	Mean diameter of culture (Mean ± S.E) in mm after (days)					
		2	3	4	5	6	7
Aqueous	Undiluted	19.5 ± 1.0	26.8 ± 1.0	35.2 ± 0.9	44.3 ± 0.9a	53.0 ± 0.9	63.8 ± 1.0
	1:1	26.3 ± 0.9	35.8 ± 0.7	48.0 ± 0.9	61.5 ± 1.0b	78.3 ± 1.0	90.0 ± 0.0
	1:2	28.0 ± 0.9	37.3 ± 0.1	52.5 ± 1.1	69.0 ± 0.9c	83.8 ± 0.7	90.0 ± 0.0
	1:5	29.5 ± 0.8	40.5 ± 0.8	57.0 ± 0.9	71.8 ± 1.2d	87.0 ± 0.9	90.0 ± 0.0
	Control	33.0 ± 0.9	43.3 ± 1.0	63.0 ± 0.8	75.3 ± 1.0e	90.0 ± 0.0	
Acetone	Undiluted	14.8 ± 0.7	21.5 ± 0.8	29.0 ± 0.0	38.5 ± 0.7a	47.3 ± 0.7	56.2 ± 0.9
	1:1	21.8 ± 1.0	32.0 ± 1.1	40.3 ± 0.7	51.8 ± 1.3b	66.0 ± 0.9	78.5 ± 0.8
	1:2	25.3 ± 0.7	37.5 ± 0.8	51.8 ± 1.1	67.5 ± 1.3c	82.8 ± 1.4	90.0 ± 0.0
	1:5	26.5 ± 0.8	39.5 ± 0.7	53.3 ± 0.7	69.3 ± 1.1c	84.5 ± 1.1	90.0 ± 0.0
	Control	28.3 ± 0.7	41.3 ± 0.7	56.3 ± 0.7	72.5 ± 0.8d	90.0 ± 0.0	
Methanol	Undiluted	13.5 ± 0.8	19.5 ± 0.8	27.0 ± 0.9	35.3 ± 0.7a	43.3 ± 1.0	53.0 ± 0.8
	1:1	20.0 ± 0.0	27.5 ± 0.8	36.0 ± 0.9	47.0 ± 1.1b	56.0 ± 1.2	65.8 ± 1.1
	1:2	23.5 ± 0.8	33.0 ± 0.9	43.0 ± 0.9	52.5 ± 1.1c	63.0 ± 1.2	74.3 ± 1.0
	1:5	25.5 ± 0.7	38.5 ± 1.0	49.8 ± 1.3	66.5 ± 1.5d	78.8 ± 1.1	90.0 ± 0.0
	Control	27.0 ± 0.9	40.3 ± 1.0	57.8 ± 1.4	73.5 ± 1.3e	90.0 ± 0.0	

Readings discontinued.

By Multiple Range Test, means at the same type of extract bearing the same letters are not significantly different at $P<0.05$.

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