EVALUATION OF POSSIBLE FUNGITOXIC AND ANTIBACTERIAL ACTIVITY OF SOME LOCAL PLANTS

A thesis presented by

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DECLARATION

I, the undersigned, ALFRED KOFI APETORGBOR, do hereby declare that except references to other peoples' work which have been duly cited, this work is the result of my own original research and that the thesis has never been presented, either in part or whole for another degree elsewhere.

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ABSTRACT

The effects of water and methanol extracts of 19 Ghanaian plants belonging to 12 families on some aspects of the physiology of five fungi (*Scopulariopsis brevicaulis, Aspergillus niger, A. flavus, Sclerotium rolfsii, Nigrospora sp.*), and five bacterial species (*Pseudomonas aeruginosa, Staphylococcus aureus, Salmonella* (Group C_1), *Escherichia coli* (EPEC O:43), *E. coli* (ETEC OK5)) were investigated *in vitro* in either liquid or agar medium amended with varying dilutions (1:1 - 1:5 v/v) of the extracts.

Scopulariopsis brevicaulis grew best at a temperature of 30°C and is being recorded for the first time in soil from Ghana.

Comparatively higher fungistatic effects were found in both the water and the methanol extracts of leaves of *Cassia rotundifolia, Pergularia daemia, Alternanthera pungens, Voacanga africana, Launaea taraxacifolia, Tridax procumbens, Zanthoxylum xanthoxyloides, Oxalis corniculata, Azadirachta indica, Desmodium triflorum, Euphorbia heterophylla* and *Crotalaria retusa* (in decreasing order) when the five test fungi were cultured on solid agar medium.

Vegetative growth of mycelial discs of test fungi (*Scopulariopsis brevicaulis, Aspergillus niger, A. flavus, Sclerotium rolfsii, Nigrospora sp.*) immersed in 1:1 v/v dilution of plant extracts for varying periods (1/4, 1/2, 1, 3, 12, 24, 48h) were variably depressed by the extract after transfer to extract-free (Potato Dextrose Broth) medium. The longer the period of immersion, the greater the depression of vegetative growth.

Oxalis corniculata showed the highest antibacterial activity among the eight plants (*Oxalis corniculata, Pergularia daemia, Desmodium triflorum, Alternanthera pungens, Voacanga africana, Cassia rotundifolia, Zanthoxylum xanthoxyloides, Azadirachta indica*) tested; the inhibitory effect of *O. corniculata* was akin to what was obtained when standard antibiotics (35 μg/ml Streptomycin, 5 μg/Chloramphenicol, 5 μg/ml Oxytetracycline) were used.

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I. INTRODUCTION

There are several examples of plant diseases caused by microorganisms. These include storage rots (*Fusarium spp.*), seedling diseases, root rots, gall diseases (*Plasmodiophora brassicae*), vascular wilts (*Fusarium oxysporum* f. cubense), leaf blights (*Alternaria solani*), rusts (*Puccinia spp.*), smuts (*Ustilago spp.*), powdery and sooty mildews (*Leveillula taurica, Meliola coffeae, etc.*) and viral diseases (Tobacco mosaic virus, Cocoa swollen shoot virus, etc) (Clerk, 1974; Tarr, 1972; Butler and Jones, 1949; Wood, 1967). The potential of disease affecting the economy of a country is vast. For example, approximately 10 per cent of the world's agricultural production is lost through the attack of crops in the field or their products in transit or storage by plant diseases (Clerk, 1974).

The major pests and pathogens taking a heavy toll on agricultural crops in the field and in storage are insects and fungi. The idea of controlling them by the use of chemical eradicants and protectants is not new. The first naturally occurring insecticide, nicotine - from extracts of tobacco leaves - was used to control the plum curculio (*Conotrachelus nenuphar*) and the lace bug (*Stephanitis sp.*) (Cremlyn, 1978).

About 141 years ago two important natural insecticides were introduced; rotenone from the roots of the derris plant (*Derris sp.*) and pyrethrum from the flower heads of a species of *Chrysanthemum*. The 1930s really represent the beginning of modern era of the synthetic organic pesticides and fungicides. Important examples include an organic fungicide salicylanide (Shirlan), in 1931; dithiocarbamate, valuable as foliar sprays for the control of a range of pathogenic fungi including scabs (*Elsinoe fawcetti*) and rots of fruit (*Sclerotium rolfsii, Penicillium digitatum*) and potato blight (*Phytophthora infestans*)

in 1934; 2,4 - dinitro 6 -(1'-methyl-n-heptyl) phenyl crotonate or dinocap in 1946 and, chloranil tetrachloro - 1,4-Benzoquinone in 1938. These were called protectant fungicides, the former was especially valuable against powdery mildew (Cremlyn, 1978).

By 1966 the major classes of systemic fungicides developed were the oxathins, benzimidazoles, thiophanates, and pyrimidines. Other effective systemic fungicides currently in use include antibiotics, morpholines, and organophosphorus compounds (Cremlyn, 1978).

Many of the original chemical fungicides developed were generally injurious to the environment with non-specific activity. Fungicides such as sulphur, Bordeaux mixture and organomercurials tended to be comparatively non-specific in their toxicity towards fungi. Later work led to the discovery of less poisonous and more selective organic chemical fungicides like the methylthio fungicides (Cremlyn, 1978).

There is now greater awareness of the dangers of environmental pollution arising from the widespread application of chemical pesticides and fungicides (Carson, 1963) and candidate chemicals have to pass increasingly stringent tests on their toxicity, and residue formation before they can be marked as pesticides and fungicides in many countries. This has provided impetus in research on new agrochemicals and fungicides with the view of applying naturally derived compounds which are safer and more selective in their action and do not affect non-target organisms.

Naturally occuring substances in plants have been used in medical preparations and herbal therapy. It is known that in the early nineteenth century, 80 per cent of the drugs were originally prepared from plants (Mossa *et al.*, 1983).

Most plants contain secondary metabolites having peculiar individual properties, and often having no known relation to the metabolism or functions of the plant as a whole. Such plant constituents may vary from one species to another. When such a substance exerts an influence on the structure or function of another organism it is known as an "active principle" (Githens, 1949). It is the presence of such principles which provide the therapeutic value of plants. Penso (1982) estimated that about 20,000 plants are used medically for treating various ailments.

The need to evaluate the biological activities of plant extracts and their phytochemical constituents is not only important for the development of new therapeutic agents but the new chemicals isolated from the plants with some biological activity become a springboard for chemists exploring to manufacture possible synthetic analogues from these naturally occuring compounds.

The use of angiosperm plant extracts to control microorganisms has been reported (Almagboul *et al.* 1985 a, b; Saksena and Tripathi, 1986; Tomes *et al.*, 1986; Chiappeta *et al.*, 1988). For example, Saksena and Tripathi (1986) studied 15 aromatic plants for their fungistatic activity against some common fungi present in the air, namely *Aspergillus fumigatus*, *A. niger*, *Rhizopus arrhizus*, *Mucor mucedo* and *Alternaria alternata*. They showed that the spore concentration of these fungi in the air could be controlled by the volatile compounds from the various plant species. The leaf, flowers, stem and root extracts of two varieties of *Ca tharanthus roseus* were antifungal in their effect against *Helminthosporium nodulosum*, *Sclerotium rolfsii*, *Fusarium oxysporum*, and *Aspergillus niger* which parasitise green gram, brinjal, tobacco, and groundnut respectively. The extracts inhibited spore germination, sporulation and mycelial growth

of the test fungi. The extracts markedly differed in their fungistatic activity. Leaf extracts were generally more repressive than extracts from flower, stem and roots.

As part of an on-going research in this laboratory, the phytochemical effect of the extract of plant parts of the flora of West Africa have been tried on many fungi including *Sclerotium rolfsii, Aspergillus niger, A. flavus, Phytophthora palmivora*, etc. (Ahiabu, 1985; Okyere, 1986; Boateng, 1986; Myles, 1986; Otoo, 1987). Encouraging results spurred on further studies using a wider spectrum of plants and test microorganisms. The following plant species were screened for their antifungal and antibacterial activity against selected microorganisms.

Plant Materials

The plants were selected from the following families: Compositae, Leguminosae (tribes Papilionoideae and Caesalpinioideae), Rutaceae, Meliaceae, Malvaceae, Amaranthaceae, Nyctaginaceae, Oxalidaceae, Euphorbiaceae, Asclepiadaceae and Apocynaceae. Information on their medicinal and phytochemical composition are readily available in the pertinent literature (Oliver, 1960; Kokwaro, 1976; Odebeyi & Sofowora, 1979; Rizk, 1982, Sofowara, 1982; Ampofo, 1983; Ayitey-Smith, 1989; etc.)

1. *Pergularia daemia* (Forsk) Chiov. :

P. daemia is used as a cure for various ailments. The whole plant is used for rheumatism and for any eye complaint; as an emenagogue for regulating menstruation; antiseptic, anaesthetic or analgesic, for fever remedies and sores (Sofowora, 1982). It is used for infantile and general diarrhoeae (Oliver, 1959); as an anthelmintic for

guinea worm, as expectorant and emetic (Sofowora, 1982); for headaches, small pox infection, as component of soap for general debility and to remove excessive oils from a baby's skin, as an analgesic or to release weakness or sluggishness in pregnant women, and as an enema for infantile tetanus (Elewude, 1979). Poultice of leaves of *P. daemia* is applied to boils and abscesses (Oliver, 1959).

The juice or latex is used as asthma remedy and for sore eyes; the charred stem is used for cough, while the bark is fried in oil which is then rubbed on the skin for treating craw-craw in Liberia by the Mano tribe, and for superficial dry skin lesions (Sofowora, 1982). In East Africa, the root is chewed or pounded and soaked in cold water, or boiled, or used in the form of an infusion for coughs, and an infusion of the root is taken for stomach pains and as an abortifacient (Kokwaro, 1976).

A decoction of the leaves of *P. daemia* is given to children for asthma while the juice of the leaves is used to treat infantile diarrhoea, catarrhal infections, amenorrhoea and dysmenorrhoea (Chopra *et al*, 1958). Investigations showed the presence of many cardenolides like calactin, calotropagenin, uzarin and coroglaucigenin, methyl sterols like α-amyrin, β-amyrin and lupeol and β- sitosterol in various parts of the plant including leaf, stem, root, etc. (Mishuhashi and Sasaki, 1963; Rhakit *et al*, 1959; Pattabiraman and Barua, 1958).

2. *Alternanthera pungens* (Linn.) Link.:

Dokosi (1969) reported decoction of the whole plant is taken as gonorrhoea remedy; it is used as an enema for abdominal pains in pregnant women; together with certain ingredients, it is abortifacient. The poultice is used externally in treating snake bite. The poultice of the leaves and seeds of *Aframomum melegueta* to which the juice of lime has been added is taken for sore-throat. Poultice inserted in the anus of

children stops protrusion of the anus. According to Dalziel (1936) it is used for constipation with griping and is applied as enema for diarrhoeic conditions. The plant is also used to treat dysentery and rheumatism (Ampofo, 1983) and in recipe for abortion, decoction for headache; is lactogenic, curing neuralgia, and as enema (Abbiw, 1990).

3. *Euphorbia heterophylla* (Linn.):

The juice of *Euphorbia* contains acrid resins and perhaps other principles which cause acute gastroenteritis if swallowed, and intense local inflammation and necrosis if injected. It is used by Native Africans for poisoning arrows, for destroying vermin, as ordeal and homicidal poisons (Githens, 1949). Associated with a resin and perhaps combined with it is euphorbon, found in the latex of many species of *Euphorbia*. The latex or parts containing it, is used as purgative, expectorant, emetic, and vermifuge, and as an application to ringworm and other skin lesions (Githens, 1949). The flower of *E. heterophylla* has been found to have antibacterial activity on *Mycobacterium tuberculosis* (Ayitey-Smith, 1989). Rizk (1982) found that the whole plant of *E. heterophylla* above ground contained alkaloids, coumarins, flavonoids sterols and/or terpenes.

4. *Zanthoxylum (Fagara) xanthoxyloides* (Lam.) Waterman:

Investigations carried out (El-Said *et al.*, 1970) on the antimicrobial activity of *Z. xanthoxyloides* on its use as chewing stick show that it possesses antibacterial activity against oral microbial flora. The antimicrobial activity of *Z. xanthoxyloides* has been shown to be due to benzoic acid derivatives (Odebeyi & Sofowora, 1979). *Z. xanthoxyloides* also contain some active principles (alkaloids) called fagaridine,

chelerythrine, skimmianine, dihydrochelerythrine and arterine (9-ethoxychelerythrine) (Torto *et al.*, 1969).

The root and bark of this plant is used for treating whooping cough (Ampofo, 1983), and in Ghana the root bark is commonly used for dental dressing. It is also used for the treatment of ganglia, swellings and rheumatic pains where ointment made from extracts of its roots and those of *Clausena anisata* and *Piper guineensis* is applied topically (Ayitey-Smith, 1989). The root extracts are used as fish and rat poison.

5. *Tridax procumbens* Linn.:

The essential oils isolated from *T. procumbens* showed inhibitory activities against houseflies (*Musca domestica*), mosquito (*Culex fatigans*) larvae, *Dysdercus similis* and cockroaches (*Supella spp.*). The oil also contained strong insect repellent activity when tested against three varieties of ants: *Cataulacus taprobanae* Sm., *Componotus compressus* Fabr. and *Solenopsis geminata* Sm. (Pathak and Dexit, 1988). During their field studies Pathak and Dexit (1988) observed that the plant was neither affected by insects nor grazed by cattle. *T. procumbens* is often regarded as a weed.

6. *Desmodium triflorum* (Linn.) DC.:

A paste of the bruised leaves of *D. triflorum* is applied to itches and indolent sores. Fresh leaves are used as galactagogue and for diarrhoea, abscesses, and wounds (Datta and Benerjee, 1979). It is known to contain tannin (Githens, 1949). The plant is used as lawn, green manure and sometimes regarded as a weed.

7. *Sida acuta* Burm. f.:

S. acuta is well known for its variety of medicinal uses in the Ayurvedic system of medicine (Dastur, 1956). The leaf juice is used as an anthelmentic, abortifacient and to heal abscesses. The root is bitter tonic, astringent, antipyretic and used in urinary and nervous diseases (Rao *et al*, 1984).

In Ghana *S. acuta* is used to treat venereal diseases (Blatter *et al*, 1975). The herb is mashed in water and the liquid used as an enema for paralysed children to help them walk. The leaves are freqently used to cause abortion.

The plant is used in Cuba and Jamaica to dispel colic. In Haiti, it is used as an enema and also as a sedative, whereas in Venezuela, it is employed in the treatment of conjunctivitis (Morton, 1981). It is also considered as astringent, cooling, and tonic; the roots are used in urinary and nervous diseases as well as disorders of bile and blood (Datta and Banerjee, 1979). The leaves serve as abortifacient in Africa and for making a poultice for sores in the Philippines.

The active constituents in *S. acuta* are cryptolepine and vasicine (Gunatilaka *et al.*, 1980)

8. *Aspilia africana* (Pers.) C.D. Adams:

Leaves or flowers of *A. africana* are used for cleaning cut wounds, ulcers, burns (Ampofo, 1983; Ayitey-Smith, 1989) and for cataract of the eye (Ampofo, 1983).

9. *Azadirachta indica* A. Juss.:

A. indica is claimed to possess various therapeutic values in Ayurveda in India

(Singh *et al*; 1987). The bark is used against cough and cold, fever, gastric and inflammatory disorders; flowers are used as anthelminthic (Chopra *et al.*, 1956; Kirkitar & Basu, 1965). The *in vitro* inhibitory action of leaves has also been reported against *Plasmodium falciparum* (Sudaratana *et al.*, 1985).

The plant is used in most West African countries for malaria fever (Sofowora, 1982; Ayitey-Smith, 1989). Decoction of the stem bark or leaves is drunk for this purpose and has been reported to possess antimalarial and antipyretic properties. The aqueous extract is also used in the treatment of zone inflammatory skin diseases and malaria (Obaseki *et al.*, 1985). It is also used as a chewing stick with some antibacterial activity.

A. indica is known to contain nimbolin, tannin and various glucosides (Ayitey-Smith, 1989), nimbin and nimbidon (Oliver-Bever, 1986).

10. *Emilia sonchifolia* (Linn.) DC.:

E. sonchifolia is used to treat convulsion in children and diarrhoea of infancy (Ampofo, 1983). *In vitro* antibacterial activities suggest that the plant has low antibacterial activity against some bacteria (Wong-Leung, 1988). It is used in China as folk medicinal herb for treating respiratory tract infections, pneumonia, enteritis, bacillary dysentery and urinary tract infections (Cheong & Li, 1983; Anonymous, 1979).

11. *Chromolaena odorata* (*Eupatorium odoratum*) (L.) King and Robinson:

Leaves of *C. odorata* are known to arrest bleeding, function as antiseptic, and help to accelerate the healing of wounds. According to Bruce (1988) preparations of *C. odorata* could cure typhoid fever, cataract of the eye, rheumatic joints, jaundice,

vaginal infections and also used as a diuretic. It is also used to cure piles (Mensah, 1988).

Sarpong (1988) identified some of the active constituents of *C. odorata* as terpenoids, alkaloids, flavonoids, thymol, tannins, odoratin, anisic acid, salvegenin, essential oils, and isosakuretin.

12. *Boerhavia diffusa* Linn:

Bedi (1979) reported that root decoction of *B. diffusa* is used to cure fever, and the leaves are used as vegetable in India.

In most parts of West Africa, the plant is used in traditional folk-medicine for the treatment of many ailments (Dalziel, 1955). In Nigeria the Yoruba - speaking people usually employ infusions of *B. diffusa* as mild laxatives and as a febrifuge for children (Ojewole & Adesina, 1985). The roots are used for prevention, management and/or teatment of convulsive disorders in babies (Ojewole & Adesina, 1985). They reported further that concoctions of the roots are used as expectorants and for treating asthma. The thick roots, softened by boiling, are applied as a poultice to draw abscesses and to encourage the extraction of guinea worms (Dalziel, 1937).

Phytochemical studies have led to the isolation and characterization of hentriacontane, sistesterol, ursolic acid (Mizra & Tiwari, 1971) and hypoxanthine-9-L-arabinofuranoside (Ahmad & Afzal,1968) from the leaves. Also an alkaloid, punarnavine has been extracted as well as boerhavic acid, reducing sugars, potassium nitrate and tannins including phlobaphenes (Oliver, 1960).

13. *Voacanga africana* Stapf.

In Senegal a root-decoction of *V. africana* is given to women orally to ward off the ontoward consequences of premature or precipitant parturition. The same prescription is used for painful hernias. The extract of the bark is used for washing sores (Kerharo & Adam, 1963, 1964). The latex is also applied to wounds in Senegal (Kerharo & Adam, 1964, 1974) and into a carious tooth in Nigeria (Dalziel, 1937).

A root-decoction is taken in Tanzania for dysmenorrhoea and bark-decoction or root-decoction for heart-troubles (Hardi *et al.*, 1974). In Cote d'Ivoire a leaf-decotion is taken by enema for diarrhoea for general oedema, by friction and draughts for leprosy, and in a lotion for convulsion in infants; sap of the leaves is given as nose-drops in insanity (Bouquet & Debray, 1974). For the treatment of fatigue due to shortness of breath, a decoction of the leaves is taken orally (Kerharo & Adam, 1964). *V. africana* is rich in alkaloids. Alkaloids isolated include voacamine (major), voacangine, voacangrine, voacorine and vebtusine which are all hypotensive. There are also tannins and flavonoids present (Kerharo & Adam, 1974; Thomas & Bieman, 1968).

14. *Griffonia simplicifolia* (Vahl ex DC.) Baill.:

This plant is of reputed medical value. The leaves are fed to sheep and goats in West Africa to stimulate reproduction (Odamtten *et al.*, 1988). All parts of the plant especially the seeds, are very rich in 5-Hydroxy-L-tryptophan and 5-Hydroxytryptamine or serotonin (Odamtten *et al.*, 1988).

Test microorganisms selected for screening the plant species mentioned above for antifungal and antimicrobial activity are as follows:

Test Fungi

Fungal species used are known to cause plant and/or human diseases.

Scopulariopsis brevicaulis (Sacc.) Bainier:

This fungus is found growing on all kinds of decomposing organic matter and, unlike many moulds, flourishes on substances containing a high percentage of protein, such as meat and ripening cheese (Smith, 1960). It is found as a human parasite, causing a serious infection of the nails.

Most species of *Scopulariopsis* (and *Paecilomycis*) can liberate arsenic in the form of very poisonous gaseous compounds from any substrate containing even a trace of this element. In the past there have been one or two serious cases of arsenic poisoning due to the growth of *S. brevicaulis* in wallpapers coloured with paris green, and it has been proposed to use this species for detecting minute traces of arsenic in suspected materials, instead of employing the usual chemical methods (Smith, 1960).

S. brevicaulis was isolated from tomato fruit harvested from and experimental farm near the Botany Department. It is the first record of this fungus in the country (Piening, 1962)

2. *Sclerotium rolfsii* Sacc.:

S. rolfsii is the most frequently encountered fruit rot pathogen of tomato *(Lycopersicon esculentum* Mill) in Ghana (Leather, 1959). It has been estimated that losses due to fruit rot in tomato by this fungus is about 30 per cent or more (Addison and Chona, 1971). S. rolfsii also causes wilt in tobacco (Nicotiana tabacum L.), wilt and

fruit rot in tomato *(Lycopersicon esculentum* Mill), bulb rot in onion (*Allium cepa* L.) and wilt in groundnut (*Arachis hypogea* L.) and potato (*Solanum tuberosum L.*) (Leather, 1959).

3. *Aspergillus niger* Van Tiegham:

Piening (1962) listed crops in Ghana which are attacked by *A. niger* as *Allium ascalonicum, Arachis hypogea, Butyrospermum parkii, Cocos nucifera, Elaeis guineense* and *Theobroma cocao.* The crown and collar rot disease widespread in groundnut (*Arachis hypogea*) is caused by *A. niger.* The brown germ disease of oil palm (*Elaeis guineense*) caused by *A. niger* can kill embryos before they emerge. *A. niger* is also a seed-borne pathogen of stored grains and cereals and is a well known component of the soil microflora in many parts of the world.

4. *Aspergillus flavus* Link:

A. flavus produces secondary metabolites called aflatoxins in grains, grain products and seeds. It also produces other mycotoxins like aflatram and cyclopiazonic acid in rice and wheat cultures. Aflatoxins are carcinogenic and contaminate many staple foods; they are the best known, most studied and most widespread of all mycotoxins.

Afedzi (1985) recorded the deleterious effect of *A. flavus* on *Amaranthus hybridus. A. flavus* metabolites were repressive in their effect on the length of leaves, seed germination and dry weight of stem and roots. The metabolites of *A. flavus* also had repressive effect on seed germination of tomato (*Lycopersicon esculentum* seedlings (Nutsugah, 1985). Similar observations have been made by Tagoe (1987) for *Cajanus cajan* seedlings.

5. *Nigrospora sp.* Zimm.:

This fungus was suspected to be a dermatophyte. Dermatophytes infect the skin, hair or nails. This fungus was scraped from the palm of an infected man. Dermatophyte infections may be highly infectious and irritating (Clegg and Clegg, 1973). Normally species of *Nigrospora* are also known to be parasitic or saprophytic on plants (Barnett & Hunter, 1972).

Test microorganisms (Bacteria)

Bacterial species used in the screening of plants for antimicrobial activity are all by and large medically important.

1. *Pseudomonas aeruginosa* (Gram negative):

This is a common saprophyte but is frequently found as a secondary or primary invader of wounds or ulcers that have not healed properly in man and animals (Frobisher, 1968).

P. aeruginosa also causes outbreaks of diarrhoea in adults and especially in newborn children; it is responsible for a leaf-rot disease in tobacco and lettuce and a fatal disease in poultry (Frobisher, 1968).

2. *Staphylococcus aureus* (Gram positive):

S. aureus causes mastitis of women, boils, carbuncles, infantile impetigo, inter abscesses and food poisoning (Frobisher, 1968).

3. *Salmonella* (Group C_1) (Gram negative):

Salmonella spp. cause infections (commonly called salmonellosis) in man and many species of domestic animals. It may include typhoid fever, food poisoning and paratyphoid (Frobisher, 1968).

4. *Escherichia coli* (Gram negative):

Two strains of *E. coli* were used - EPEC O:43 and ETEC OK5.

E. coli occurs commonly in the intestinal tract of man and animals. Certain strains of *E. coli* cause mild to severe diarrhoea especially in infants. *E. coli* is found in sewage and material polluted by faeces (Frobisher, 1968).

The effect of water and alcohol (methanol) extracts of 19 plants belonging to 12 families on some aspects of the physiology of the listed microorganisms were investigated and are reported in this thesis.

II. LITERATURE REVIEW

Naturally occurring antifungal and antibacterial compounds in plants have received much attention in recent years because of the increasing anxiety of the effect of agrochemicals on the ecosystem. Biological and phytochemical evaluation have also been carried out on many higher plants.

There are several reports in the pertinent literature on the antifungal and antibacterial effects of many essential oils from plants (Maruzella & Liguori, 1958; Maruzella & Sieurella, 1960; Vanhaelen, 1973; Sharma & Singh, 1979). Essential oils of 28 plants were tried for antifungal activity against some test fungi (*Microsporum gypseum, Trichophyton equinum* and *T. rubrum*). The oils of *Anethum graveolus, Artemisia officinalis, A. nilagarica, Cymbopogon flexuosus, C. winterianus, Cyperus scariosus, Melissa officinalis, Santalum album, Trachyspermum ammi* and *Vetiveria zizaniodes* were toxic against one, two or all the test organisms (Dikshit & Husain, 1984). Out of these active oils, five (*C. flexuosus, C. winterianus, M. officinalis, T. ammi*, and *V. zizaniodes*) were found to be fungicidal.

Batra and Mehta (1985) extracted oil from the seed of *Argyreia speciosa* and found the main component to be oleic acid. The oil had moderate antiseptic activity against several Gram positive and Gram negative bacteria and phytopathogenic fungi.

Moleyar and Narasimham (1986) evaluated 15 essential oil components for antifungal activity towards five spoilage-causing fungi. In liquid shake cultures, unsaturated aldehydes (citral, cinnamic aldehyde and citronellal) followed by geraniol, an unsaturated alcohol, were most inhibitory to *Aspergillus niger, Fusarium oxysporum* and *Penicillium digitatum*; their minimal inhibitory concentrations (MIC) was 100 μg/ml.

Methol, a terpene alcohol was strongly inbitory to *Rhizopus stolonifer*, and *Mucor sp.* with a MIC of 20 μg/ml. Hydrocarbons like camphene, limonene and α-terpinene were least inhibitory. When incorporated in agar medium different patterns of activity were found. Thus citral, cinnamic aldehyde, citronellal, geraniol and methol not only failed to completely inhibit *A. niger, F. oxysporum* and *P. digitatum* but were more active against *R. stolonifer* and *Mucor sp.* than in liquid medium. The differences were due to vapour of the volatile test compounds which accumulated over the agar medium.

Salih and Nadir (1984) investigated some Iraqi plants for possible antifungal activities against *Candida albicans*. About 47 total extracts, representing 38 species, were studied for their anticandidal activity. Only eight of these extracts (from *Calligonum comosum, Hypericum triquetrifolium, Myrtus communis, Propsis farcta, Pteropyrum qucheria and Quercus infectoria*) were found active against the four *Candida* species (*C. tropicalis, C. utilis, C. albicans, C. pseudotropicalis*).

Recently Gundidza (1986) tested 60 extracts from twelve plants *in vitro* for antifugal properties. *Candida albicans* was used as the test microorganism. Among the investigated plants, *Monotes engleiri, Vernonia glabra, Musa sapientum, Carica papaya, Ziziphus mucronata* and *Cyphostemma junceum* showed greatest antifungal properties.

Kumar and Nene (1968) showed that leaf extracts of *Cleome isocandra* completely inhibited the growth of several fungi, namely *Helminthosporium maydis, Alternaria solani, Glomerella cingulata, H. turcicum* and *Sclerotium rolfsii*. Growth of *Aspergillus niger* and *Rhizopus nigricans*, however, were not inhibited. Root, stem, seed and flower extracts of the plants also prevented vegetative growth of the listed fungi. The leaf

extracts were inhibitory even at a dilution of 1:200. The active ingredient appears to be quite stable as it could withstand the effect of heat, pH and ageing. The benzene extracts of the dried seeds of *C. isocandra* yield a fixed oil which on standing deposits palmitic, myristic and viscosic acids(Gupta and Dutt, 1950). From the alcoholic extracts Gupta and Dutt (1950) obtained a flavone, viscosin, which is a monomethoxy-trihydroxy flavone. The yellow pigments of flavone type were suggested by Newton and Anderson (1929) to be the main phenolic compounds partly responsible for the resistance which some varieties of wheat show against the stem rust fungus.

The activities of the crude extracts, three purified groups of compounds and the volatile oil of *Aframomum melegueta* were tested against several bacterial and fungal strains (Oloke *et al.*, 1988). The crude extract showed considerable fungicidal activities against *Candida albicans, Trichophyton mentagrophytes, Aspergillus niger, Botryodiplodia theobromae* and species of *Cladosporium cladiosporioides* at very low concentrations. Similarly, the three purified groups of compounds, namely gingerols, paradols and shagaols and the volatile oil showed appreciable activities against these microorganisms. The paradols showed the greatest activity followed by the shagaols and the gingerols. The activity of the volatile oil was comparable to that of the paradols and both compared favourably with the activity of trimethoprim - sulphamethoxazole and ticonazole.

The alcoholic extracts of 32 Egyptian plants were investigated by Ross *et al.* (1980 a) for their antimicrobial properties against four bacteria and five fungi. About 62 per cent of these plants showed antibacterial activity while 15 per cent exhibited a marked antifungal property. The alcoholic extracts were proved to be the most active.

Ross *et al.* (1980 b) also found that the ethanolic extract of the seeds of *Peganum harmala* demonstrated a marked antimicrobial activity. They found that P. harmala contained the alkaloids harmaline and harmalol with antimicrobial activity.

Almagboul *et al.* (1988 b) investigated 102 extracts of 18 plants, belonging to 12 families, for their antifungal activity towards *Aspergillus niger* and *Candida albicans*. Out of the extracts 32 (31 per cent) exhibited inhibitory effect against the two mentioned fungi.

In Ghana very little work has been done on antifungal properties of plant extracts. Okyere (1986) found some Ghanaian weeds *(Commelina vogeli*, *Euphorbia heterophylla, Synedrella nodiflora* and *Tridax procumbens*) suppressing growth of sclerotia of *Sclerotium rolfsii*. Okyere (1986) also reported the killing of sclerotia of *S. rolfsii* in soil and *in vitro* by leaves of *Tapinanthus bangwensis*. Earlier, Ahiabu (1985) found that the leaf extract of *T. bangwensis* could prevent the growth and sporulation of *Aspergillus flavus*.

The pertinent literature is replete with examples of the antibacterial activity of plant extracts. Kumar *et al.* (1988) investigated essential oils of 24 different species of *Eucalyptus* for their antimicrobial activities. The oils were effective against bacteria. In general Gram positive organisms were found to be more sensitive to the oils than Gram negative; of all the essential oils tested that of *Eucalyptus teriticarnis, E. camaldulensis* and *E. grandis* were found to be effective against 13 of the 15 organisms. *Bacillus subtilis* and *Micrococcus glutamicus* were found sensitive to almost all the oils.

Eugenia uniflora is a volatile oil-containing plant, native of Northeast Brazil. In Uruguay, tea made from the young leaf and an alcoholic liqueur flavoured with the leaf

and fruit of *E. uniflora* are used for all disorders of the digestive tract (Coppetti & Gonzales, 1922). These activities were suggested to be due to the volatile oil content. In Mauritius the hot water extract of the dried leaves is given orally to adult female as an emmenagogue (Sussman, 1980) and in Nigeria as a febrifuge and antimalarial (Adebajo, 1988). Antimicrobial activities have been reported for volatile oils and expressed juice of the *Eugenia* genus (Garg, 1974; Rao & Nigam, 1970; Bushnell *et al.*, 1950). Adebajo *et al.* (1989) assessed the antimicrobial efficacy of the essential oils of *E. uniflora* and their transformed microbial products collected at different times. The results obtained especially against *Proteus vulgaris, Pseudomonas aeruginosa, Klebsiella pneumoniae, Candida albicans* and *Trichophyton mentagrophytes* may be a biological confirmation of the variation of the oils. Most of the oils were inactive against *Staphylococcus aureus, Serratia marcescens* and *Yersinia enterocolitica*. *P. aeruginosa* was the most sensitive bacterium while *T. mentagrophytes* was the most susceptible fungus. The results may provide a scientific explanation for the folkloric uses of *E. uniflora* against digestive tract disorders.

The steam distillates of leaves and flowers of *Tanacetum macrophyllum* were tested for antimicrobial activity against five widely occuring and medically important bacteria (*Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Proteus spp.* and *Salmonella spp* (Thomas, 1989). The oils exhibited antibacterial property.

Rao *et al.* (1989) studied the antifungal and antibacterial activities of ten essential oils of *Limnophila gratissima in vitro* on some Gram positive, Gram negative bacteria and fungi. Its activity was compared with those of standard antibiotics. The antibacterial activity was found to be comparable with that of streptomycin and chloramphenicol and

the antifungal activity was higher than that of griseofulvin. *L. gratissima* possesses the odour of turpentine and yields 0.13 per cent of an essential oil containing d-limonene and d-perillaldehyde as the principal constituents. It is regarded as antiseptic, galactogogue and aperient.

Plants belonging to Lamiaceae are reputed for their medicinal uses. Due to their content of essential oils, several species of this family show antimicrobial activity (Allegrini *et al.*, 1974; El-Keltawi *et al.*, 1980; Dikshit and Husain, 1984; Melegari *et al.*, 1985). However, investigations on plants utilized in folk medicine demonstrate that the antimicrobial activity is not only attributable to essential oils, but also to non-volatile substances, ie. tannins (Duquenois & Greib, 1955) and flavonoids (Kubo *et al.*, 1981; Miski *et al.*, 1983). Diaz *et al.* (1988) examined 43 species of Spanish Lamiaceae for phytochemical content and antibacterial activity. The plants contained alkaloids, volatile oils, tannins, saponins, flavonoids, leucoanthocians, cyanogenetic heterosides and anthraquinones.

The petrol and methanol-water extract of *Jatropha podagrica* possesses both antimicrobial and antifungal activities. In the petrol extract the presence of citral, thymol and carvocrol was observed and a flavonoid compound, 5-hydroxy - 7, 4' - dimethoxyflavone, was isolated from the methanol extract (Odebeyi, 1985). The effects showed by these compounds were however not significant when compared with griseofulvin, nystatin, streptomycin sulphate and chloramphenicol. From the stems of *J. podagrica* the presence of tannins and alkaloid tetramethylpyrazine was observed (Odebeyi & Sofowora, 1978; Odebeyi, 1980). The antimicrobial, neuromuscular and cardiovascular actions of the plant extract were attributed to the presence of this alkaloid

(Ojewole & Odebeyi, 1980, 1981).

Farouk *et al.* (1983) screened certain Sudanese plants used in folkloric medicine for different purposes for antibacterial activity. 76 extracts of 31 plants belonging to 21 families were investigated for their antibacterial activity. Out of these extracts 64 (84 per cent) exhibited inhibitory effects against at least one organism. The results showed that when the activity is present it is not restricted to any morphological part of the plant. The tested microganisms were *Staphylococcus aureus, Bacillus subtilis, Escherichia coli* and *Pseudomonas aeruginosa*.

Almagboul *et al.* (1985 a) carried out investigation on 198 extracts of 40 plants belonging to 18 families for antibacterial activity against four different bacterial species (*Staphylococcus aureus, Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa*). Out of the 198 extracts 134 (68 per cent) exhibited inhibitory effects against one or more of the microorganisms. In the same year they carried out two more investigations against the same microorganisms. Almagboul *et al.* (1985 b) investigated 135 extracts of 31 plants belonging to 15 families. Out of the 135 extracts, 101 (75 per cent) exhibited inhibitory effects against one or more of the microorganisms. Further studies by the same workers (1985 c) on 126 extracts of 24 plants, belonging to 21 families showed that out of the 126 extracts, 97 (77 per cent) exhibited inhibitory effects against one or more of the microorganisms. The plants which exhibited marked antibacterial activity were shown to be rich in flavonoids, tannins and alkaloids. Later Almagboul *et al.* (1988 a) made 102 extracts of 15 plant species, belonging to six families. Out of these extracts 87 (85 per cent) exhibited inhibitory effects against one or more of the microorganisms. Preliminary phytochemical screening of the most active seven plants showed that five

plants are rich in tannins and/or flavonoids. Alkaloids were detected in four plants but only one plant was rich in alkaloid.

An active antimicrobial fraction isolated from *Pteropyrum aucheri* had been tested against *Micrococcus luteus, Staphylococcus aureus, Escherichia coli* and *Bacillus subtilis* (Mubarak *et al.* 1988). The Minimum Inhibitory Concentration (MIC) has been determined and found to be 0.40 mg/ml against *E. coli* and 1.2 mg/ml against *S. aureus*. *P. aucheri* is used by the people of Al-Jezira (Iraq) as a paste for the treatment of injuries.

The antimicrobial activity of several extracts from leaves and flowers of three *Hypericum* species was evaluated against eight different microorganisms (Sakar *et al.*, 1988). The extracts of *H. salsugineum* and *H. origanifolium* exerted antimicrobial activity against Gram positive bacteria, the fungus (*Candida utilis*) and *Mycobacterium smegmatis* only. Generally, *Hypericum* species contain hypericin, pseudohypericin (Brockman, 1957), flavonoids (Kitanov, 1985; Berghöfer and Hözl, 1986), volatile oils (Mathias & Qurisson, 1964; Mathela & Mathela, 1984), xanthones (Cardona *et al.*, 1985; Chen & Chen, 1983) γ-pyrone (Kikuchi *et al.*, 1985a), hyperenon B (Kikuchi *et al.*, 1985 b), n-alkanes (Brondz *et al.*, 1983) n-1-alkanols (Brondz *et al.*, 1983) and tannins (Michahok *et al.*, 1956). Antimicrobial activity of other *Hypericum* species are also known (Nadir & Salih, 1985; Tanker *et al.*, 1980). The antimicrobial activity of *H. perforatium* and *H. hircinum*, all of Sicilian origin, was investigated by Barbagallo and Chisari (1987). *H. perforatium* was found to be most active and showed activity against Gram positive and Gram negative bacteria.

Aqueous, petrol, chloroform and dichloromethane extracts of both the bark and

leaves of *Helinus integrifolius* were tested for activity against *S. aureus* and *C. albicans* (Gundidza, 1987). The aqueous extracts showed significant activity against *S. aureus* and *C. albicans*.

Wong-Leung (1988) tested 40 Hong Kong plants against selected Gram positive and Gram negative bacteria. These plants have been used traditionally in folk medicine as antibacterial agents. Four of these plants *Glochidion eriocarpum* , *Cratoxylum ligustrinum, Psychotria rubra* and *Desmodium triquetrum*) showed high level *in vitro* antibacterial activities against two or more strains of bacteria. Six of the tested herbs including *Emilia sonchifolia* showed no appreciable *in vitro* antibacterial actions although there were clinical records in China reporting that two of these herbs (*Plantago major* and *Eclipta prostrata*) were effective in treating bacillary dysentery.

The extracts of different parts of *Solanum viarum* showed antibacterial and antifungal activities (Chiappeta *et al.*, 1988). Fruits and seeds showed activity against Gram positive, Gram negative, and acid-fast bacteria and yeast. The leaf and root extracts appeared to be ineffective against the microorganisms. The ethanolic and methanolic stem extracts inhibited all the test microorganisms except the acid-fast bacteria, *Mycobacterium smegmatis*.

The roots of *Aegle marmelos* are known in ethnomedicine, having properties of anti-diarrhoeitic and antidote to snake venom (Kirtikar & Basu, 1935). The presence of alkaloids, coumarins and sterols had been described in this drug (Karawya *et al.*, 1982).

Pitre and Srivastava (1987) found that ethanoate extract of the root of *A. marmelos* showed moderate to appreciable activity against *Vibrio cholerae, Salmonella typhimurium, Klebsiella pneumoniae, Candida albicans, Aspergillus fumigatus* and

Trichophyton mentagrophytes. From this extract a coumarin named marmin was isolated.

The alcohol extract of *Peltophorum pterocarpum* had been tested by Sethuraman *et al.*, (1984) for its anti-inflammatory and antibacterial effects. At high doses (200 and 400 mg/kg) the extract exhibited significant anti-inflammatory activity. The extract was also effective against *Streptococcus pyosenes* (Gram positive). The bark of *P. pterocarpum* is used to cure dysentery, gargle for sore-throat and to make tooth powders. A lotion of the bark is employed as external application in muscular pains (C.S.I.R., 1966; Hooker, 1954).

Tomes *et al.* (1986) screened a number of Argentine higher plants for antimicrobial activity. Petrol extract of *Gomphrena boliviana, G. meyeniana, Poa heucu, Wedelia glauca* and *Erythroxylon argentinum* were active against *Mycobacterium phlei*. Petrol extracts of *Vigna luteola* was active against *Micrococcus luteus*. Chloroformic percolates of *Senecio pampeanus* and *S. bonariensis* were active against *Micrococcus luteus* and *Mycobacterium phlei*. The petrol extract of *Wedelia glauca* was also active against *Streptococcus faecalis, Micrococcus luteus* and *Bacillus subtilis*.

Jaffer *et al.* (1988) extracted *Withania somnifera* plant parts (fruits, leaves, stem and roots) separately using petrol, chloroform and methanol. The resulted twelve extracts were tested against representative Gram positive, Gram negative and two *Candida* species. None of these extracts showed any antimicrobial actions against Gram negative bacteria. However, leaf chloroformic, leaf methanolic and stem chloroformic extracts were the most significant anti-Gram positive bacterial agent. Leaf methanolic extract gave the highest yield in comparison with the plant's other parts. Some phytochemical studies on this plant resulted in isolation of many constituents such as

tannins, sugars, phytosterols, alkaloids and steroidal lactones (Kirson *et al.*, 1970, 1971; Schwarting, 1963; Schroter *et al.*, 1966; Atal & Schwarting, 1960).

Recently, Sabir *et al.* (1987) carried out *in vitro* antibacterial studies with hexane, chloroform and methanol extracts of the leaves, stems and seeds of *Ardisia solanacea*. The ethanol extracts showed a good activity against most of the Gram positive and Gram negative microorganisms. Qualitative phytochemical tests indicated that the plant might contain alkaloids, steroids, resins, tannins as well as reducing sugars.

Ikram and Inam (1984) studied the antimicrobial activity of extracts of 42 plants of Pakistan origin. Only nine of the 42 plants including *Peganum harmala* showed significant activity. It is interesting to note that only the alkaloid part of *P. harmala* is active while the non-alkaloidal part has very little activity.

The African savannah grass (*Hyparrhenia sp.*) produces a thermolabile, partly water-soluble toxin in soil in Ghana and Zimbabwe that inhibit growth of *Nitrobacter* and *Nitrosomonas* (Meiklejohn, 1962; Clark & Paul, 1970).

Nineteen Ghanaian plants belonging to twelve families were tested for antifungal and antibacterial activity *in vitro* using both water and methanol extracts. There is hardly any information in the pertinent literature on their potential use for controlling diseases of microbial origin in Ghana.

III. MATERIALS AND GENERAL METHODS

(i) **Materials:**

The leaves of the following plants were used:

PLANT	FAMILY
Pergularia daemia (Forsk.) Chiov.	Asclepiadaceae
Oxalis corniculata Linn.	Oxalidaceae
Cassia rotundifolia	Leguminosae – Caesalpinioideae
Alternanthera pungens (Linn.) Link.	Amaranthaceae
Euphorbia heterophylla Linn.	Euphorbiaceae
Launaea (Lactuca) taraxacifolia (Willd.) Schum. ex Hornemann	Compositae
Zanthoxylum (Fagara) xanthoxyloides (Lam.) Waterman	Rutaceae
Tridax procumbens Linn.	Compositae
Crotalaria retusa Linn.	Leguminosae – Papilionoideae
Desmodium triflorum (Linn.) DC.	Leguminosae – Papilionoideae
Sida acuta Burn.f.	Malvaceae
Aspilia africana (Pers.) C.D. Adams	Compositae
Azadirachta indica A. Juss.	Meliaceae
Boerhavia diffusa Linn.	Nyctaginiaceae
Emilia sonchifolia (Linn) DC.	Compositae
Synedrella nodiflora Gaertn.	Compositae
Chromolaena odorata (*Eupatorium odoratum*) (L.)King and Robinson.	Compositae
Voacanga africana Stapf.	Apocynaceae
Griffonia simplicifolia (Vahl ex DC.) Baill.	Leguminosae – Caesalpinioideae

The test fungi used were *Scopulariopsis brevicaulis, Sclerotium rolfsii, Aspergillus niger, A. flavus* and *Nigrospora sp.* The following test microorganisms (bacteria) were also used: *Pseudomonas aeruginosa* (Gram negative), *Staphylococcus aureus* (Gram positive), Salmonella (Group C_1), and two strains of *Escherichia coli*: Enteropathogenic *E. coli* (EPEC O:43) and Enterotoxigenic *E. coli* (ETEC 0K5) (Gram positive).

(ii) **General Methods**:

(a) Preparation of Plant extracts

1. WATER EXTRACT

Leaves of the listed plants were sun-dried. 50g of the dry leaves were ground in a mortar. This was then blended with distilled water. The supernatant liquid was strained with cheese cloth and then with filter paper using a vacuum pump (Compton Vacuum Pump, Type D/351 VM). The resulting clear liquid was made up to 1,000 ml. Dilutions of the filtrate were made as required.

2. ALCOHOL (METHANOL) EXTRACT

The leaves of the plants were sun-dried and then coarsely powdered. Alcohol extract of 50g of the powdered material was obtained using Soxhlet apparatus (Plate 1) with methanol as the solvent. The solvent was evaporated to dryness on a Rotary evaporator (Eyela Vacuum Evaporator NE) and the gummy residue suspended in 1,000 ml sterile distilled water.

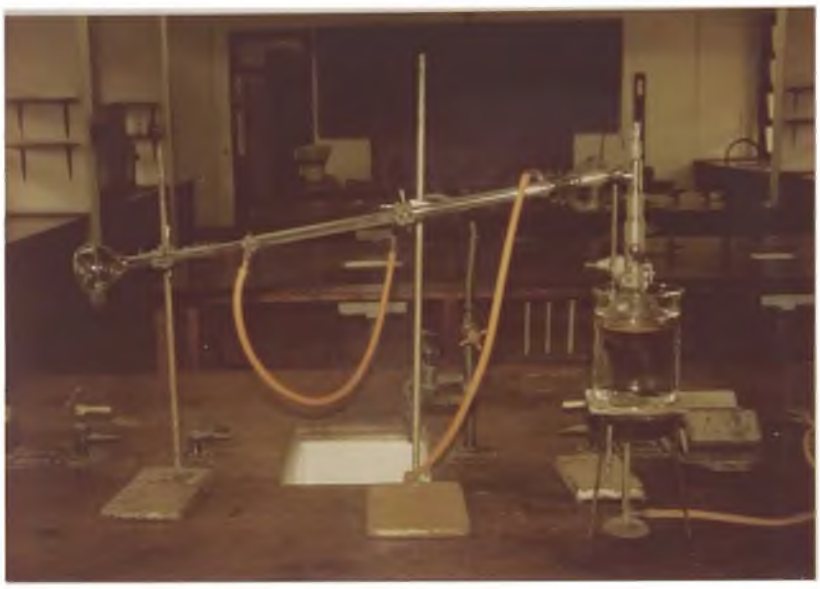


Plate 1. Photograph showing apparatus used for Sohxlet extraction of methanol extract of plants.
(x 0.08)

(b) Composition of culture media:

1. POTATO DEXTROSE AGAR (PDA)

200g of peeled Irish potato was boiled in 500 ml of distilled water, strained and made up to 1,000 ml. 20g dextrose and 20g agar were added.

2. POTATO DEXTROSE BROTH (PDB)

200g of peeled Irish potato was boiled in 500 ml of distilled water, strained and made up to 1,000 ml. 20g dextrose was added.

3. BASAL MEDIUM

Composition of basal medium was as follows:

Glucose;	10g
Yeast extract;	1.0g
KH_2PO_4;	0.5g
$FeCl_3$;	0.001g
Distilled water;	1000 ml.

(c) Method of sterilization

All glassware were sterilized by heating in an electrically heated oven (Gallenkamp Oven 300, Plus series) at 165°C for 8 hours. All culture media were autoclaved at 1.05 kg/cm² steam pressure (121°C for 15 minutes). Cotton wool plugs were covered with aluminium foil or cellophane paper to prevent penetration of any condensed water during autoclaving.

(d) Assessment of vegetative growth by oven-dry method.

Growth in the liquid cultures was assessed by estimating the dry weight of the harvested mycelium at the end of the required period of incubation indicated at the appropriate places in the text.

The mycelium was collected on a previously dried and weighed filter paper and then dried for 24 hours in an electrically heated oven of temperature 75°C. The filter paper with the dried mycelium was weighed, after being allowed to cool in a dessicator.

(e) Assessment of vegetative growth of test fungi on Agar

The stock plant extract was autoclaved at 1.05 kg/cm² steam pressure (121°C for 10 minutes) before use. The extract was then amended with sterile basal medium containing 20g agar to obtain 1:1, 1:2 and 1:5 v/v dilutions of the extract.

20 ml of the mixture was made to mix uniformly in the Petri plate by swirling. The plates were inoculated with 3 -mm discs of the mycelium from the growing edges of 7-day old cultures of the appropriate fungus growing on PDA. The Petri plates were inoculated at the centre along two diameters drawn at the bottom of the plates. There were two replicates for each dilution level. Unamended agar medium containing only basal medium served as control.

The plates were incubated at 30°C for those inoculated with *Scopulariopsis brevicaulis*, *Aspergillus flavus*, *Sclerotium rolfsii* and *Nigrospora sp.* and at 35°C for *Aspergillus niger*. Diameters of fungal colonies were measured daily for up to 8 days.

(f) Antibacterial activity of plant extracts

This was done using the paper diffusion disc method (Fairbrother and Rao, 1957; Egorov, 1985). The filter paper discs (6mm in diameter) were obtained by punch perforation of Whatman No. 1 filter paper and sterilized at 160°C for 1 hour. The sterile filter paper discs were immersed in the stock plant extracts. The pH of the extracts were adjusted to neutral by 2% ammonia solution.

The test microorganisms were first incubated in 0.1% bacteriological peptone solution for 24 hours at 37°C before use. Sterile Nutrient agar (about 20 ml) was poured into each Petri plate. The test microorganisms were evenly spread over the cooled agar surface by streaking with a sterile inoculating loop. Three sterile filter paper discs were immersed in each plant extract and placed on the plates containing the microorganisms with sterile forceps. There were four replicates for each plant extract used. Filter paper discs immersed in 5 μg/ml Chloramphenicol, 35 μg/ml Streptomycin and 5 μg/ml Oxytetracycline served as reference standards.

The Petri plates were incubated at 37°C for 24 hours. Zones of inhibition between the discs and the growing culture of bacteria were measured in millimetres.

(g) Statistical Analysis

The data, where appropriate, were analysed statistically and the results quoted at the 5% and 1% levels of significance.

IV. EXPERIMENTAL PROCEDURE

A. EFFECT OF TEMPERATURE ON GROWTH OF *SCOPULARIOPSIS BREVICAULIS*.

The optimum temperature for growth of fungi differs from one geographical region to another. The optimum recorded in connection with any specific factor has not been the same for each species and it appears desirable to examine separately each isolate used in any studies.

Scopulariopsis brevicaulis isolated from soil in Ghana for the first time in the investigations reported in this thesis, is of pathological importance. The optimum temperature for the isolate of *S. brevicaulis* from Ghana may have a different optimum temperature for growth. This was investigated in this experiment to provide the temperature to be adopted in subsequent investigations.

About 30 ml of the basal liquid medium (10g glucose, 1.0g yeast extract, 0.5g KH_2PO_4, 0.001g $FeCl_3$, 1000 ml distilled water) was used in each conical flask. The flasks were inoculated with 3-mm agar discs of the test fungus and then incubated at 15°, 20°, 25°, 30°, 35° and 40°C respectively. At each predetermined incubation period of 2, 4, 8, 12 and15 days, four flasks were harvested from each temperature treatment and vegetative growth was determined using the oven-dry weight method (see materials and general methods, page 30). Results are presented in Fig.1 and in Appendix A.

B. VEGETATIVE GROWTH OF *SCOPULARIOPSIS BREVICAULIS* IN BASAL MEDIUM AMENDED WITH WATER EXTRACT OF SIX PLANTS

In this preliminary experiment water extract of six plants, *Alternanthera pungens* (Amaranthaceae), *Euphorbia heterophylla* (Euphorbiaceae), *Oxalis corniculata* (Oxalidaceae), *Sida acuta* (Malvaceae), *Crotalaria retusa* (Papilionaceae) and *Tridax*

procumbens (Compositae) was used in amending the basal medium used in Procedure A to obtain dilution of 1:1, 1:2 and 1:5 $^{v}/_{v}$ of the plant extracts.

Approximately 30 ml of the amended medium was poured in Erlenmeyer flasks. Vegetative growth of *S. brevicaulis* was assessed after 2, 4, 8, 12 and 15 days. Results are presented in Fig. 2 and in Appendices 6-a.

C. VEGETATIVE GROWTH OF FIVE TEST FUNGI ON SOLID MEDIUM AMENDED WITH WATER AND METHANOL EXTRACTS OF PLANTS IN THE FAMILY COMPOSITAE

Plants contain many compounds that have been used in herbal therapy and in inhibiting growth of microorganisms. Test fungi (*Scopulariopsis brevicaulis, Aspergillus niger, A. flavus, Sclerotium rolfsii* and *Nigrospora sp.*) used in this Procedure are of economic importance to man. It was anticipated that if extracts of the plants belonging to the family Compositae (*Launaea teraxacifolia, Tridax procumbens, Aspilia africana, Emilia sonchifolia, Synedrella nodiflora*, and *Chromolaena odorata*) are able to depress vegetative growth and sporulation of the fungal species, the plants could provide active ingredients to be used in biocontrol of pathogenic fungi.

Agar media amended with either water or methanol extracts of the listed plants were inoculated with 3-mm discs of mycelium of test fungi and the vegetative growth was measured along two diameters.

Results are presented in Figs. 3-8 and Tables 1-4

D. VEGETATIVE GROWTH OF FIVE TEST FUNGI ON AGAR (SOLID MEDIUM) AMENDED WITH WATER AND METHANOL EXTRACTS OF PLANTS IN THE FAMILY LEGUMINOSAE (TRIBE PAPILIONOIDEAE AND CAESALPINOIDEAE)

The experiments in Procedure C were repeated, this time using plants in the family Leguminosae (Tribe Papilionoideae and Caesalpinoideae). The plants are *Crotalaria retusa, Desmodium triflorum* (Papilionoideae), *Cassia rotundifolia, Griffonia simplicifolia* (Caesalpinoideae). The same test fungi, namely *Scopulariopsis brevicaulis, Aspergillus niger, A. flavus, Sclerotium rolfsii and Nigrospora sp.* were used.

Results obtained are presented in Figs. 9-12 and Tables 5-9

E. VEGETATIVE GROWTH OF FIVE TEST FUNGI ON AGAR (SOLID MEDIUM) AMENDED WITH WATER AND METHANOL EXTRACTS OF PLANTS IN THE FAMILY RUTACEAE AND MELIACEAE.

Two plants *Zanthoxylum xanthoxyloides* (Rutaceae) and *Azadirachta indica* (Meliaceae) were used. Their inhibitory effect on growth of test fungi (*Scopulariopsis brevicaulis, Aspergillus niger, A. flavus, Sclerotium rolfsii* and *Nigrospora sp.*) were ascertained in the same way as in Procedures C and D.

Results obtained are presented in Figs. 13-14 and in Tables 10-11

F. STUDIES ON THE EFFECT OF WATER AND METHANOL EXTRACTS OF PLANTS IN THE FAMILY MALVACEAE, AMARANTHACEAE, NYCTAGINACEAE AND OXALIDACEAE ON VEGETATIVE GROWTH OF FIVE FUNGI.

The screening of plants for antifungal principles was extended to cover selected plants from the families Malvaceae, Amaranthaceae, Nyctaginaceae and Oxalidaceae. The plants are *Sida acuta* (Malvaceae), *Alternanthera pungens* (Amaranthaceae), *Boerhavia diffusa* (Nyctaginaceae) and *Oxalis corniculata* (Oxalidaceae). The same procedure followed in C and D was followed. Vegetative growth on solid agar amended with water and methanol extracts (1:1 - 1:5 $^{v}/_{v}$ dilution) were recorded and are presented in Figs. 15 - 18 and in Tables 12-16

G. STUDIES ON THE VEGETATIVE GROWTH OF FIVE FUNGI ON SOLID MEDIUM AMENDED WITH WATER AND METHANOL EXTRACTS OF PLANTS FROM THE FAMILY APOCYNACEAE, ASCLEPIADACEAE AND EUPHORBIACEAE.

It was observed in previous experiments (C-F) that the inhibitory effect of the plant extracts was variable and marginal in some instances. The wider the number of plants examined from different families the better the chance of encountering higher plants with considerable antifungal principles. The experiments were extended to include plants of the family Apocynaceae, Asclepiadeceae and Euphorbiaceae

The same procedure was adopted and results are presented on Figs. 19-21 and in Tables 17-20.

H. COMPARATIVE FUNGISTATIC ACTIVITY OF EXTRACTS OF NINETEEN PLANTS ON VEGETATIVE GROWTH OF FIVE SELECTED FUNGI.

The ability of plant extracts to exert inhibitory effect on fungal growth is also measured by the mathematical relationship:

$$E/C = \frac{\text{Diameter of colony in control medium}}{\text{Diameter of colony in medium amended with extract at same temperature and growth period.}}$$

The experiments in Procedures C-G were repeated and the E/C ratio were determined for each fungal species tested in either the water or the methanol extract of the listed nineteen angiosperm plants. High E/C ratio, >1.0 shows some measurable inhibition of growth of the fungus.

Results are presented in Tables 21-24

I. GROWTH OF FIVE FUNGI STORED IN WATER AND METHANOL EXTRACTS OF NINE PLANTS.

It is possible that the metabolism of the selected fungi subjected to possible toxic effect of the water and methanol extracts from the nine selected plants may be permanently impaired or modified. The shorter the period to achieve impairment of metabolism, the better the antifungal principle exuding from the extract.

An investigation was designed to find out whether mycelium of the five fungi would recover from the depressing effect of the plant extracts. The plant extracts were from *Zanthoxylum xanthoxyloides* (Rutaceae) *Azadirachta indica* (Meliaceae), *Desmodium*

triflorum (Leguminosae-Papilionoideae), *Alternanthera pungens* (Amaranthaceae), *Voacanga africana* (Apocynaceae), *Cassia rotundifolia*, *Griffonia simplicifolia* (Leguminosae-Caesalpinoideae), *Oxalis corniculata* (Oxalidaceae) and *Pergularia daemia* (Asclepiadaceae). The nine plants were those with the highest fungistatic activity among the nineteen plants used. The investigation was carried out by studying the growth rate of 3-mm discs of the mycelium obtained from the growing edge of the appropriate test fungus after immersion in 30 ml of 1:1 $^{v}/_{v}$ dilution of either the water or methanol extract of the plants for varying periods from 15 minutes to 48 hours.

After the period of immersion in the extract, the mycelium in each case was washed in three changes of sterile distilled water to remove traces of the extract from the surface of the hyphae. The mycelium discs were then used to inoculate 250 ml Erlenmeyer flasks containing 30 ml of Potato Dextrose Broth (PDB). Control cultures received no plant extract treatment.

The flasks were incubated at 30°C for those incubated with *Scopulariopsis brevicaulis*, *Aspergillus flavus*, *Sclerotium rolfsii* and *Nigrospora sp.* and at 35°C for *Aspergillus niger*. Vegetative growth was assessed by the dry weight method after 10 days growth.

Results obtained are presented in Figs. 22-26.

J. ANTIBACTERIAL ACTIVITY OF SELECTED PLANTS

There are several reports of antibacterial activities of plant extracts(Dikshit and Hussain, 1984; Batra and Mehta, 1985; Kumar *et al.*, 1988; Adebajo *et al.*, 1989; etc) but the antibacterial activity of the Ghanaian plants used in this thesis has not been tried.

The experiments on the antibacterial activity of both water and methanol extracts of *Oxalis corniculata* (Oxalidaceae), *Pergularia daemia* (Asclepiadaceae), *Desmodium triflorum* (Leguminosae-Papilionoideae), *Alternanthera pungens* (Amaranthaceae), *Voacanga africana* (Apocynaceae), *Cassia rotundifolia* (Leguminosae-Caesalpinoideae), *Zanthoxylum xanthoxyloides* (Rutaceae) and *Azadirachta indica* (Meliaceae) were carried out with the following test bacteria: *Pseudomonas aeruginosa* (Gram negative), *Staphylococcus aureus* (Gram positive), *Salmonella* (Group C_1) (Gram negative), *Escherichia coli* (EPEC 0:43), (Gram negative), *E. coli* (ETEC OK5) (Gram negative). The eight plants were those with the highest fungistatic activity among the nineteen plants used. Solutions of standard antibiotics, Streptomycin (35 μg/ml), Chloramphenicol (5 μg/ml) and Oxytetracycline (5 μg/ml) served as reference. Discs of the solutions on sterile filter paper (6 mm in diameter) were placed on culture of the listed bacterial species. Diameter of inhibition zones were measured after 24 hours.

Results are presented in Table 25

V. RESULTS

A. EFFECT OF TEMPERATURE ON GROWTH OF *SCOPULARIOPSIS BREVICAULIS*

Results are presented in Fig. 1 and Appendix A. The best vegetative growth of the fungus was between 25° - 30°C (Fig.1). Optimum growth (60 mg) in liquid culture was obtained in 12 days at 30°C and thereafter declined. Vegetative growth at 35° and 40°C was clearly inferior as the lowest vegetative growth (25.0 mg and 10.0mg respectively) were recorded at these temperatures.

Vegetative growth of the fungus at 15°C can be described as relatively good (32.5 mg; about half of what was obtained at 30°C) and was intermediate between growth at 30°C and 35°C (Fig.1).

The pH of the medium drifted from 5.2 to 6.1 in 15 days at 30°C and to pH 5.8 and pH 4.7 at 35°C and 40°C respectively (Appendix A).

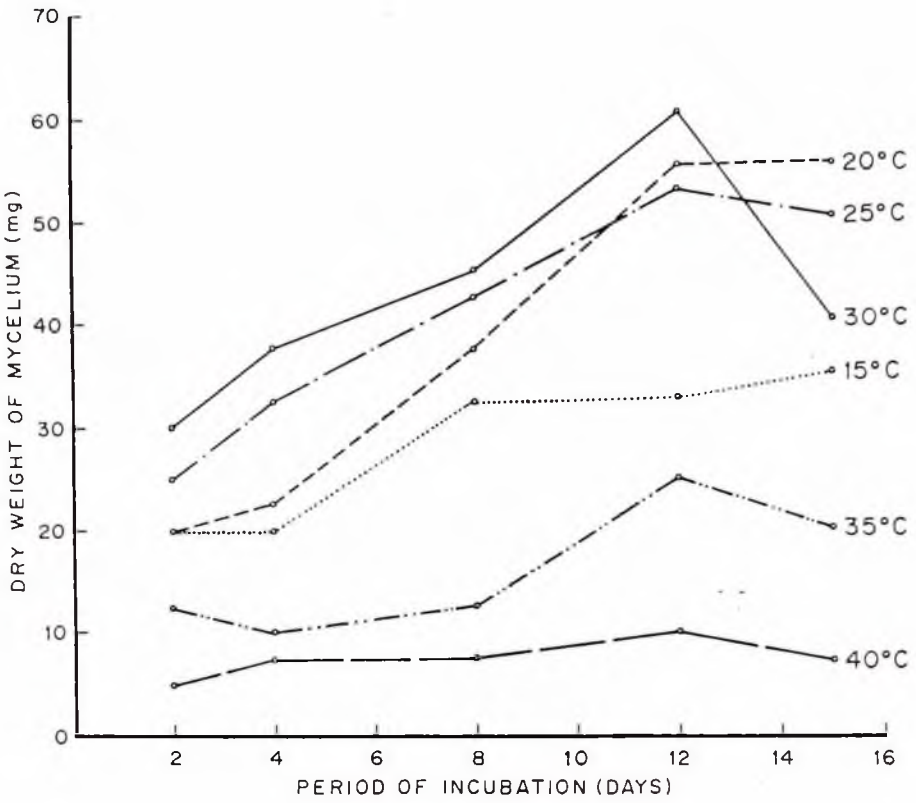


Fig.1. Vegetative growth of Scopulariopsis brevicaulis in basal liquid medium at indicated temperatures.

B. VEGETATIVE GROWTH OF *SCOPULARIOPSIS BREVICAULIS* IN BASAL LIQUID MEDIUM AMENDED WITH WATER EXTRACT OF SIX PLANTS.

Results obtained are presented in Fig.2 and Appendices B-G. Water extract of *Oxalis corniculata* depressed growth of *S. brevicaulis*. 1:1 v/v dilution of the extract depressed growth of the fungus by 41.7 per cent in 15 days and prevented sporulation. This inhibitory effect was gradually removed with increasing dilution of the extract. The pH in this medium increased from an initial 3.0 to 7.7.

The extracts of the other plants namely *Alternanthera pungens, Sida acuta, Euphorbia heterophylla and Crotalaria retusa* promoted growth of *S. brevicaulis*. The highest dry weight of 87.5 mg was recorded in the 1:1 v/v dilution of *Tridax procumbens* after 15 days growth. This stimulation or increased vegetative growth was removed with increasing dilution of the extract. The pH of the medium in all instances drifted from acid to basic side.

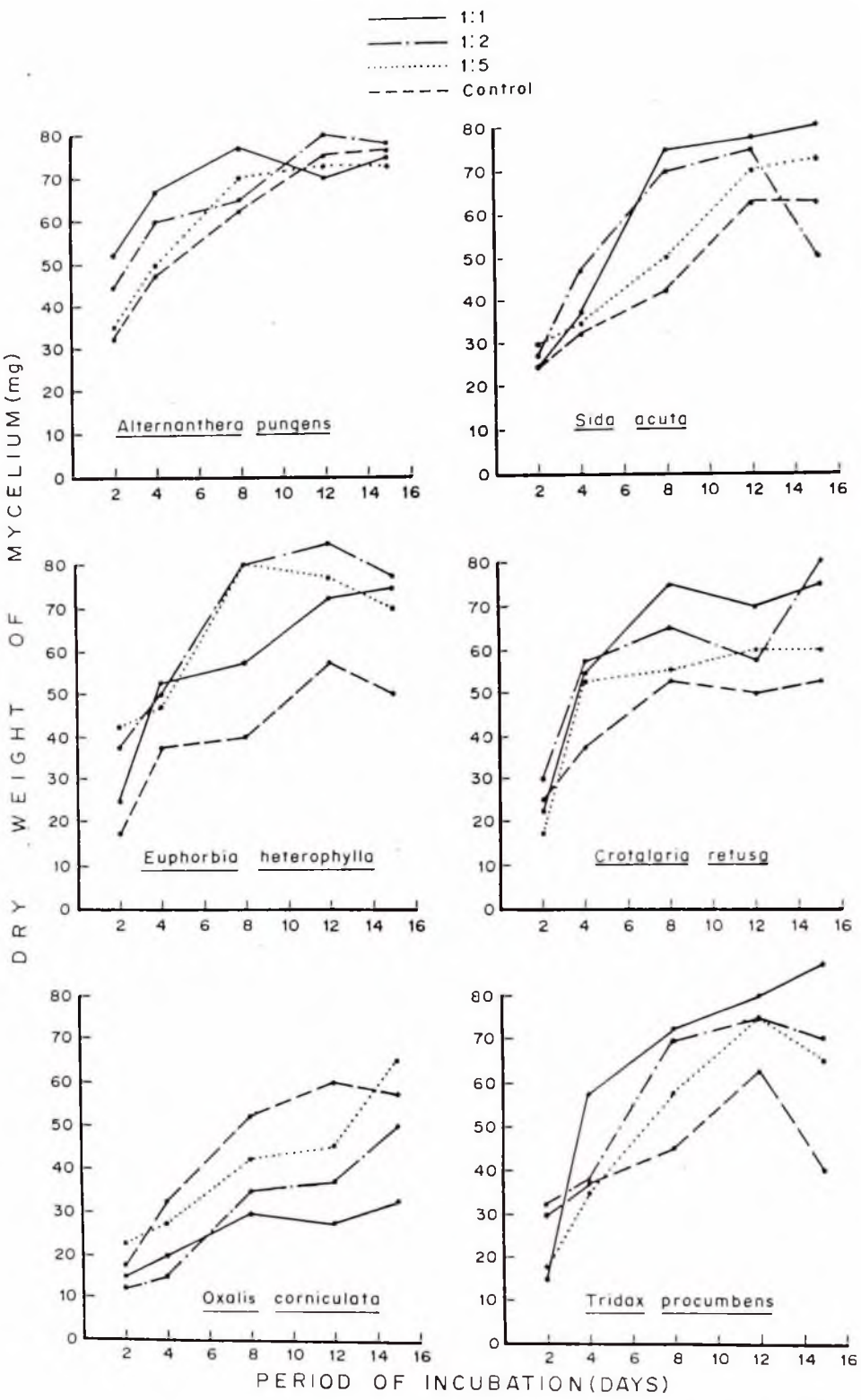


Fig.2. Vegetative growth of Scopulariopsis brevicaulis in different concentrations of water extracts of indicated plants at 30°C.

C. VEGETATIVE GROWTH OF FIVE TEST FUNGI ON AGAR (SOLID MEDIUM) AMENDED WITH WATER AND METHANOL EXTRACT OF PLANTS IN THE FAMILY COMPOSITAE.

Results obtained are summarised below:

1. *Launaea taraxacifolia*

(a) Water extract

There was no statistical difference ($p \leq 0.05$) between vegetative growth of all test fungi on agar medium in the control and in the media ammended with water extract of this plant (Fig.3). Growth of the test fungi *Scopulariopsis brevicaulis*, *Aspergillus niger*, *A. flavus*, *Sclerotium rolfsii* and *Nigrospora sp.* in the various dilutions of the extract (1:1-1:5 v/v) was close to the control. The water extract of *L. taraxacifolia* therefore does not seem to exert any inhibitory effect on the test fungi.

(b) Methanol extract

The effect of the methanol extract on the test fungi on agar medium was variable (Fig.3 and Tables 1a - 1e). The methanol extract (1:1 v/v dilution) of *L. taraxacifolia* depressed vegetative growth of *S. brevicaulis* by about 67.0 per cent, *A flavus* by about 34.0 per cent and *Nigrospora sp.* by about 51.5 per cent. Its effect on *S. rolfsii* was neglegible. Statistical analysis of the results are presented in Tables 1a - 1e.

2. *Tridax procumbens*

(a) Water extract

Except for *S. brevicaulis* there was no statistical difference ($p \leq 0.05$) between vegetative growth of the other test fungi in the control and in the media amended with the

water extract of *T. procumbens* (Fig. 4; Tables 2a-2e). The water extract (1:1 v/v dilution) depressed vegetative growth of *S. brevicaulis* by about 36.5 per cent (Plate 2).

(a) Methanol extract

The methanol extract of this plant had significant inhibitory effect on the vegetative growth of *S. brevicaulis*, *A. niger* and *S. rolfsii* ($p \leq 0.05$) in all dilutions (Fig. 4; Tables 3a - 3e). Extracts of 1:1 v/v dilution depressed growth of *S. brevicaulis*, *A. niger* and *S. rolfsii* by 25.0, 28.6 and 38.0 per cent respectively.

Vegetative growth of *A. flavus* in medium ammended with methanol extract did not differ significantly from what obtained in the unammended control. The methanol extract of *T. procumbens* enhanced the vegetative growth of *Nigrospora sp.*

3. *Aspilia africana*

Both the water and the methanol extracts of this plant had no significant inhibitory effect on the vegetative growth of the five test fungi (Fig. 5; Tables 4a - 4e). The water extract on the other hand improved vegetative growth of *S. brevicaulis* (Plate 3), *A. niger* and *A. flavus*; the methanol extract enhanced growth of *S. brevicaulis* (Fig. 5).

4. *Emilia sonchifolia*

Both the water and the methanol extracts suppressed vegetative growth of *S. brevicaulis*. Water extract of 1:1 v/v dilution depressed growth of the fungus by about 23.2 per cent while the methanol extract depressed its growth by 11.9 per cent.

Plate 2. Vegetative growth of Scopulariopsis brevicaulis in nutrient medium ammended with indicated concentrations of water extract of Tridax procumbens at 30 °C. (Note the depression of vegetative growth in 1:1 and 1:2 v/v concentrations after 8 days.)

Plate 3. Vegetative growth of Scopulariopsis brevicaulis in nutrient medium ammended with indicated concentrations of water extract of Aspilia africana at 30°C for 8 days.

Growth of the other fungi (*A. niger, A. flavus, S. rolfsii* and *Nigrospora sp.*) was not very much affected by any of the concentrations of the two extracts.

5. *Synedrella nodiflora*

(a) Water extract

The extract had no significant inhibitory effect on the vegetative growth of the test fungi.

(b) Methanol extract

The effect of the extract was significant on the vegetative growth of *S. rolfsii*. Extract of 1:1 v/v dilution depresed growth of the fungus by 31.2 per cent. The effect on the other fungi can be described as marginal.

6. *Chromolaena odorata*

(a) Water extract

The water extract depressed vegetative growth to different extent depending on the fungus. Effect on *S. rolfsii* was marginal, but it suppressed growth of *Nigrospora sp.* by 14.1 per cent. Vegetative growth of *A. niger* and *A. flavus* after 7 days was depressed by 10.3 and 13.5 per cent respectively.

(b) Methanol extract

The effect of the extract on vegetative growth of the test fungi also varied. Depression of vegetative growth was highest on *A. flavus* (19.6 per cent). This was followed by that of *S. rolfsii* (12.5 per cent), and by *Nigrospora sp.* (12.1 per cent) and *S. brevicaulis* (11.8 per cent) (Fig. 8).

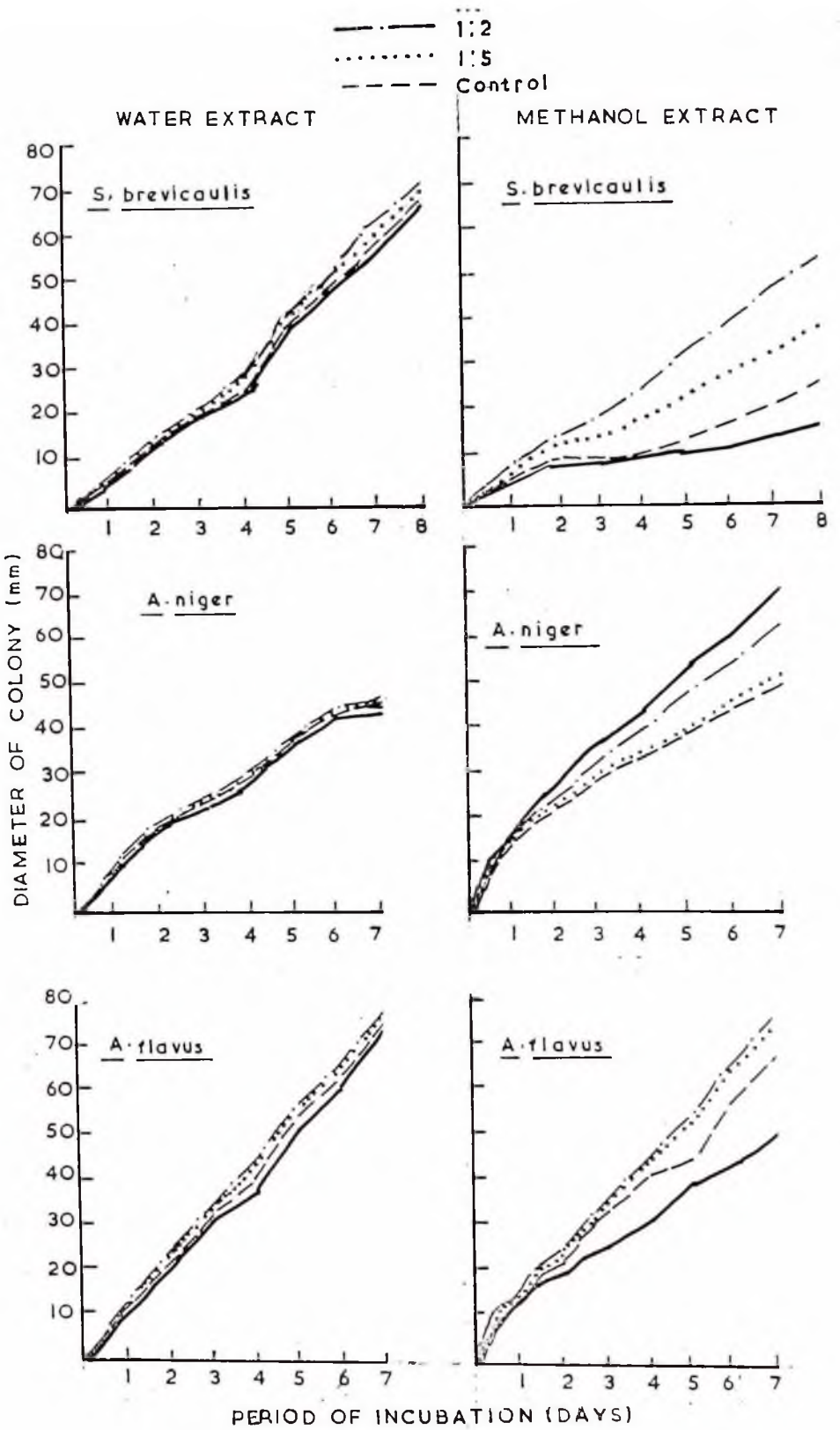


Fig.3. Effect of varying dilutions of water and methanol extracts of Launaea (Lactuca) taraxacifolia on vegetative growth of indicated fungi.

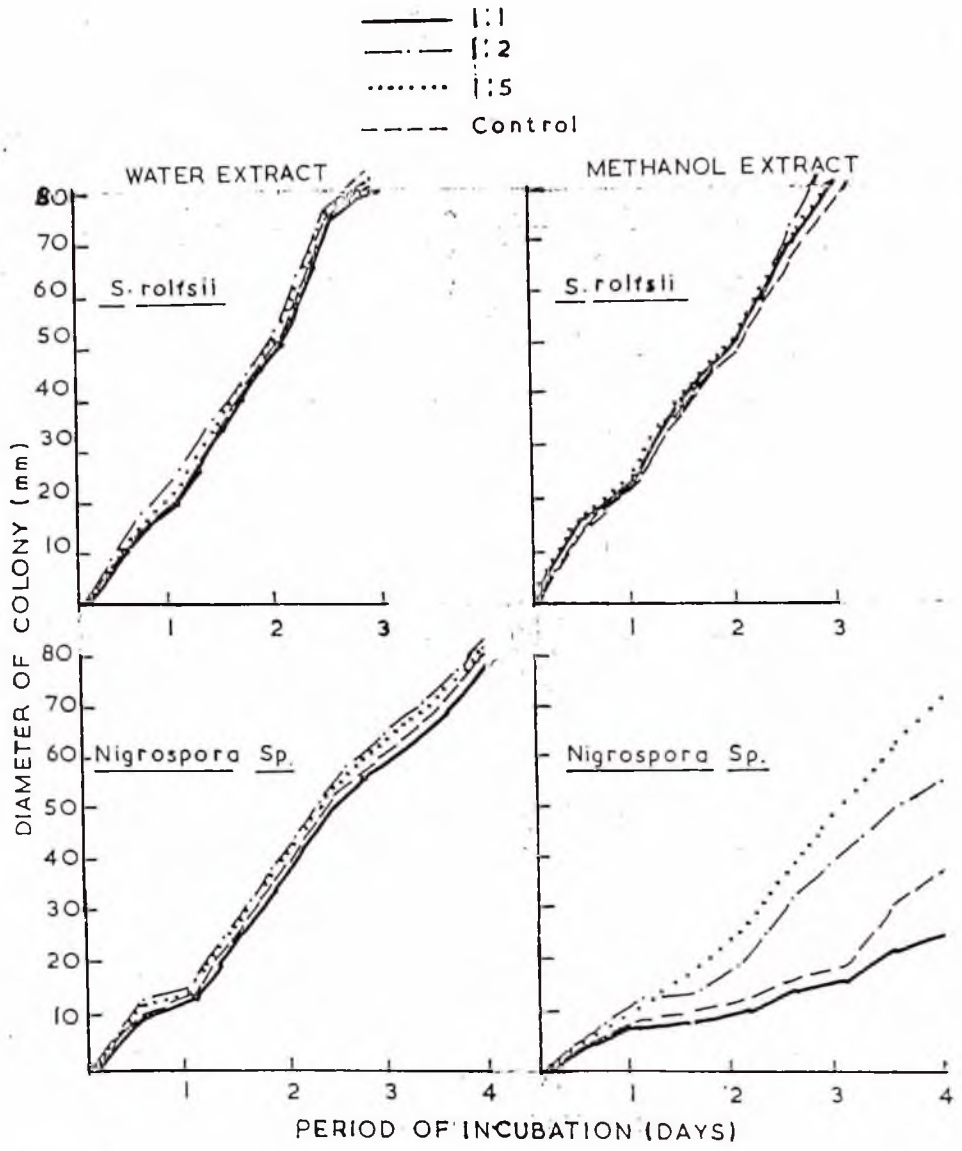


Fig.3. (Cont'd). Effect of varying dilutions of water and methanol extracts of Launaea (Lactuca) taraxacifolia on vegetative growth of indicated fungi.

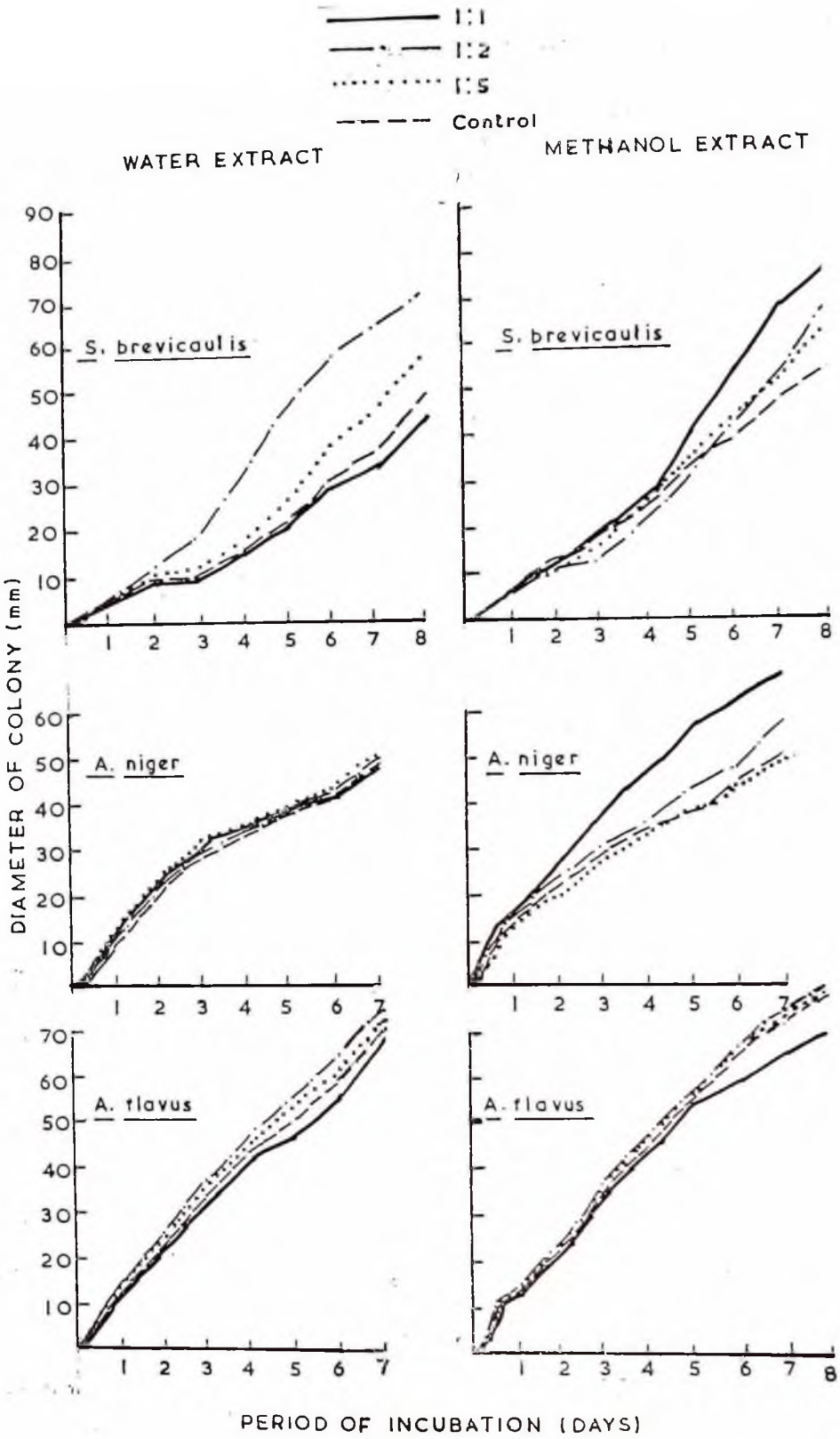


Fig.4. Effect of varying dilutions of water and methanol extracts of Tridax procumbens on vegetative growth of indicated fungi.

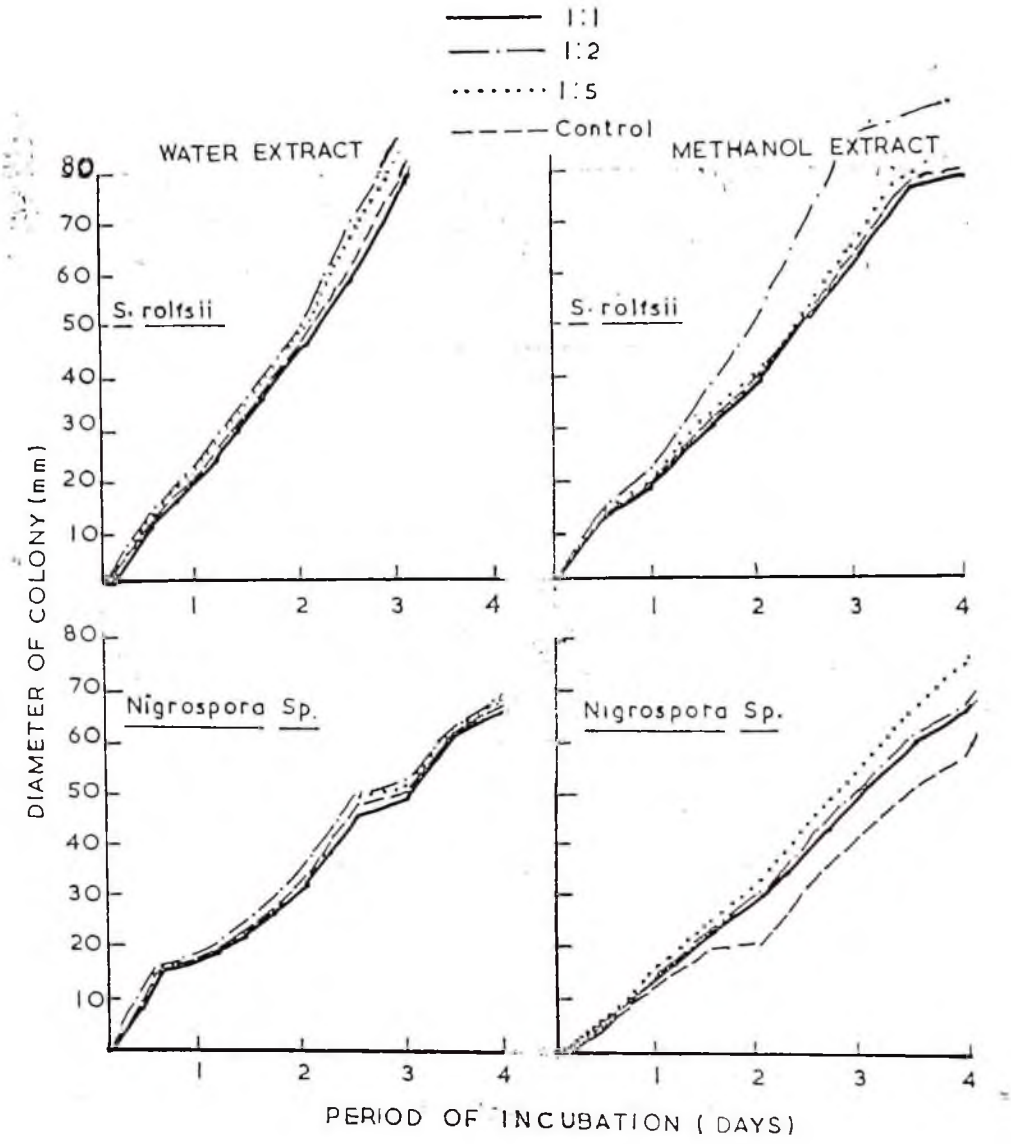


Fig.4 (Cont'd). Effect of varying dilutions of water and methanol extracts of Tridax procumbens on vegetative growth of indicated fungi.

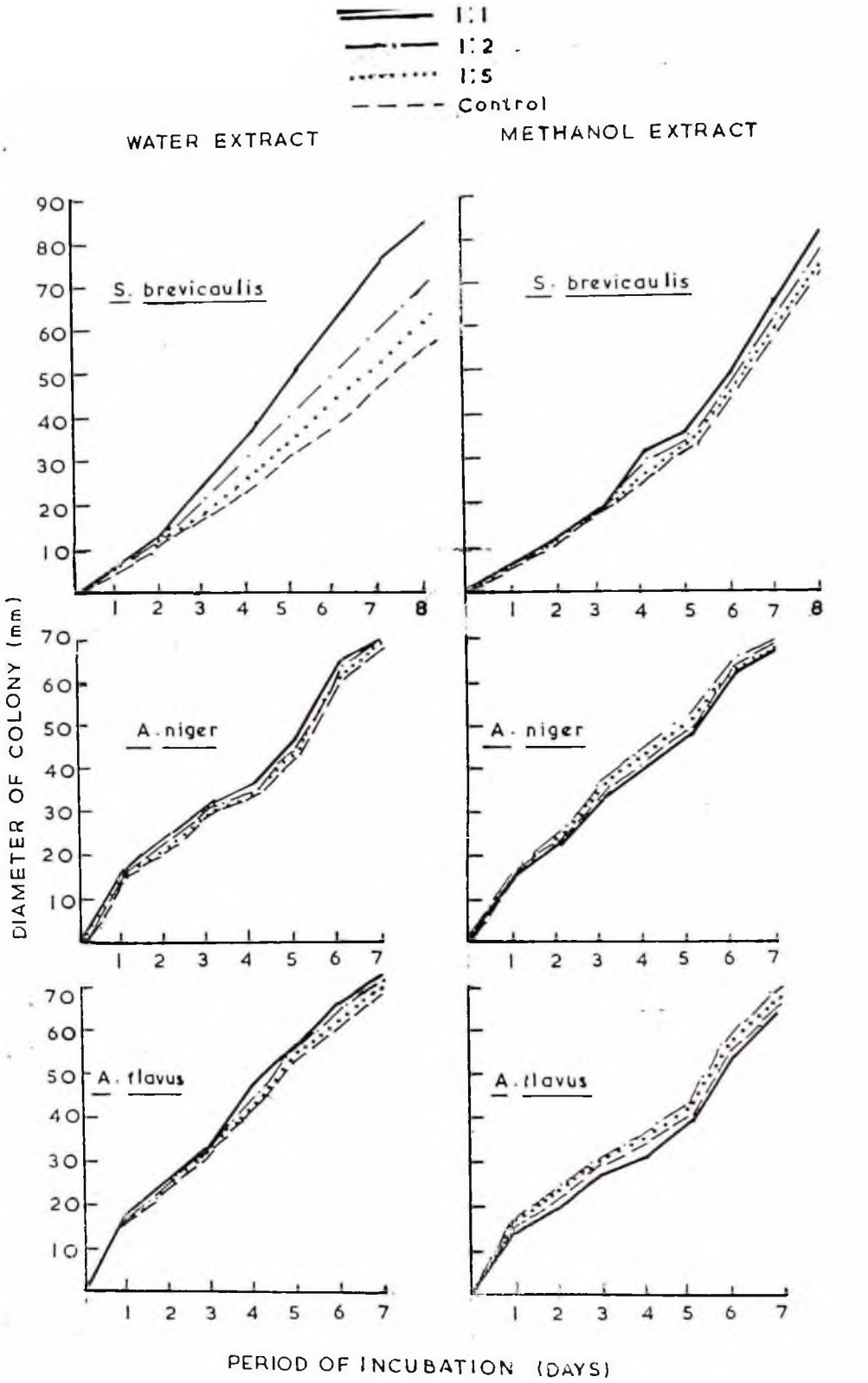


Fig.5. Effect of varying dilutions of water and methanol extracts of Aspilia africana on vegetative growth of indicated fungi.

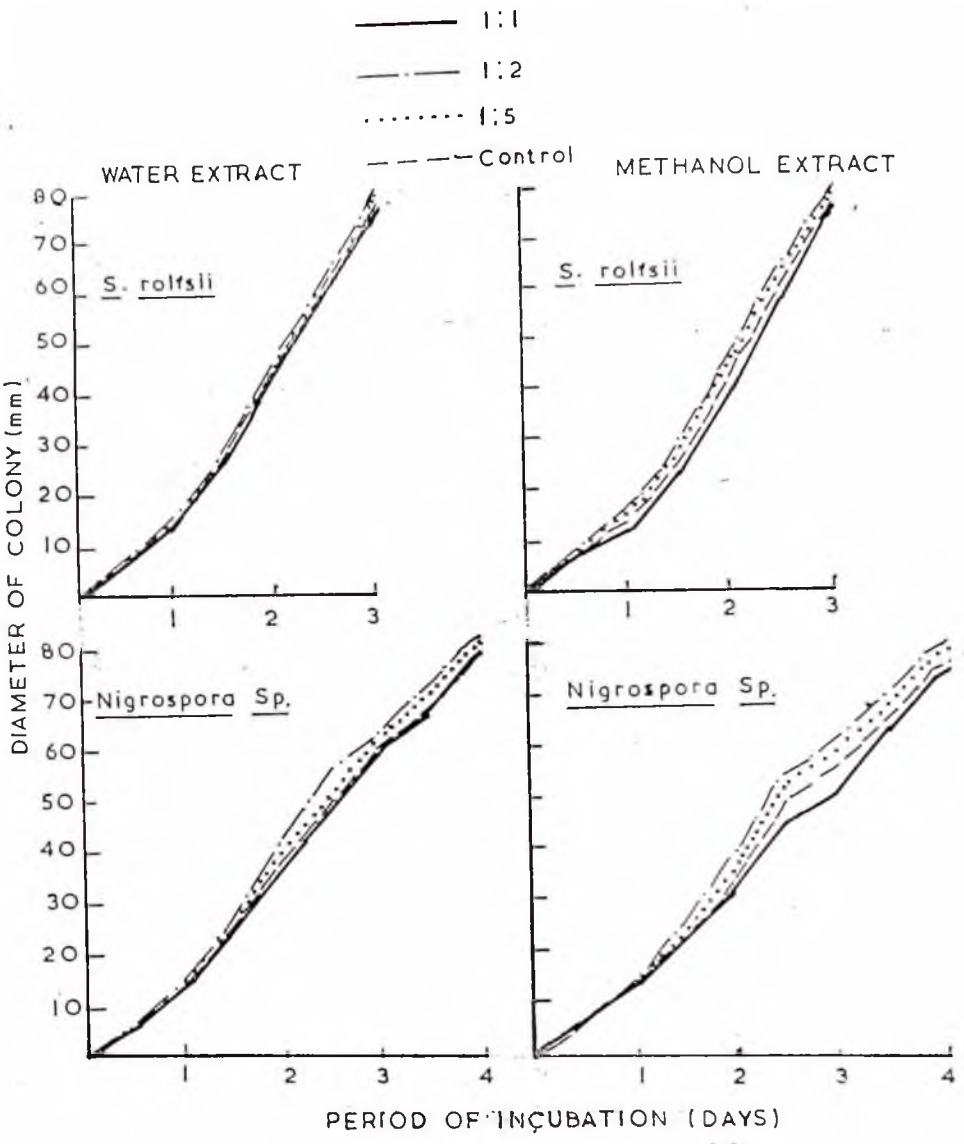


Fig.5 (Cont'd). Effect of varying dilutions of water and methanol extracts of Aspilia africana on vegetative growth of indicated fungi.

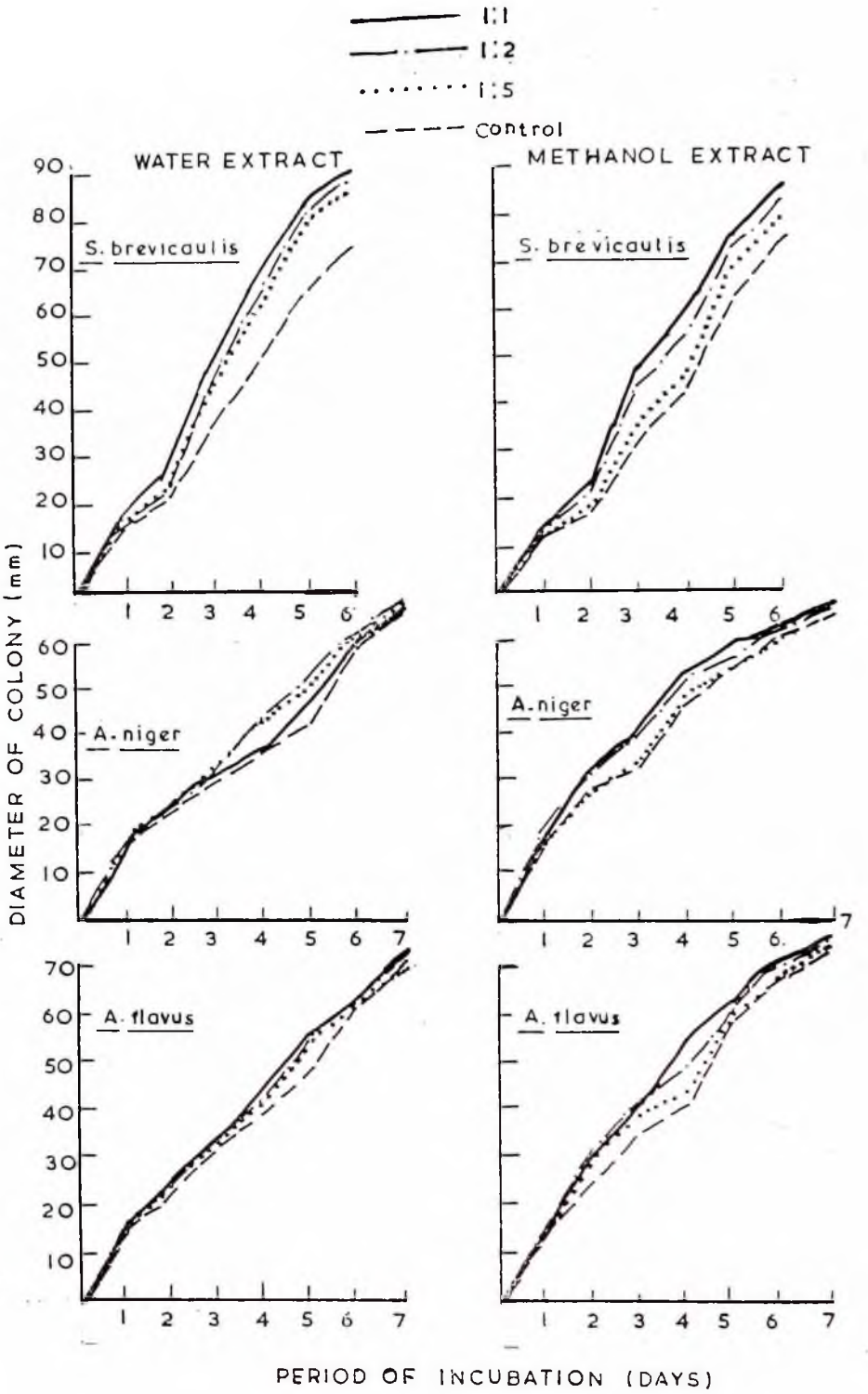


Fig.6. Effect of varying dilutions of water and methanol extracts of Emilia sonchifolia on vegetative growth of indicated fungi.

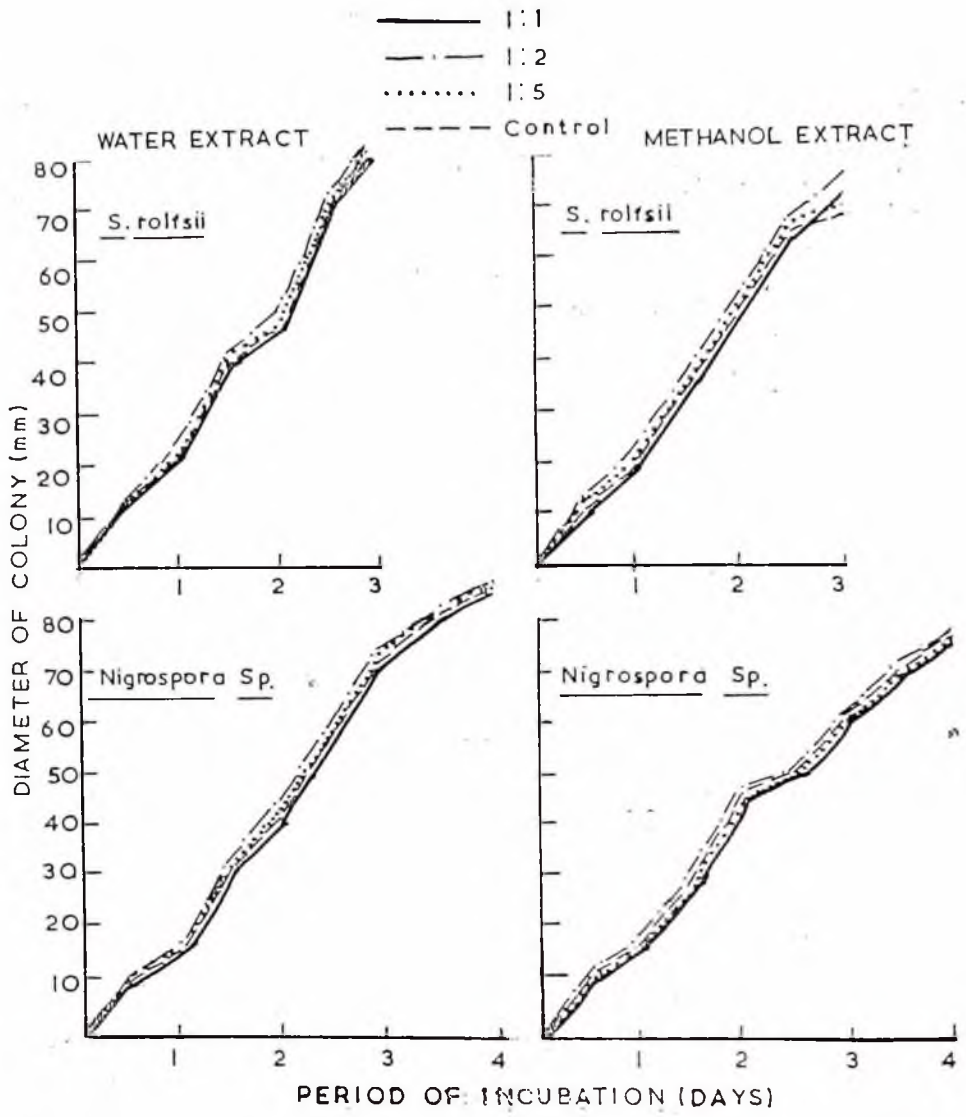


Fig.6 (Cont'd). Effect of varying dilutions of water and methanol extracts of Emilia sonchifolia on vegetative growth of indicated fungi.

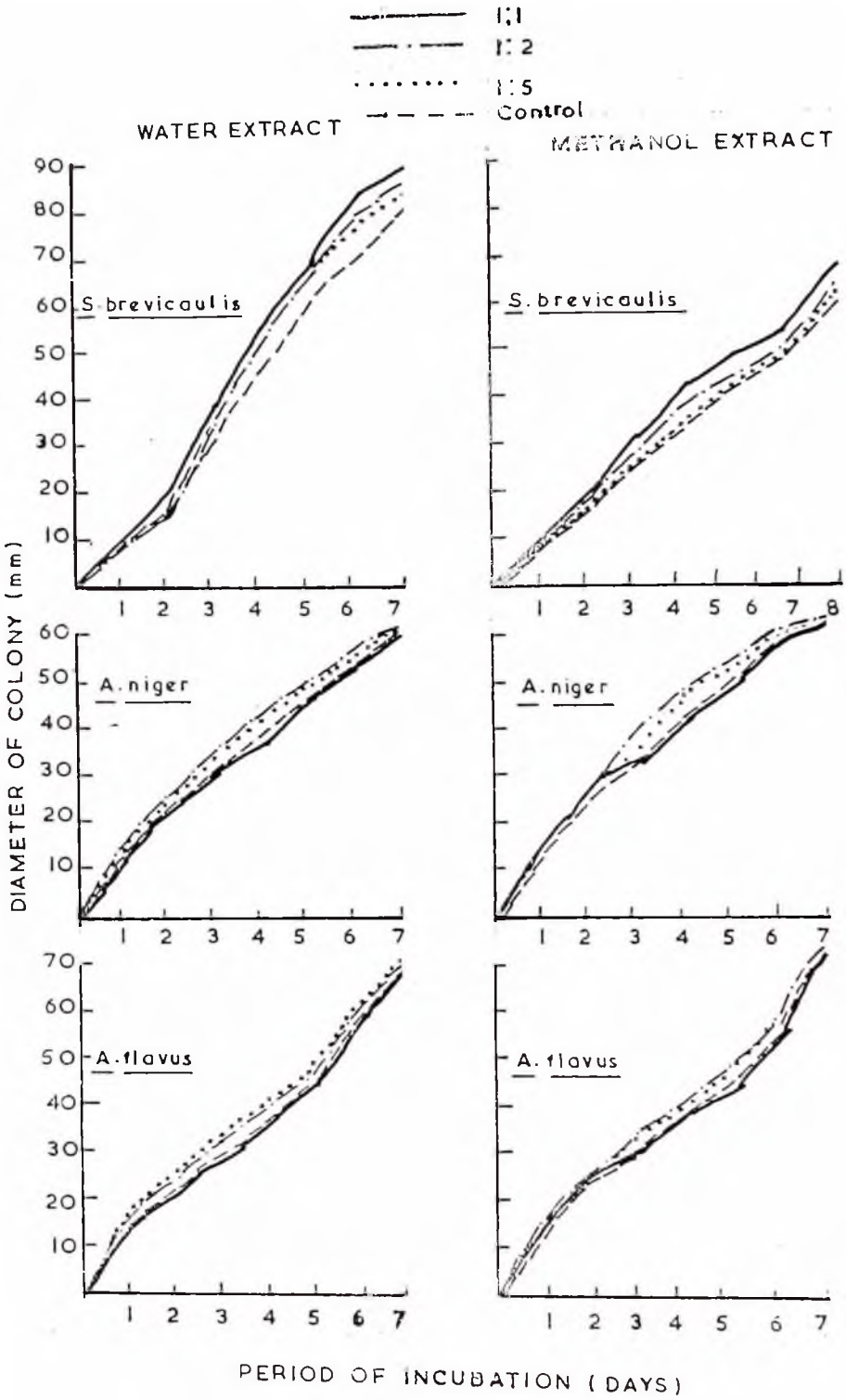


Fig.7. Effect of varying dilutions of water and methanol extracts of Synedrella nodiflora on vegetative growth of indicated fungi.

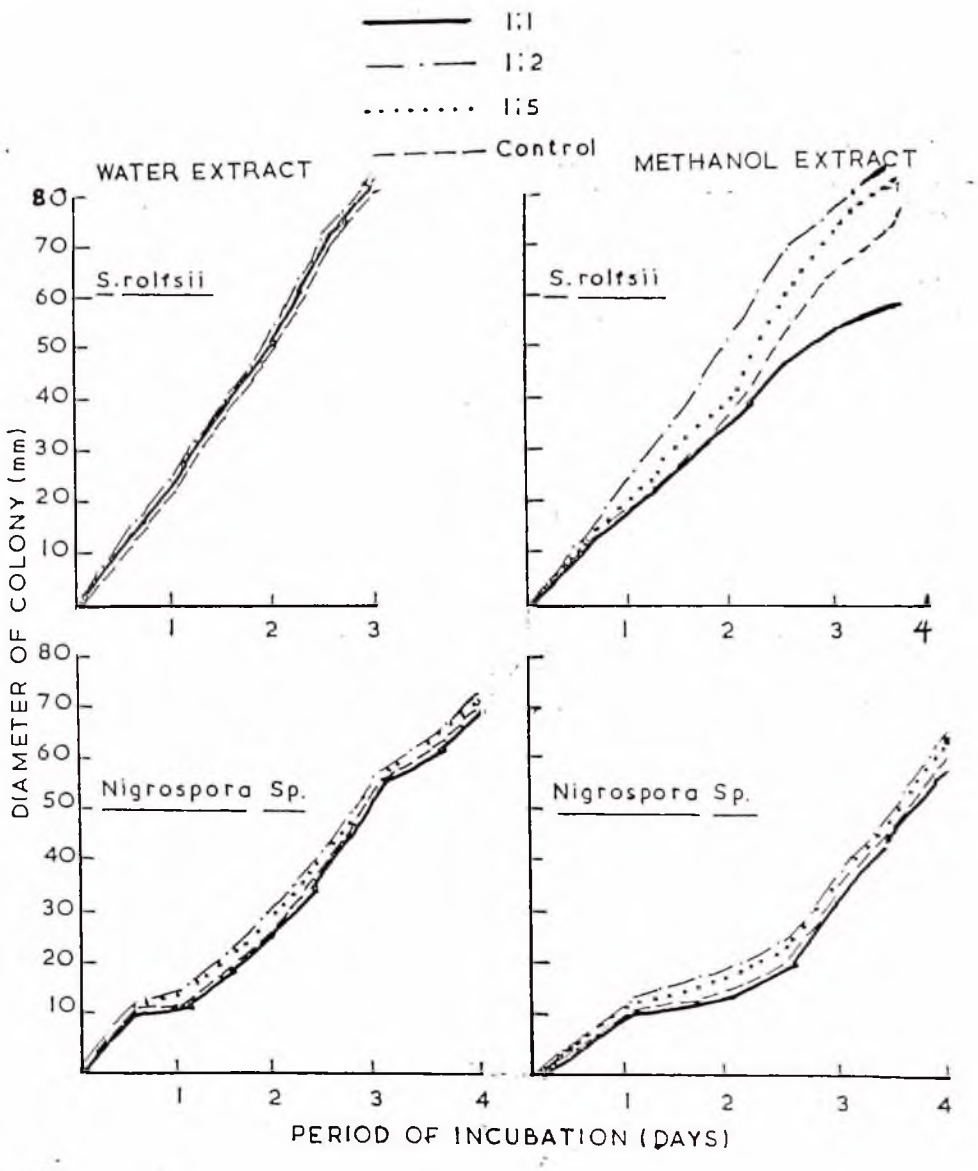


Fig.7 (Cont'd). Effect of varying dilutions of water and methanol extracts of Synedrella nodiflora on vegetative growth of indicated fungi.

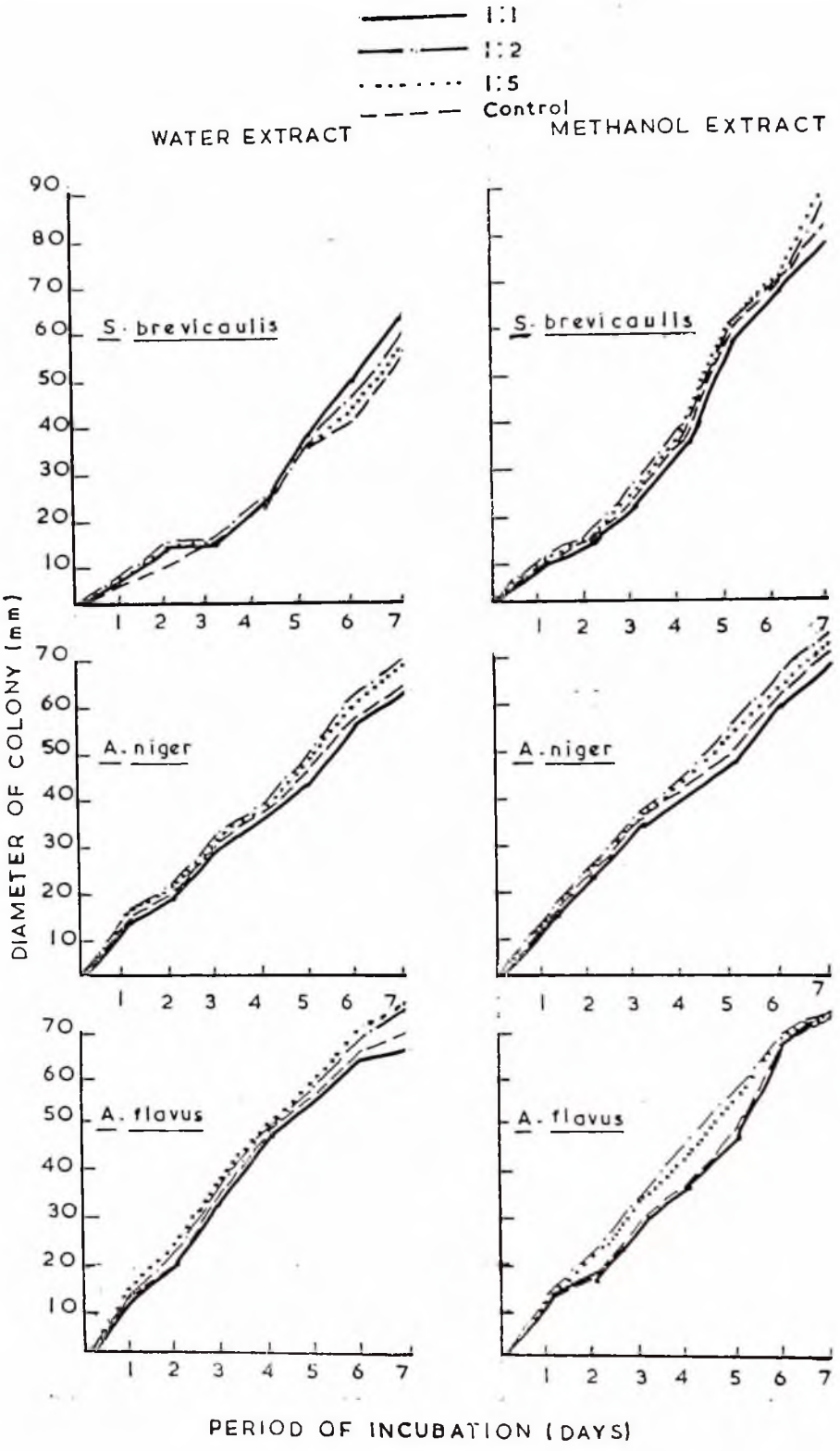


Fig.8. Effect of varying dilutions of water and methanol extracts of Chromolaena odorata on vegetative growth of indicated fungi.

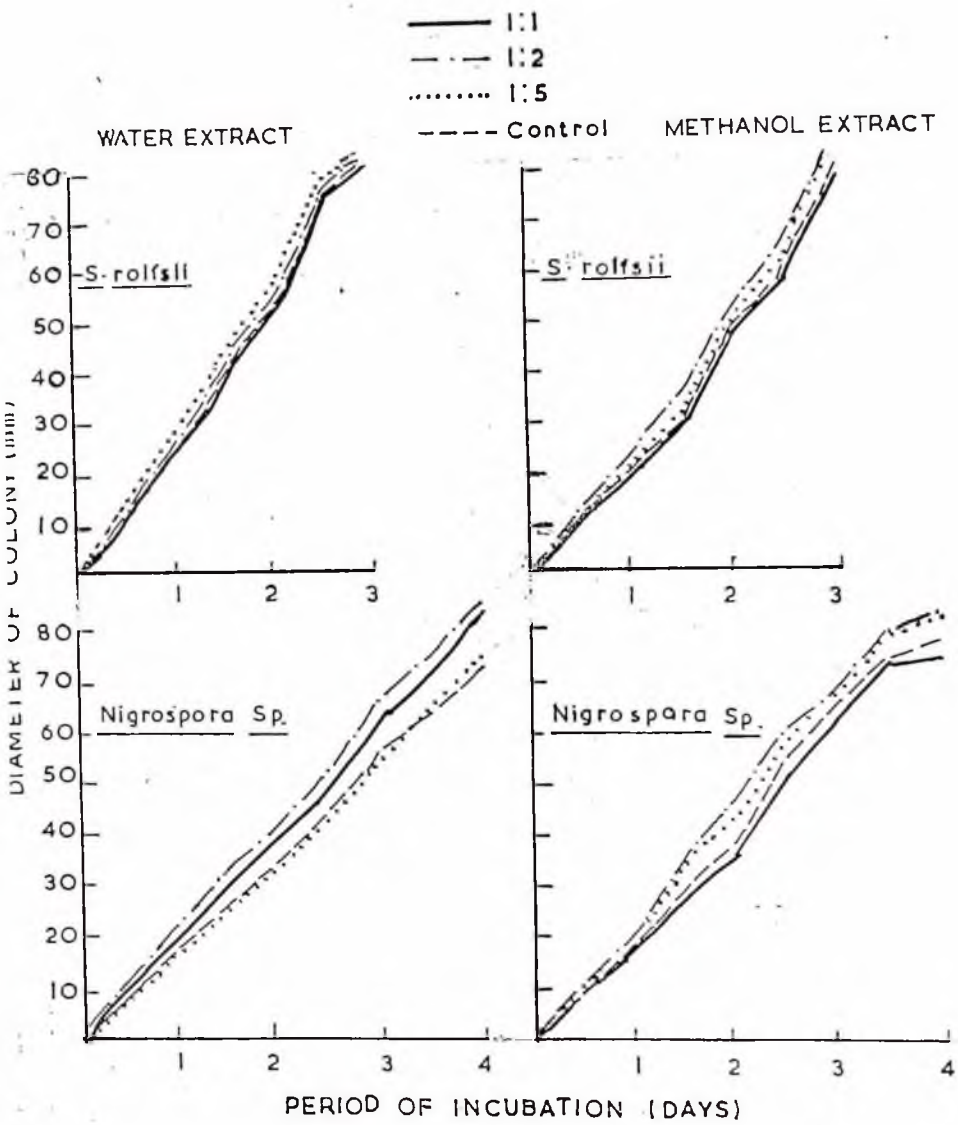


Fig.8 (Cont'd). Effect of varying dilutions of water and methanol extracts of Chromolaena odorata on vegetative growth of indicated fungi.

TABLE 1a

thanol extract of *Launaea taraxacifolia* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	43	9839.55		
	10	6616.30	661.630	22.61
ract	3	2345.32	781.773	26.71
	30	877.93	29.264	
ty	1	586.28	586.277	58.30
	29	291.65	10.057	
	Table F-value at	p = 0.05 is 2.92 p = 0.01 is 4.51		

TABLE 1b

thanol extract of *Launaea taraxacifolia* on vegetative growth of *Aspergillus niger* at 35°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	39	9380.27		
	9	8567.65	951.961	88.54
ract	3	522 32	174.108	16.19
	27	290.30	10.752	
ty	1	280.24	280.244	724.57
	26	10.06	0.387	
	Table F-value at	p = 0.05 is 2.96 p = 0.01 is 4.60		

TABLE 1c

thanol extract of *Launaea taraxacifolia* on vegetative growth of *Aspergillus flavus* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	39	14959.19		
	9	13790.26	1532.251	84.25
tract	3	677.87	225.956	12.42
	27	491.07	18.188	
ity	1	469.08	469.081	28.62
	26	21.99	0.846	
	Table F-value at	p = 0.05 is 2.96 p = 0.01 is 4.60		

TABLE 1d

thanol extract of *Launaea taraxacifolia* on vegetative growth of *Sclerotium rolfsii* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	23	13709.83		
	5	13605.71	2721.142	589.06
ract	3	34.83	11.611	2.51
	15	69.29	4.619	
ity	1	44.31	44.311	24.83
	14	24.98	1.784	
	Table F-value at	p = 0.05 is 3.29 p = 0.01 is 5.42		

TABLE 1e

ethanol extract of *Launaea taraxacifolia* on vegetative growth of *Nigrospora sp.* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	35	19451.19		
	8	12395.88	1549.484	11.23
tract	3	3744.58	1248.192	9.05
	24	3310.74	137.947	
ity	1	978.75	978.753	9.65
	23	2331.98	101.391	
	Table F-value at	p = 0.05 is 3.01 p = 0.01 is 4.72		

TABLE 2a

of water extract of *Tridax procumbens* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C.

of on	Degrees of freedom	Sum of squares	Mean square	F-value
	31	15148.47		
ates	7	11680.59	1668.656	49.70
of extract	3	2762.78	920.927	27.43
	21	705.09	33.576	
dditivity	1	498 06	498.061	48.11
al	20	207.03	10.352	
	Table F-value at	p = 0.05 is 3.07 p = 0.01 is 4.87		

TABLE 2b

of water extract of *Tridax procumbens* on vegetative growth of *Aspergillus niger* at 35°C.

e of on	Degrees of freedom	Sum of squares	Mean square	F-value
	27	3686.68		
ates	6	3668.43	611.405	1388.05
of extract	3	10.32	3.440	7.81
	18	7.93	0.440	
dditivity	1	0.69	0.685	1.61
ual	17	7.24	0.426	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 2c

of water extract of *Tridax procumbens* on vegetative growth of *Aspergillus flavus* at 30°C.

e of ion	Degrees of freedom	Sum of squares	Mean square	F-value
	27	10335.93		
cates	6	10199.30	1699.884	828.97
of extract	3	99.71	33.238	16.21
	18	36.91	2.051	
additivity	1	23.16	23.165	28.62
ual	17	13.76	0.809	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 2d

ect of water extract of *Tridax procumbens* on vegetative growth of *Sclerotium rolfsii* at 30°C.

ırce of iation	Degrees of freedom	Sum of squares	Mean square	F-value
tal	23	12937.33		
plicates	5	12760.21	2552.042	487.39
nc. of extract	3	98.58	32.861	6.28
or	18	78.54	5.236	
n-additivity	2	62.27	65.266	68.83
sidual	17	19.28	0.948	

Table F-value at p = 0.05 is 5.42
p = 0.01 is 3.29

TABLE 2e

ect of methanol extract of *Tridax procumbens* on vegetative growth of *Nigrospora sp.* at 30°C.

ırce of iation	Degrees of freedom	Sum of squares	Mean square	F-value
tal	35	17216.50		
plicates	8	17164.50	2165.663	30.94
nc. of extract	3	35.39	11.795	17.04
or	24	19.61	0.692	
n-additivity	1	1.28	1.284	1.93
sidual	23	15.33	0.866	

Table F-value at p = 0.05 is 3.01
p = 0.01 is 4.72

TABLE 3a

ffect of methanol extract of *Tridax procumbens* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C.

ource of ariation	Degrees of freedom	Sum of squares	Mean square	F-value
otal	43	26249.70		
eplicates	10	24960.76	2496.076	90.32
onc. of extract	3	459.34	153.278	5.55
rror	30	829.10	27.637	
on-additivity	1	591.14	591.141	72.04
esidual	29	236.96	8.206	

Table F-value at p = 0.05 is 2.92
p = 0.01 is 4.51

TABLE 3b

ffect of methanol extract of *Tridax procumbens* on vegetative growth of *Aspergillus niger* at 35°C.

ource of ariation	Degrees of freedom	Sum of squares	Mean square	F-value
otal	29	9073.90		
eplicates	9	8106.27	900.697	69.71
onc. of extract	3	618.75	206.250	15.96
rror	27	348.88	12.921	
on-additivity	1	314.68	314.684	239.29
esidual	26	34.19	1.315	

Table F-value at p = 0.05 is 2.96
p = 0.01 is 4.60

TABLE 3c

ffect of methanol extract of *Tridax procumbens* on vegetative growth of *Aspergillus flavus* at 30°C.

ource of ariation	Degrees of freedom	Sum of squares	Mean square	F-value
otal	39	17707.60		
eplicates	9	17531.73	1947.969	494.20
onc. of extract	3	69.45	23.150	5.87
rror	27	106.42	3.942	
on-additivity	1	75.58	75.583	63.72
esidual	26	30.84	1.186	

Table F-value at p = 0.05 is 2.96
p = 0.01 is 4.60

TABLE 3d

fect of methanol extract of *Tridax procumbens* on vegetative growth of *Sclerotium rolfsii* at 30°C.

urce of riation	Degrees of freedom	Sum of squares	Mean square	F-value
tal	23	9929.99		
plicates	5	8969.55	1793.910	66.10
inc. of extract	13	553.36	184.455	6.80
ror	15	407.07	27.138	
on-additivity	1	386.96	386.960	269.34
sidual	14	20.11	1.437	

Table F-value at p = 0.05 is 3.29
p = 0.01 is 5.42

TABLE 3e

fect of methanol extract of *Tridax procumbens* on vegetative growth of *Nigrospora sp.* at 30°C.

urce of riation	Degrees of freedom	Sum of squares	Mean square	F-value
tal	31	14749.72		
plicates	7	13948.22	1992.603	309.03
inc. of extract	3	666.09	222.031	34.48
ror	21	135.41	6.448	
on-additivity	1	100.41	100.414	57.39
sidual	20	34.99	1.750	

Table F-value at p = 0.05 is 3.07
p = 0.01 is 4.87

TABLE 4a

ect of water extract of *Aspilia africana* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C.

urce of iation	Degrees of freedom	Sum of squares	Mean square	F-valu
tal	31	15558.43		
plicates	7	13684.74	1954.963	104.94
nc. of extract	9	1482.46	494.154	26.52
or	21	391.23	18.630	
n-additivity	1	303.00	302.996	68.68
sidual	20	88.23	4.412	

Table F-value at p = 0.05 is 3.07
p = 0.01 is 4.87

TABLE 4b

ect of water extract of *Aspilia africana* on vegetative growth of *Aspergillus niger* at 35°C.

urce of iation	Degrees of freedom	Sum of squares	Mean square	F-valu
tal	27	9567.74		
plicates	6	9534.80	1589.134	1975.15
nc. of extract	3	18.46	6.152	7.65
or	18	14.48	0.805	
n-additivity	1	6.30	6.300	13.09
sidual	17	8.18	0.481	

Table F-value at p = 0.05 is 3.29
p = 0.01 is 5.42

TABLE 4c

fect of water extract of *Aspilia africana* on vegetative growth of *Aspergillus flavus* at 30°C.

urce of iation	Degrees of freedom	Sum of squares	Mean square	F-valu
tal	27	9827.24		
plicates	6	9773.18	1628.863	2047.25
nc. of extract	3	39.74	13.247	16.65
ror	18	14.32	0.796	
n-additivity	1	6.08	6.080	12.54
sidual	17	8.24	0.485	

Table F-value at p = 0.05 is 3.16
p = 0.01 is 5.09

TABLE 4d

ct of water extract of *Aspilia africana* on vegetative growth of *Scleriotium rolfsii* at 30°C.

ce of ation	Degrees of freedom	Sum of squares	Mean square	F-value
l	23	14106.00		
icates	5	14095.38	2819.075	10048.19
. of extract	3	6.42	2.139	7.62
r	15	4.21	0.281	
-additivity	1	1.71	1.705	9.54
dual	14	3.50	0.179	

Table F-value at p = 0.05 is 3.29
p = 0.01 is 5.42

TABLE 4e

ct of water extract of *Aspilia africana* on vegetative growth of *Nigrospora sp.* at 30°C.

rce of ation	Degrees of freedom	Sum of squares	Mean square	F-value
al	31	18319.47		
licates	7	18212.47	2601.781	1480.44
c. of extract	3	70.09	23.365	13.29
or	21	36.91	1.757	
-additivity	1	0.05	0.050	0.03
idual	20	36.86	1.843	

Table F-value at p = 0.05 is 3.07
p = 0.01 is 4.87

D. VEGETATIVE GROWTH OF FIVE TEST FUNGI ON AGAR (SOLID MEDIUM) AMENDED WITH WATER AND METHANOL EXTRACTS OF PLANTS IN THE FAMILY LEGUMINOSAE (TRIBE PAPILIONOIDEAE AND CAESALPINOIDEAE)

Results obtained are summarised below:

1. *Crotalaria retusa* (Papilionoideae)

(a) Water extract

Effect of the water extract from *C. retusa* on the test fungi was variable (Fig.9). The depressing effect on vegetative growth of *Scopulariopsis brevicaulis, Aspergillus flavus* and *Nigrospora sp.* were significant at all the concentrations of the extract (1:1-1:5 v/v dilutions) as compared with the control. Water extract dilution (1:1 v/v) of the plant suppressed vegetative growth of *S. brevicaulis* by 20.0 per cent and that of *A. flavus* by 22.6 per cent; growth of *Nigrospora sp.* was depressed by 10.1 per cent.

Vegetative growth of *A. niger* and *Sclerotium rolfsii* in water extract at all the concectrations (1:1-1:5 v/v dilutions) were close to that in the control (unamended medium).

(b) Methanol extract

Vegetative growth of *S. brevicaulis* and *A. niger* were significantly depressed by 1:1 $^{v}/_{v}$ dilution of the extract. Growth in the 1:2 and 1:5 $^{v}/_{v}$ dilutions were close to that in the control. Radial diameter of mycelium of *A. flavus*, *S. rolfsii* and *Nigrospora sp.* in all the dilutions of the extract were also close to what obtained in the control.

2. *Desmodium triflorum* (Papilionoideae)

Both water and methanol extract were quite repressive on growth of the fungi (Fig.10; Tables 5a-5e, 6a-6e).

(a) Water extract

Vegetative growth of *A. niger, A. flavus, S. rolfsii* and *Nigrospora sp.* was significantly inhibited by this extract (Fig.10; Tables 5a - 5e). The highest effect was on *A. flavus* where vegetative growth was suppressed in the 1:1 $^{v}/_{v}$ dilution of the extract by 41.4 per cent. Radial diameter of *A. niger, S. rolfsii* and *Nigrospora sp.* was depressed by 24.2, 17.3 and 12.9 per cent respectively.

(b) Methanol extract

This extract significantly ($p \leq 0.05$) suppressed vegetative growth of *A. niger, A. flavus, S. rolfsii* and *Nigrospora sp.* (Fig.10 ; Tables 6a - 6e). The highest inhibition was 27.9 per cent on growth of *A. flavus* followed by nearly the same depression of growth of S. rolfsii (27.1 per cent). Vegetative growth of *A. niger* and *Nigrospora sp.* was depressed by 26.9 and 16.5 per cent respectively.

3. *Cassia rotundifolia* (Caesalpinoideae)

(a) Water extract

The effect of this extract on the fungi was variable (Fig.11). Vegetative growth of *S. brevicaulis* was the most affected. In the 1:1 $^{v}/_{v}$ dilution of the extract radial diameter of the

fungus was suppressed by 86.9 per cent; 1:2 $^{v}/_{v}$ and 1:5 $^{v}/_{v}$ dilutions of the extract depressed vegetative growth of *S. brevicaulis* by 32.1 and 16.6 per cent respectively. Radial diameter of *A. niger, Nigrospora sp., A. flavus* and *S. rolfsii* was depressed by 20.0, 19.0. 15.6 and 10.6 per cent respectively by 1:1 $^{v}/_{v}$ dilution of the water extract of this plant.

(b) Methanol extract

This extract also affected the test fungi to varying extent (Fig.11; Tables 7a-7e). The effects on *S. brevicaulis* and *A. flavus* were significant. The highest repression of growth by 41.1 per cent was obtained on *Nigrospora sp.*, followed by 32.8 per cent on *A. niger*. In all instances, the inhibitory effect was gradually removed with increasing dilution.

4. *Griffonia simplicifolia* (Caesalpinoideae)

(a) Water extract

Water extract (1:1 - 1:5 $^{v}/_{v}$ dilution) of *G. simplicifolia* stimulated vegetative growth of *A. niger*. Radial diameter of the fungi in the 1:1 $^{v}/_{v}$ dilution was increased by 34.3 per cent (Fig. 12; Tables 8a - 8e). Growth of the other test fungi in all dilutions of the extract was only marginally depressed as compared to what obtained in the control.

(b) Methanol extract

The extract suppressed growth of the fungi to varying extent (Fig. 12; Tables 9a - 9e). Inhibition of growth of *A. niger*, *S. rolfsii* and *A. flavus* was quite negligible. The highest inhibition of 28.6 per cent was on *Nigrospora sp.*; vegetative growth of *S. brevicaulis* was depressed by 20.8 per cent.

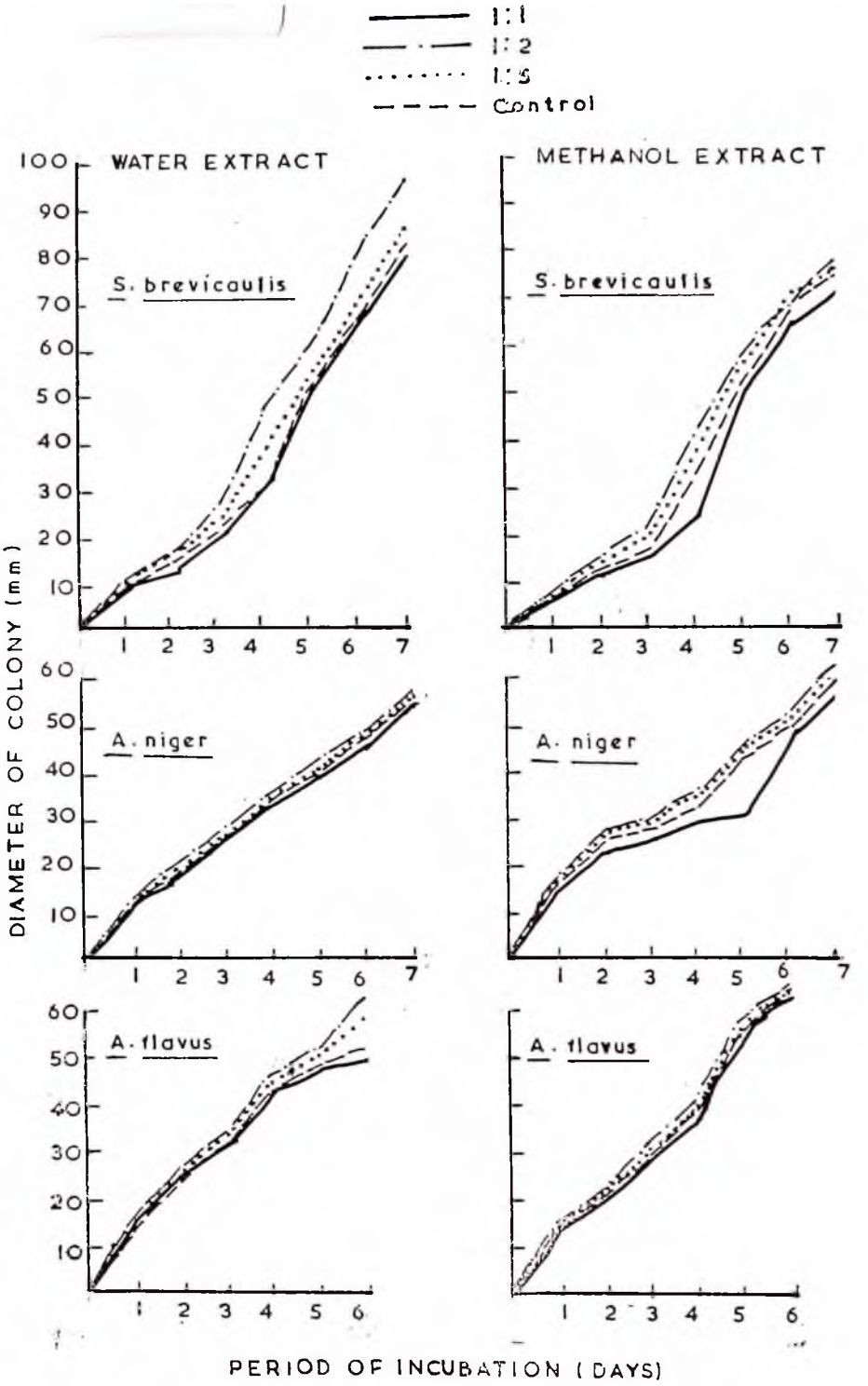


Fig.9. Effect of varying dilutions of water and methanol extracts of Crotalaria retusa on vegetative growth of indicated fungi.

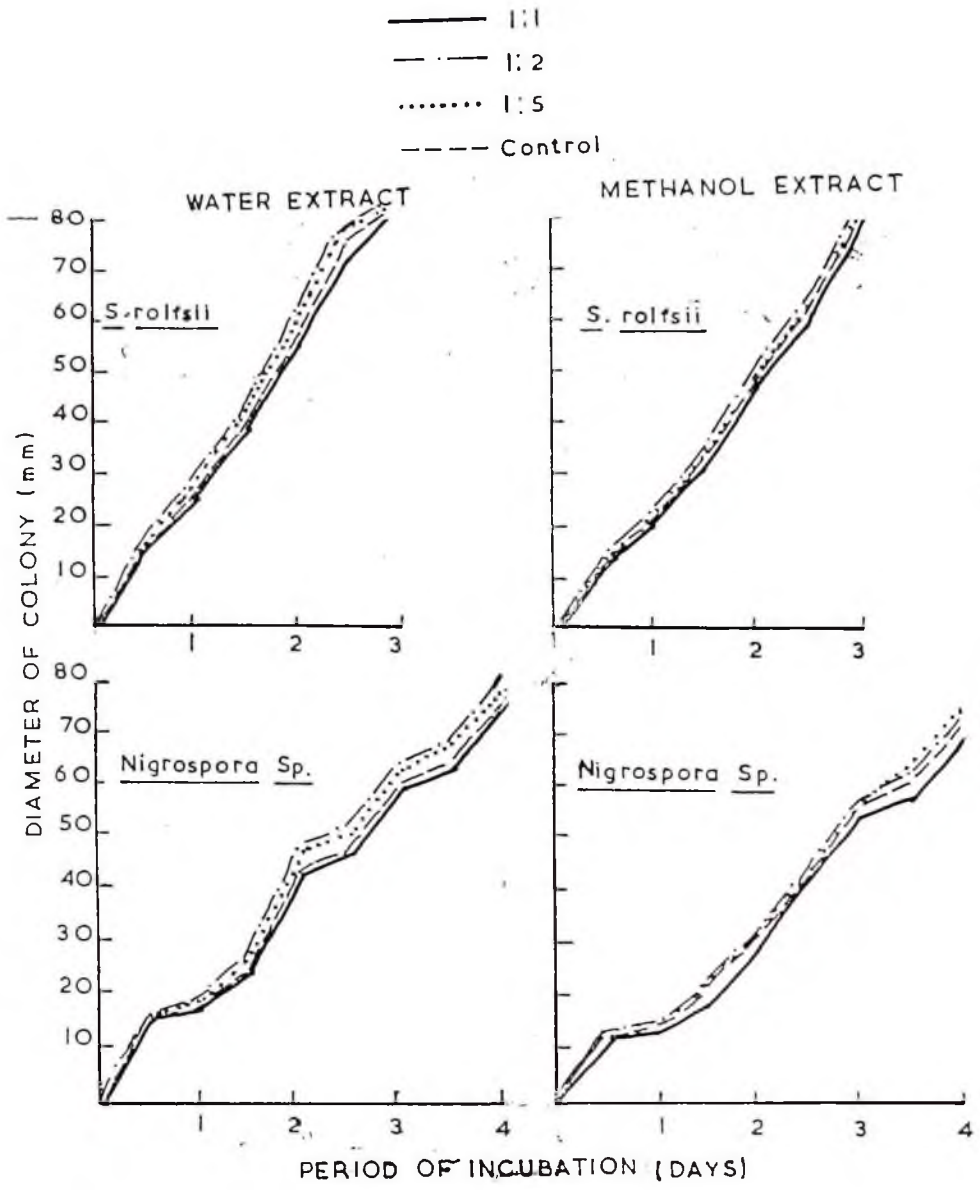


Fig.9 (Cont'd). Effect of varying dilutions of water and methanol extracts of Crotalaria retusa on vegetative growth of indicated fungi.

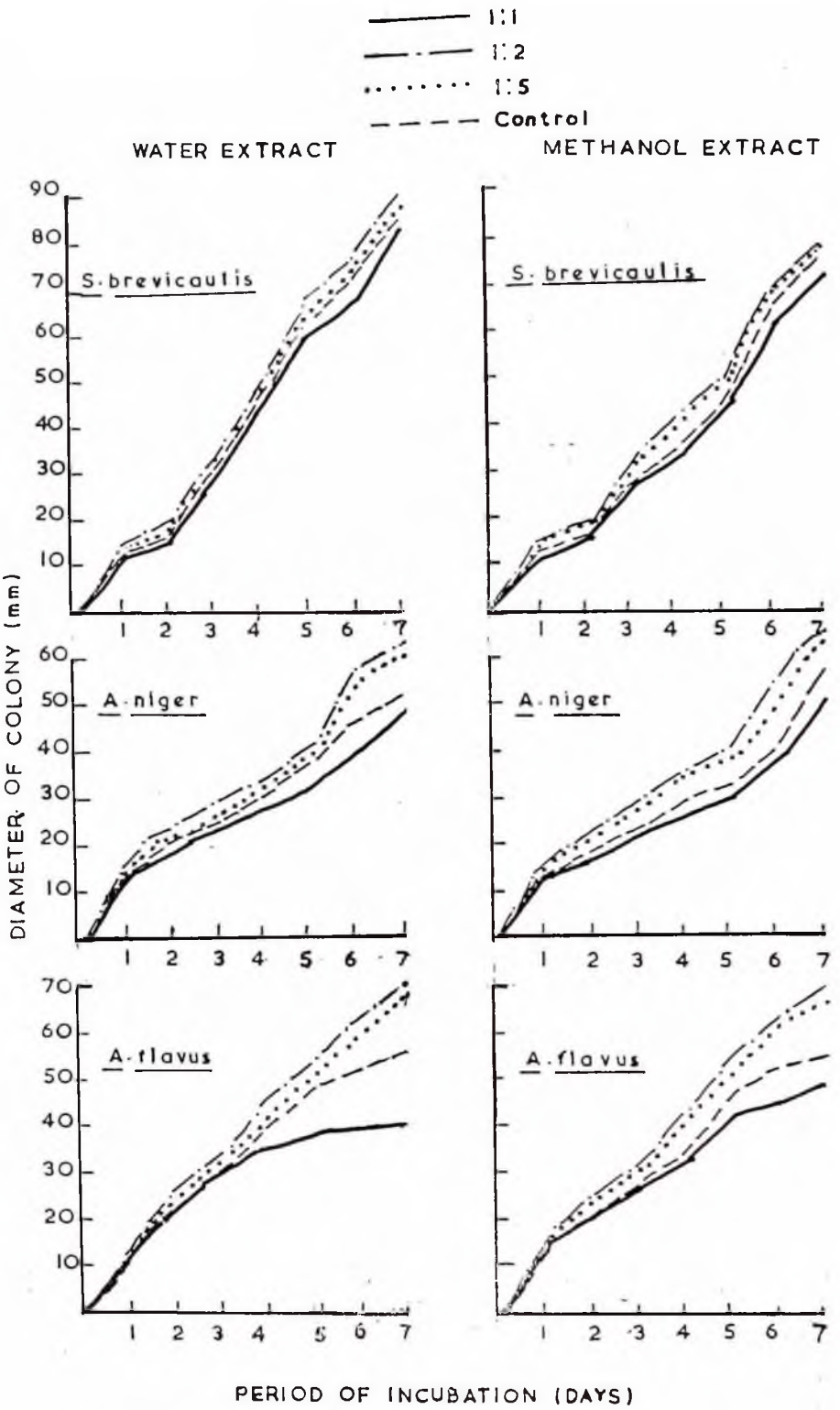


Fig.10. Effect of varying dilutions of water and methanol extracts of Desmodium trifolium on vegetative growth of indicated fungi.

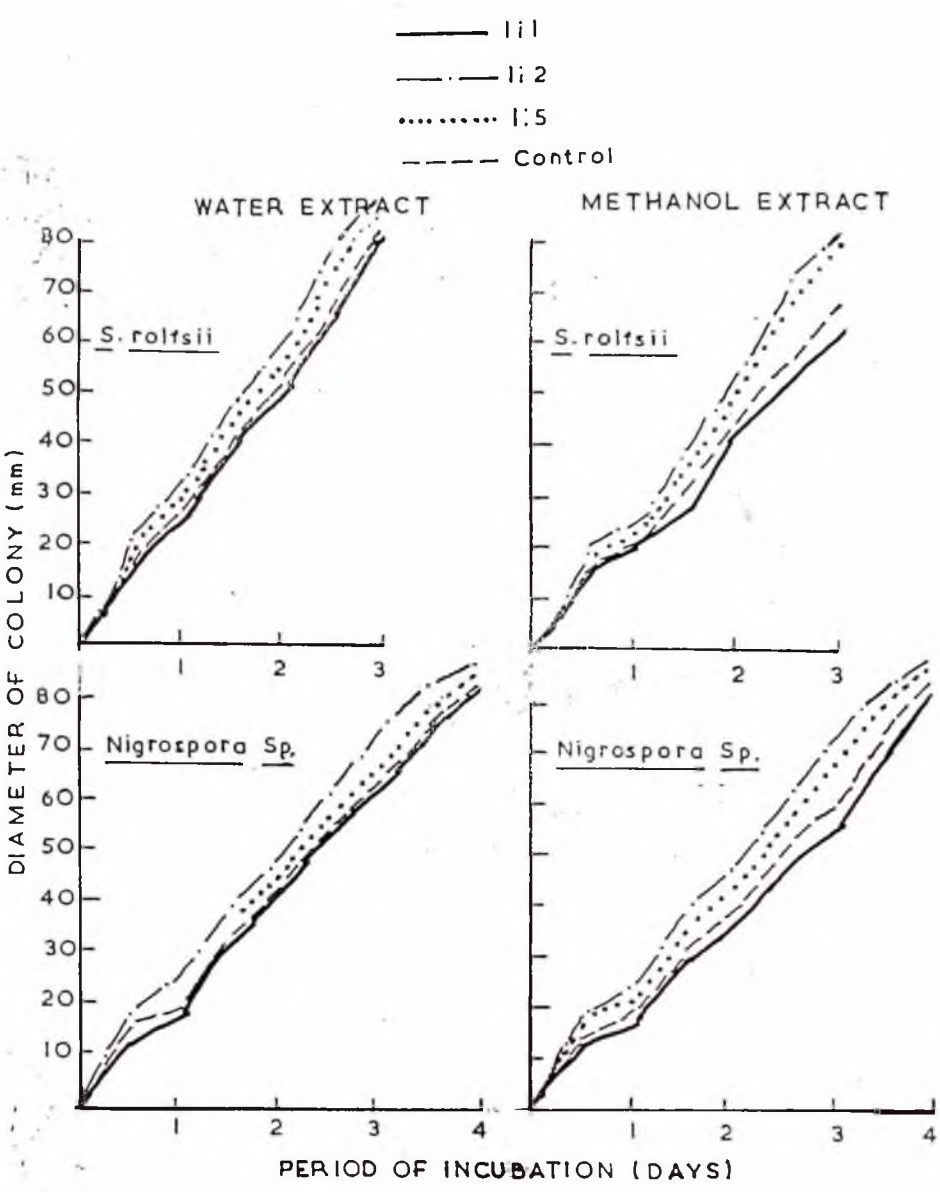


Fig.10 (Cont'd). Effect of varying dilutions of water and methanol extracts of Desmodium trifolium on vegetative growth of indicated fungi.

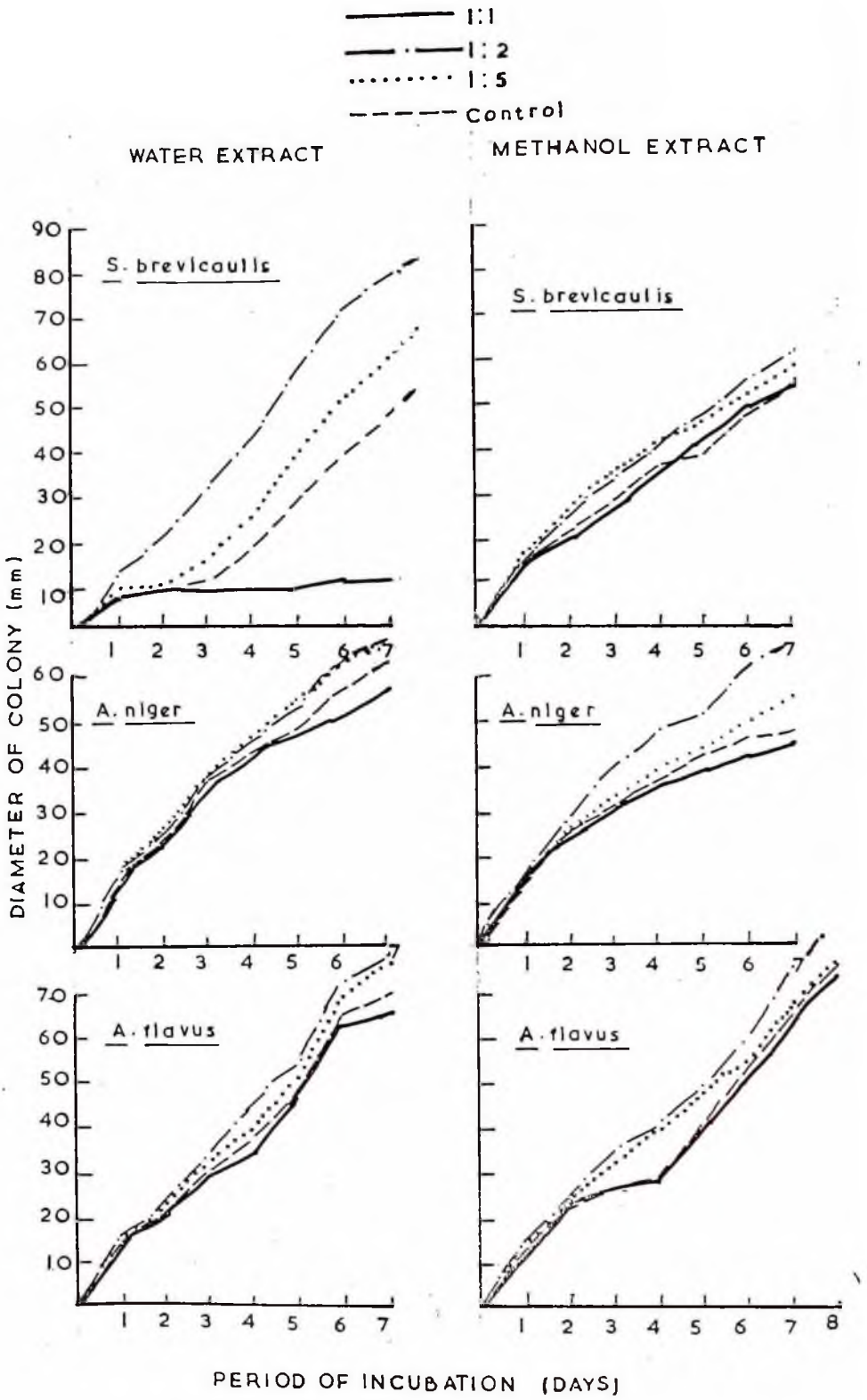


Fig.11. Effect of varying dilutions of water and methanol extracts of Cassia rotundifolia on vegetative growth of indicated fungi.

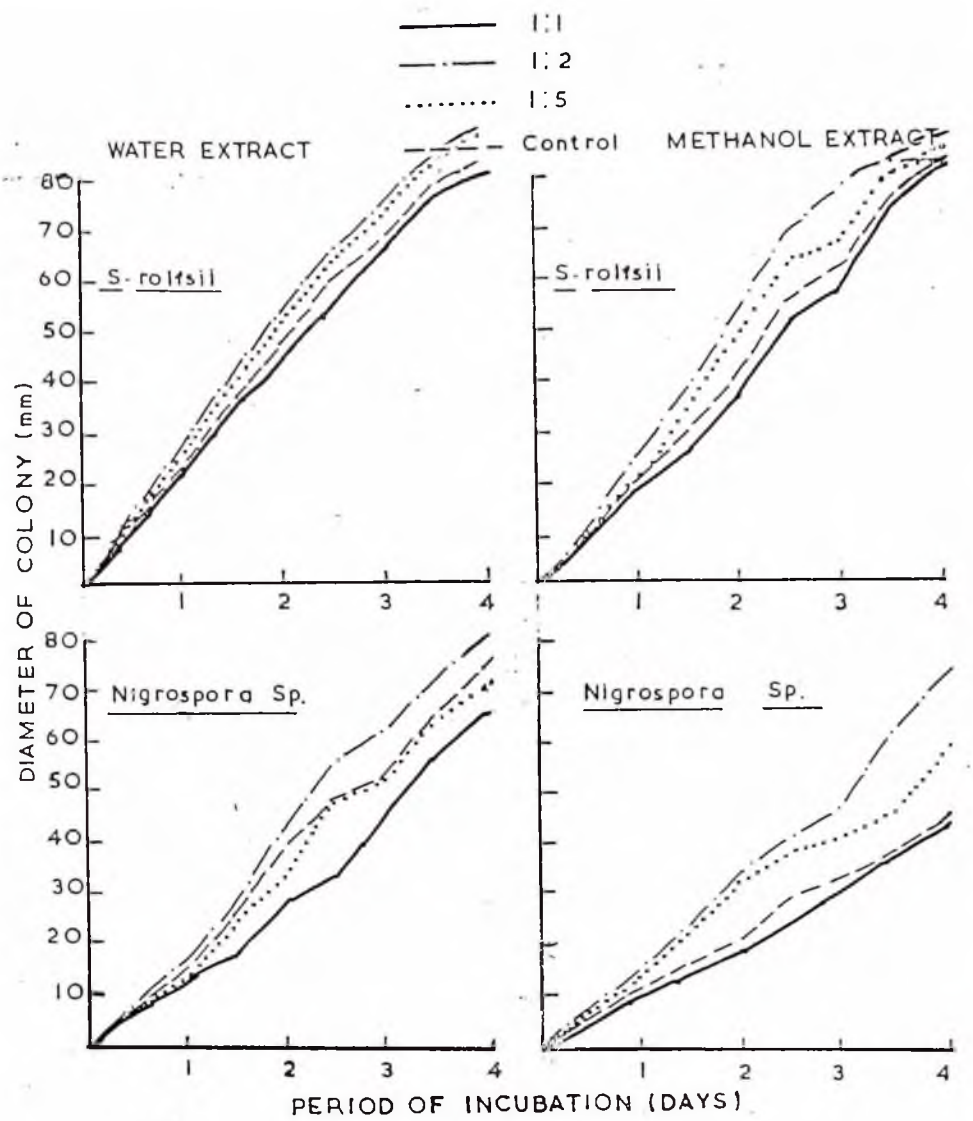
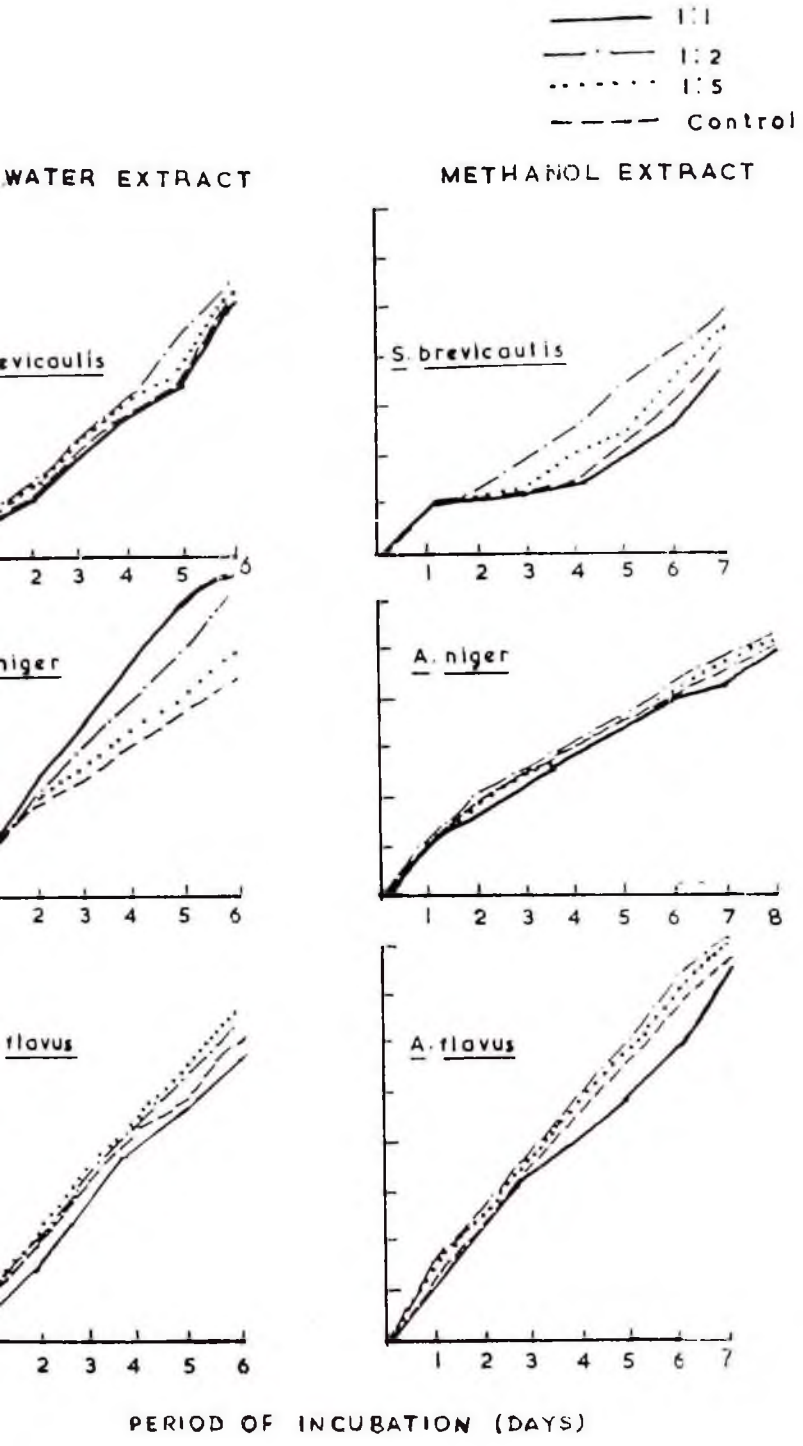


Fig.11 (cont'd). Effect of varying dilutions of water and methanol extracts of Cassia rotundifolia on vegetative growth of indicated fungi.



2. Effect of varying dilutions of water and methanol extracts of Griffonia simplicifolia on vegetative growth of indicated fungi.

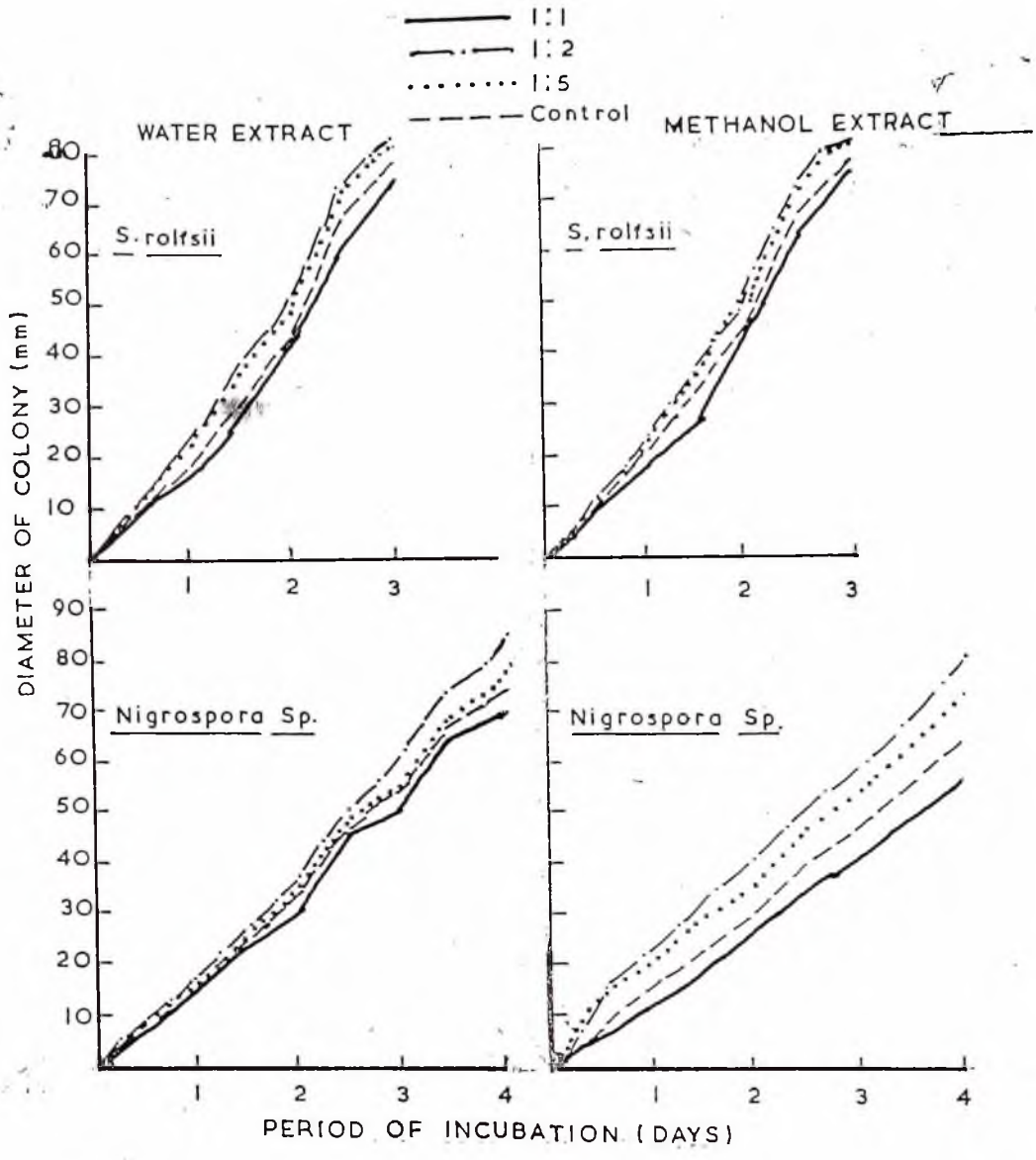


Fig.12 (Cont'd). Effect of varying dilutions of water and methanol extracts of Griffonia simplicifolia on vegetative growth of indicated fungi.

TABLE 5a

ter extract of *Desmodium triflorum* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	23	11483.96		
	5	11377.21	2275.442	1536.88
ract	3	84.54	28.181	19.03
	15	22.21	1.481	
ty	1	11.06	11.056	13.88
	14	11.15	0.797	

le F-value at p = 0.05 is 3.29
p = 0.01 is 5.42

TABLE 5b

ter extract of *Desmodium triflorum* on vegetative growth of *Aspergillus niger* at 35°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	31	7045.99		
	7	6434.68	919.240	109.23
tract	3	434.59	144.862	17.21
	21	176.73	8.416	
ity	1	140.23	140.228	76.34
	20	35.50	1.825	

ble F-value at p = 0.05 is 3.07
p = 0.01 is 4.87

TABLE 5c

ater extract of *Desmodium triflorum* on vegetative growth of *Aspergillus flavus* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	31	8807.12		
	7	7627.43	1089.633	41.76
xtract	3	631.77	210.59	18.07
	21	547.91	26.091	
vity	1	478.39	478.386	137.61
	20	69.53	3.476	

ble F-value at p = 0.05 is 3.07
p = 0.01 is 4.87

TABLE 5d

ter extract of *Desmodium triflorum* on vegetative growth of *Sclerotium rolfsii* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	19	7815.20		
	4	7469.20	1867.300	922.12
ract	3	321.70	107.233	52.95
	12	24.30	2.025	
ty	1	22.26	22.256	119.80
	11	2.04	0.186	

le F-value at p = 0.05 is 3.49
p = 0.01 is 5.95

TABLE 5e

ter extract of *Desmodium triflorum* on vegetative growth of *Nigrospora sp.* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	13260.17		
	6	12962.23	2160.372	915.37
tract	3	255.46	85.152	36.08
	18	42.48	2.360	
ity	1	23.85	23.846	21.75
	17	18.64	1.096	

le F-value at p = 0.05 is 3.16
p = 0.01 is 5.09

TABLE 6a

t of methanol extract of *Desmodium triflorum* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C.

e of ion	Degrees of freedom	Sum of squares	Mean square	F-value
	27	13194.50		
cates	6	12982.00	2163.667	1110.48
of extract	3	117.43	59.143	30.35
	18	35.07	1.948	
dditivity	1	10.22	10.224	6.99
ual	17	24.85	1.462	
	Table F-value at	p = 0.05 is 3.29 p = 0.01 is 5.42		

TABLE 6b

of methanol extract of *Desmodium triflorum* on vegetative growth of *Aspergillus niger* at 35°C.

e of on	Degrees of freedom	Sum of squares	Mean square	F-value
	27	6659.96		
ates	6	6037.46	1006.244	124.03
of extract	3	476.46	158.821	19.58
	18	146.04	8.113	
dditivity	1	124.29	124.289	97.16
al	17	21.75	1.279	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.01		

TABLE 6c

of methanol extract of *Desmodium triflorum* on vegetative growth of *Aspergillus*
t 30°C.

of n	Degrees of freedom	Sum of squares	Mean square	F-value
	27	7533.75		
les	6	6795.63	1132.604	96.78
f extract	3	527.46	175.821	15.02
	18	210.66	11.703	
litivity	1	194.94	194.942	210.83
l	17	15.72	0.925	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.01		

TABLE 6d

hanol extract of *Desmodium triflorum* on vegetative growth of *Sclerotium rolfsii* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	23	11074.74		
	5	10174.30	2034.860	146.52
ract	3	692.11	230.705	16.61
	15	208.32	13.888	
y	1	177.72	177.719	81.80
	14	30.60	2.186	

Table F-value at p = 0.05 is 3.16
p = 0.01 is 5.01

TABLE 6e

thanol extract of *Desmodium triflorum* on vegetative growth of *Nigrospora sp.* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	13827.18		
	6	13157.80	2192.884	538.73
ract	3	596.61	198.869	48.86
	18	73.27	4.070	
ty	1	52.70	52.698	43.55
	17	20.57	1.210	

le F-value at p = 0.05 is 3.16
p = 0.01 is 5.01

TABLE 7a

anol extract of *Cassia rotundifolia* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	31	8831.38		
	7	8493.63	1213.375	599.15
ct	3	294.50	98.167	47.66
	21	43.25	2.060	
	1	8.20	8.203	4.68
	20	35.05	1.752	
	Table F-value at	p = 0.05 is 3.07 p = 0.01 is 4.87		

TABLE 7b

anol extract of *Cassia rotundifolia* on vegetative growth of *Aspergillus niger* at 35°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	5120.74		
	6	4337.93	722.988	52.75
act	3	536.10	178.699	39.04
	18	246.71	18.706	
y	1	222.82	222.821	158.54
	17	23.89	1.405	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 7c

hanol extract of *Cassia rotundifolia* on vegetative growth of *Aspergillus flavus* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	9477.81		
	6	8110.88	1351.813	197.17
ract	3	243.53	81.176	11.94
	18	123.41	6.856	
y	1	38.33	38.329	7.66
	17	85.08	5.005	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 7d

ethanol extract of *Cassia rotundifolia* on vegetative growth of *Sclerotium rolfsii* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	23	10024.96		
	5	9184.96	1836.992	306.59
xtract	3	750.13	250.042	41.73
	15	89.88	5.992	
vity	1	19.60	19.600	3.90
	14	70.27	5.020	

Table F-value at p = 0.05 is 3.29
p = 0.01 is 5.42

TABLE 7e

ethanol extract of *Cassia rotundifolia* on vegetative growth of *Nigrospora sp.* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	31	11277.47		
	7	9402.84	1343.263	77.37
xtract	3	1510.00	503.344	28.99
	21	364.59	17.362	
vity	1	224.39	224.391	32.01
	20	140.20	7.010	

Table F-value at p = 0.05 is 3.07
p = 0.01 is 4.87

TABLE 8a

vater extract of *Griffonia simplicifolia* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	23	5555.33		
	5	5464.33	1092.867	336.27
xtract	3	42.25	14.083	4.33
	15	48.75	3.250	
vity	1	21.05	21.048	10.64
	14	27.70	1.979	
	Table F-value at	p = 0.05 is 3.29 p = 0.01 is 5.42		

TABLE 8b

vater extract of *Griffonia simplicifolia* on vegetative growth of *Aspergillus niger* at 35°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	23	6133.63		
	5	5201.25	1040.250	55.23
extract	3	649.88	216.625	11.50
	15	282.50	18.833	
ivity	1	267.78	267.776	254.61
	14	14.72	1.052	
	Table F-value at	p = 0.05 is 3.29 p = 0.01 is 5.42		

TABLE 8c

water extract of *Griffonia simplicifolia* on vegetative growth of *Aspergillus flavus* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	23	7572.49		
s	5	7531.30	1506.260	1169.28
extract	3	21.86	7.288	5.66
	15	19.32	1.288	
tivity	1	8.32	8.319	10.58
	14	11.00	0.786	
	Table F-value at	p = 0.05 is 3.29 p = 0.01 is 5.42		

TABLE 8d

r extract of *Griffonia simplicifolia* on vegetative growth of *Sclerotium rolfsii* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	23	14686.83		
	5	14333.58	2866.717	957.35
ct	3	308.33	102.778	34.32
	15	44.92	2.994	
	1	21.77	21.770	13.17
	14	23.15	1.653	
	Table F-value at	p = 0.05 is 3.29 p = 0.01 is 5.42		

TABLE 8e

r extract of *Griffonia simplicifolia* on vegetative growth of *Nigrospora sp.* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	11945.71		
	6	11741.59	1956.932	747.48
act	3	157.00	52.333	19.99
	18	47.13	2.618	
y	1	34.02	34.023	44.15
	17	13.10	0.771	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 9a

anol extract of *Griffonia simplicifolia* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	3918.36		
	6	3499.73	583.289	77.74
act	3	283.57	94.524	12.60
	18	135.05	7.503	
	1	53.58	53.582	11.18
	17	81.47	4.792	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 9b

anol extract of *Griffonia simplicifolia* on vegetative growth of *Aspergillus niger* at 35°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	31	5157.49		
	7	5116.93	730.990	1663.76
act	3	31.34	10.445	23.77
	21	9.23	0.439	
y	1	0.70	0.696	1.63
	20	8.53	0.427	
	Table F-value at	p = 0.05 is 3.07 p = 0.01 is 4.87		

TABLE 16c

hanol extract of *Griffonia simplicifolia* on vegetative growth of *Aspergillus flavus* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	31	17280.72		
	7	17001.09	2428.728	582.27
ract	3	192.03	64.010	15.35
	21	87.59	4.171	
ty	1	30.31	30.309	10.58
	20	57.29	2.864	
	Table F-value at	p = 0.05 is 3.07 p = 0.01 is 4.87		

TABLE 9d

thanol extract of *Griffonia simplicifolia* on vegetative growth of *Sclerotium rolfsii* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	23	14516.83		
	5	14306.08	2861.217	1009.84
ract	3	168.25	56.083	19.79
	15	42.50	2.233	
ty	1	33.86	33.860	54.87
	14	8.64	0.617	
	Table F-value at	p = 0.05 is 3.29 p = 0.01 is 5.42		

TABLE 16e

thanol extract of *Griffonia simplicifolia* on vegetative growth of *Nigrospora sp.* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	35	17828.47		
	8	16172.10	2021.512	360.08
tract	3	1521.64	507.213	90.35
	24	134.74	5.614	
ity	1	128.01	128.010	437.76
	23	6.73	0.292	
	Table F-value at	p = 0.05 is 3.01 p = 0.01 is 4.72		

E. VEGETATIVE GROWTH OF FIVE TEST FUNGI ON AGAR (SOLID MEDIUM) AMENDED WITH WATER AND METHANOL EXTRACTS OF PLANTS IN THE FAMILY RUTACEAE AND MELIACEAE.

A summary of results obtained are as follows:

1. *Zanthoxylum xanthoxyloides* (Rutaceae)

(a). Water extract

The various dilutions of the water extract decreased vegetative growth of test fungi (*Scopulariopsis brevicaulis, Aspergillus niger, A. flavus, Sclerotium rolfsii* and *Nigrospora sp.*) (Fig. 13). The inhibitory effect was, however, removed with increasing dilution of the extract (Plate 4).

(b). Methanol extract

Growth of the test fungi were variably affected by the methanol extract of this plant. The highest inhibition was on the growth of *S. rolfsii*. Dry matter accumulation was depressed by 28.4 per cent (Fig. 13). The other test fungi also showed decline in vigour of vegetative growth. Thus *S. brevicaulis* was depressed by 26.2 per cent, *Nigrospora sp* by 22.4 per cent and *A. flavus* by 14.9 per cent. Again the severity of the inhibition was removed with increasing dilution of the extract.

2. *Azadirachta indica* (Meliaceae)

(a). Water extract

Vegetative growth of *Nigrospora sp.* in the 1:1 v/v dilution of the extract was depressed by 24.4 per cent after 4 days. Growth of the other fungi in all the extract dilution was only marginally inferior to the control. Conversely, the water extract at 1:1 v/v dilution improved growth of *S. brevicaulis* (Fig. 14, Tables 10a - 10e).

Plate 4. Vegetative growth of Scopulariopsis brevicaulis in nutrient medium ammended with water extract of Zanthoxylum xanthoxyloides at 30 °C.
(Note the depression of radial growth by all (1:1 - 1:5 v/v) dilutions after 7 days as well as the change in cultural characteristics of the fungus).

(b). Methanol extract

Statistical analyses showed that the depression in vegetative growth of *S. rolfsii* and *Nigroapora sp.* in 1:1v/v dilution were significant ($P \leq 0.05$) (Tables 11a - 11e) and that further dilution of the extract gradually removed the inhibitory effect. The highest depression in vegetative growth of 41.8 per cent on *Nigrospora sp.* was obtained in 1:1 v/v methanol extract of *A. indica*. The depression in vegetative growth was less severe (22.4 per cent) on *S. rolfsii.*

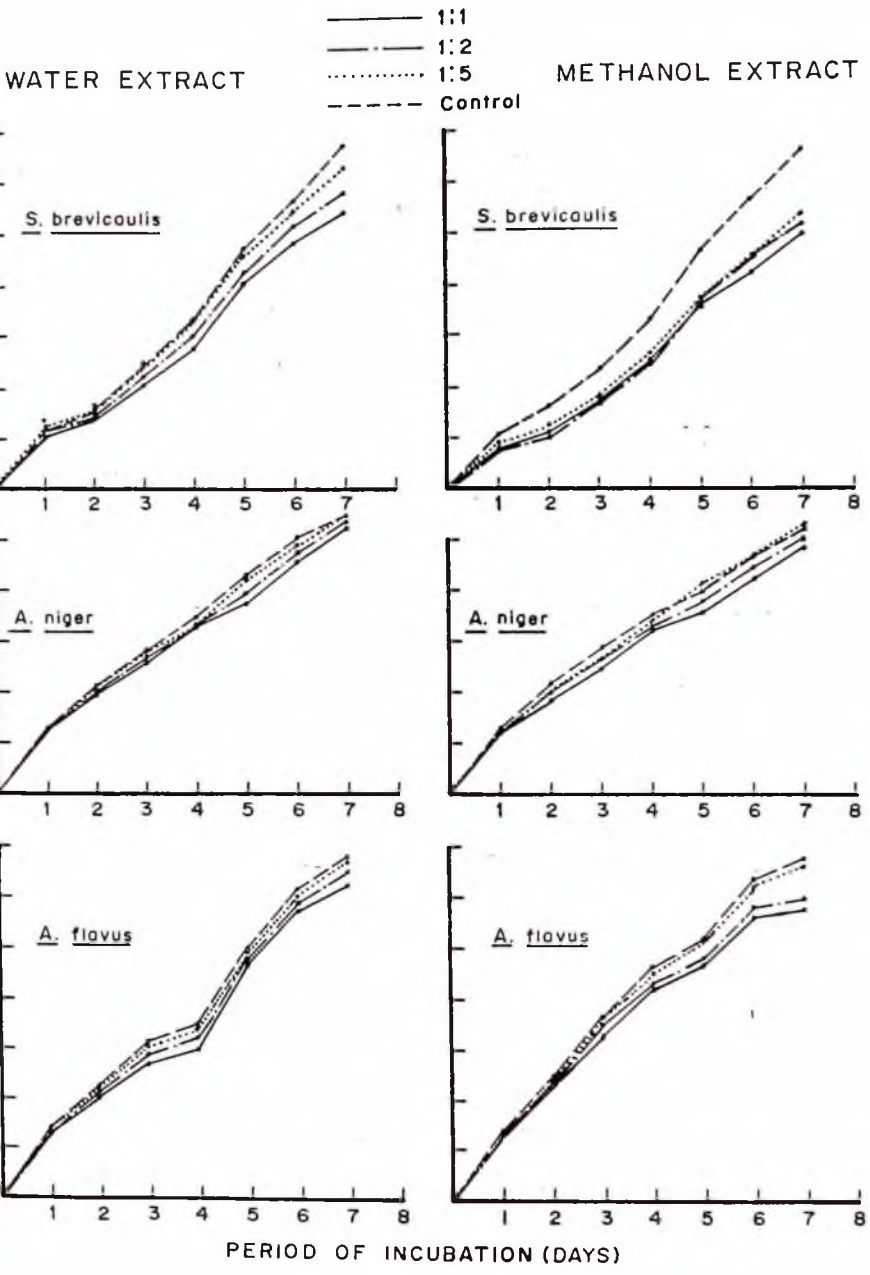


Fig.13. Effect of varying dilutions of water and methanol extracts of Zanthoxylum xanthoxyloides on vegetative growth of indicated fungi.

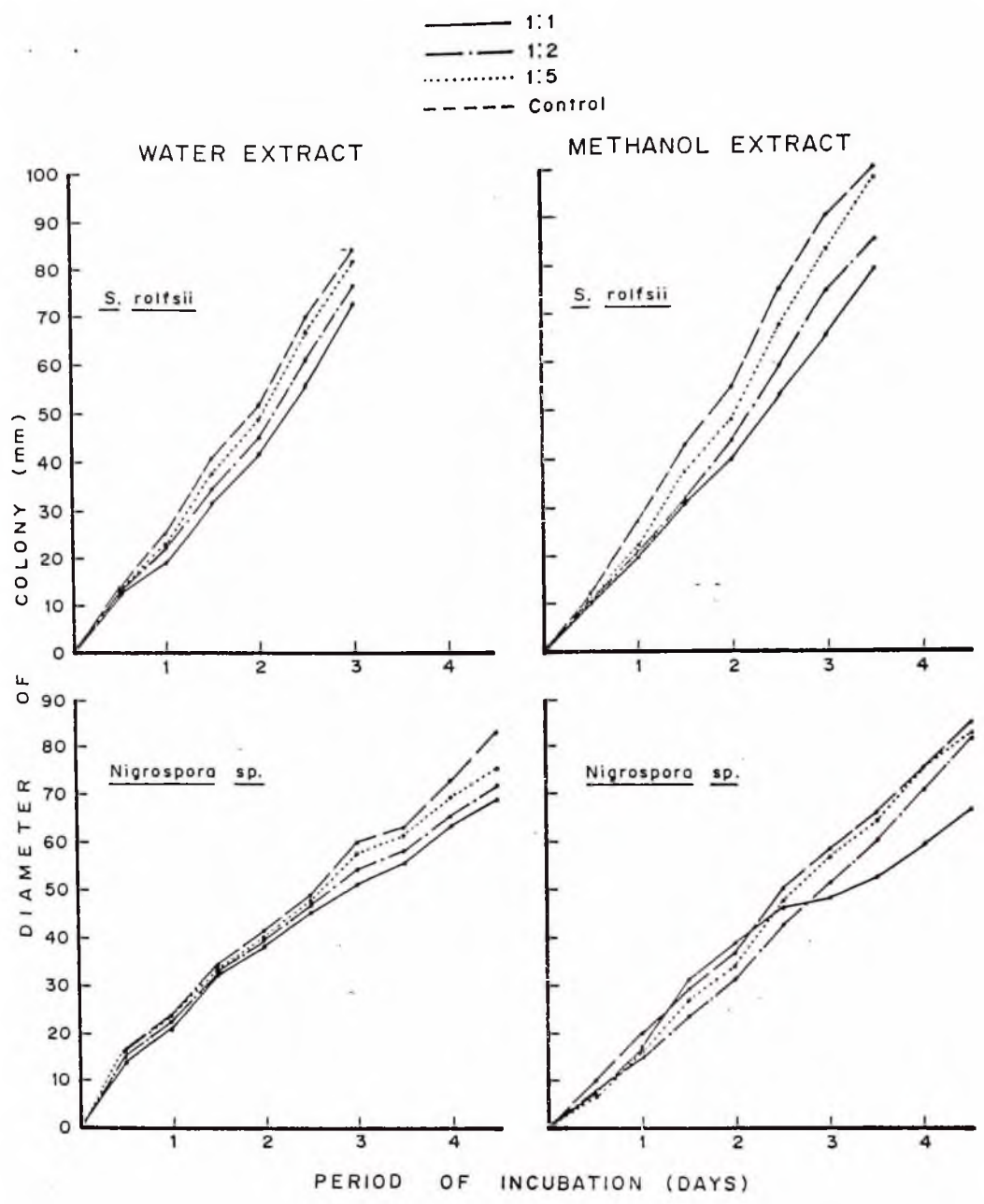
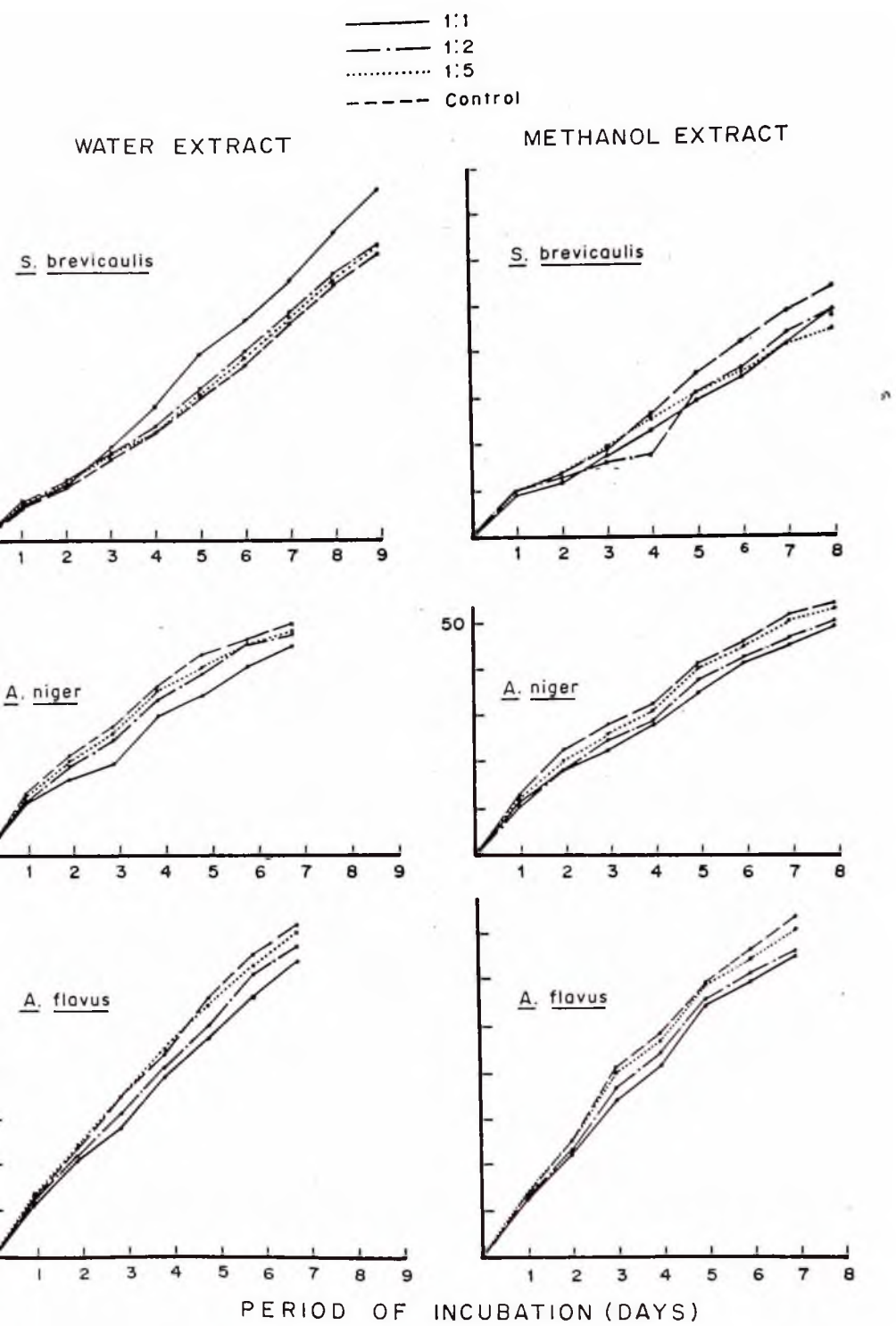


Fig.13 (Cont'd). Effect of varying dilutions of water and methanol extracts of Zanthoxylum xanthoxyloides on vegetative growth of indicated fungi.



g. 14. Effect of varying dilutions of water and methanol extracts of Azadirachta indica on vegetative growth of indicated fungi.

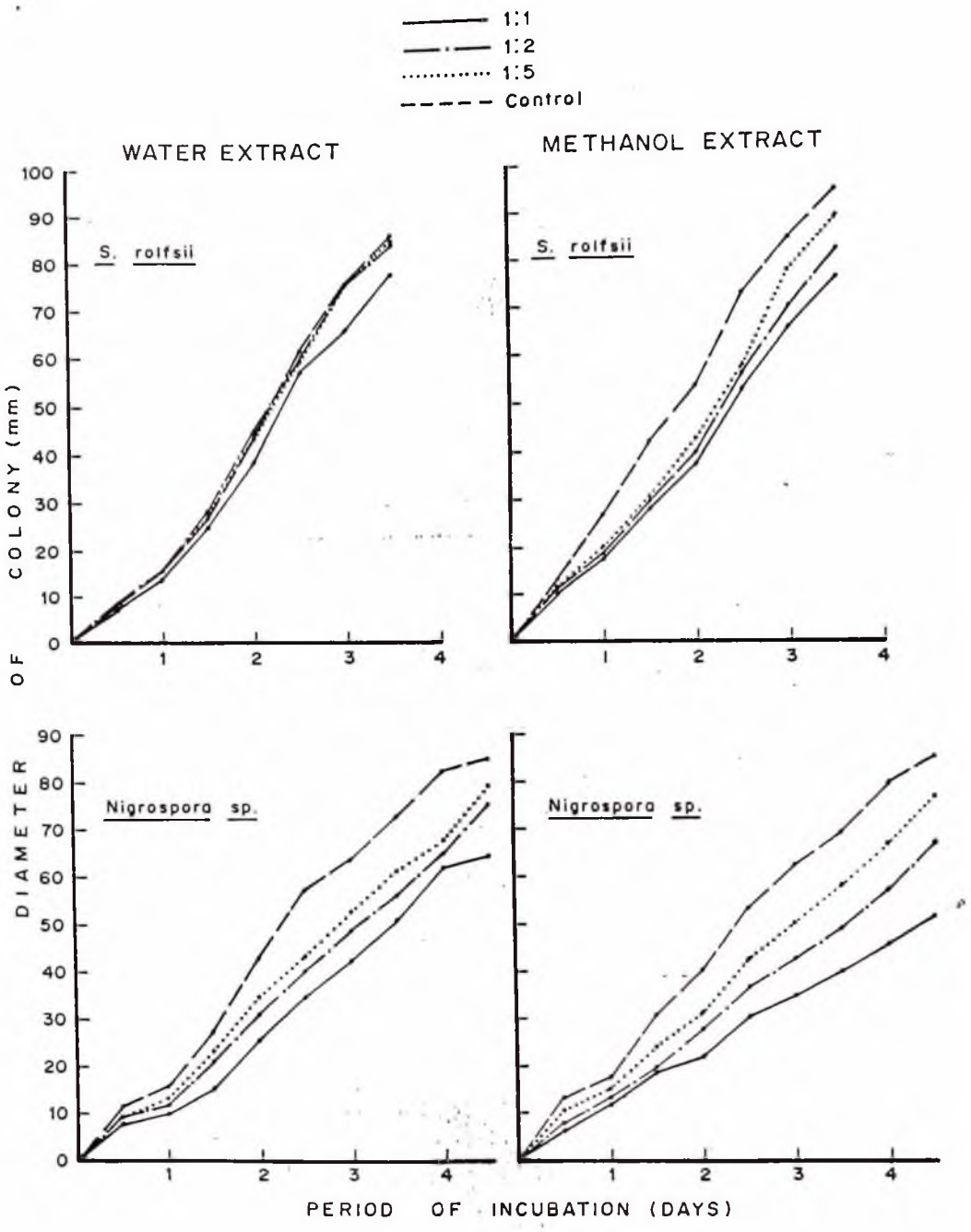


Fig. 14 (Cont'd). Effect of varying dilutions of water and methanol extracts of Azadirachta indica on vegetative growth of indicated fungi.

TABLE 10a

extract of *Azadirachta indica* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	39	20004.48		
	9	19496.35	2166.261	343.65
	3	337.93	112.642	17.87
	27	170.20	6.301	
	1	145.78	145.78	155.21
	26	24.42	0.939	

e at p = 0.05 is 2.96
p = 0.01 is 4.60

TABLE 10b

extract of *Azadirachta indica* on vegetative growth of *Aspergillus niger* at 35°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	4668.43		
	6	4507.05	751.176	568.03
t	3	137.09	45.857	34.68
	18	23.80	1.322	
	1	1.96	1.963	1.53
	17	21.84	1.285	
	Table F value at	p = 0.05 is 3.16		
		p = 0.01 is 5.09		

TABLE 10c

extract of *Azadirachta indica* on vegetative growth of *Aspergillus flavus* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	10917.21		
	6	10706.46	1784.411	865.59
t	3	173.64	57.881	28.08
	18	37.11	2.062	
	1	23.34	23.338	28.82
	17	13.77	0.810	
	Table F value at	p = 0.05 is 3.16		
		p = 0.01 is 5.09		

TABLE 10d

extract of *Azadirachta indica* on vegetative growth of *Sclerotium rolfsii* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	20335.18		
	6	20170.05	3361.676	1071.99
ct	3	108.68		36.226
	18	56.45		3.136
	1	37.97	37.970	34.94
	17	18.48	1.087	
	Table F value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 10e

extract of *Azadirachta indica* on vegetative growth of *Nigrospora sp.* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	35	20482.74		
	8	18982.43	2372.804	200.08
ct	3	1215.69	405.229	34.17
	24	284.62	11.859	
	1	172.59	172.592	35.43
	23	112.03	4.871	
	Table F value at	p = 0.05 is 2.78 p = 0.01 is 4.22		

TABLE 11a

ol extract of *Azadirachta indica* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	31	6135.99		
	7	5954.80	850.686	192.53
	3	88.40	29.466	6.67
	21	92.79	4.419	
	1	32.60	32.596	10.83
	20	60.19	3.010	
	Table F value at	p = 0.05 is 3.07 p = 0.01 is 4.87		

TABLE 11b

ol extract of *Azadirachta indica* on vegetative growth of *Aspergillus niger* at 35°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	31	6216.87		
	7	6084.55	869.222	1001.49
	3	114.09	38.029	43.82
	21	18.23	0.868	
	1	6.69	6.688	11.59
	20	11.54	0.577	
	Table F value at	p = 0.05 is 3.07 p = 0.01 is 4.87		

TABLE 11c

ıol extract of *Azadirachta indica* on vegetative growth of *Aspergillins flavus* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	11155.71		
	6	10996.21	1832.702	1137.54
	3	130.50	43.500	27.00
	18	29.00	1.611	
	1	19.34	19.341	37.04
	17	9.66	0.568	
	Table F value at p = 0.01 is 5.09	p = 0.05 is 3.16		

TABLE 11d

ıol extract of *Azadirachta indica* on vegetative growth of *Sclerotium rolfsii* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	23	12421.74		
	5	11617.80	2323.560	232.11
	3	653.78	217.927	21.77
	15	150.16	10.010	
	1	103.03	103.029	30.61
	14	47.13		3.365
	Table F value at	p = 0.05 is 3.29 p = 0.01 is 5.42		

TABLE 11e

extract of *Azadirachta indica* on vegetative growth of *Nigrospora sp.* at 30°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	35	17150.64		
	8	14442.01	1805.252	80.38
t	3	2169.64	723.213	32.20
	24	538.99	22.458	
	1	479.39	479.387	185.00
	23	59.60	2.591	
	Table F value at	p = 0.05 is 3.01 p = 0.01 is 4.72		

F. STUDIES ON THE EFFECT OF WATER AND METHANOL EXTRACTS OF PLANTS IN THE FAMILY MALVACEAE, AMARANTHACEAE, NYCTAGINACEAE AND OXALIDACEAE ON VEGETATIVE GROWTH OF FIVE FUNGI

A summary of the results is as follows:

1. *Sida acuta* (Malvaceae)

(a) Water Extract.

Water extract of this plant significantly depressed vegetative growth of *Sclerotium rolfsii* (Fig. 15). Growth of the other fungi in all dilutions (1:1-1:5 v/v) of the extract was very close to those in the control media.

(b) Methanol Extract

The extract did not suppress growth of *Aspergillus niger* and *A. flavus* (Fig. 15; Tables 12a-12e). It rather promoted the growth of these fungi. The highest inhibition of 24.4 per cent of the extract (1:1 v/v dilution) was on vegetative growth of *S. rolfsii*. Its effect on *S. brevicaulis* and *Nigrospora sp.* was not significant. Dilutions 1:5 and 1:2 v/v of the extract stimulated growth. Extract of 1:1 v/v dilution, however, suppressed growth of *S. brevicaulis* by 13.3 per cent and that of *Nigrospora sp.* by 7.6 per cent.

2. *Alternanthera pungens* (Amaranthaceae)

a) Water Extract

Effect of this extract on test fungi was significant but varied from species to species (Fig. 16; Tables 13a-13e). The highest inhibitory effect was obtained on *S.*

brevicaulis; vegetative growth was depressed by 52.9 per cent. This was followed by 45.2 per cent on *A. niger* and 36.5 per cent on *S rolfsii*. Vegetative growth of *A. flavus* in 1:1 v/v dilution was depressed by 23.9 per cent.

(b) Methanol Extract.

Inhibition of vegetative growth of the test fungi by this extract was also variable but significant (Fig. 16; Tables 14a-14e). Vegetative growth of *A. niger* was depressed by 47.0 per cent by 1:1v/v dilution of the extract. Vegetative growth of *S. rolfsii* was depressed by 36.7 per cent, *S. brevicaulis* by 30.0 per cent and *A. flavus* by 23.9 per cent.

3. *Boerhavia diffusa (Nyctaginaceae)*

(a) Water Extract

All dilutions (1:1-1:5v/v) of the water extract of *B. diffusa* did not have any significant effect on any of the test fungi (Fig. 17). Growth in all dilutions of the extract were close to those in the controls.

(b) Methanol Extract

The methanol extract too did not suppress vegetative growth of any of the test fungi to any significant extent (Fig. 17). The extract improved vegetative growth of *S. brevicaulis* and *Nigrospora sp.* (Fig. 17).

4. *Oxalis corniculata* (Oxalidaceae)

(a) Water extract

The extract had very significant effect on growth of *S. brevicaulis* and *A. niger*. Vegetative growth of *A. flavus*, *S. rolfsii* and *Nigrospora sp.* was also significantly suppressed (Fig. 18, Tables 15a-15e). Vegetative growth of *A. niger* was suppressed by 43.1 per cent while vegetative growth of *S. brevicaulis* in 1:1 v/v dilution was depressed by 41.7 per cent (Plate 5).

(b) Methanol Extract

Vegetative growth of *S. brevicaulis*, *A. niger* and *A. flavus* was only marginally inhibited by the methanol extract of *O. corniculata*. On the other hand dry matter accumulation of *Nigrospora sp.* and *S. rolfsii* in the presence of 1:1 v/v dilution of the methanol extract was depressed by 12.9 and 32.9 per cent respectively (Tables 16a–16e).

Plate 5. Vegetative growth of Scopulariopsis brevicaulis in nutrient medium ammended with water extract of Oxalis corniculata at 30 °C.
(Note the depression of radial growth by all (1:1 - 1:5 v/v) dilutions after 8 days.)

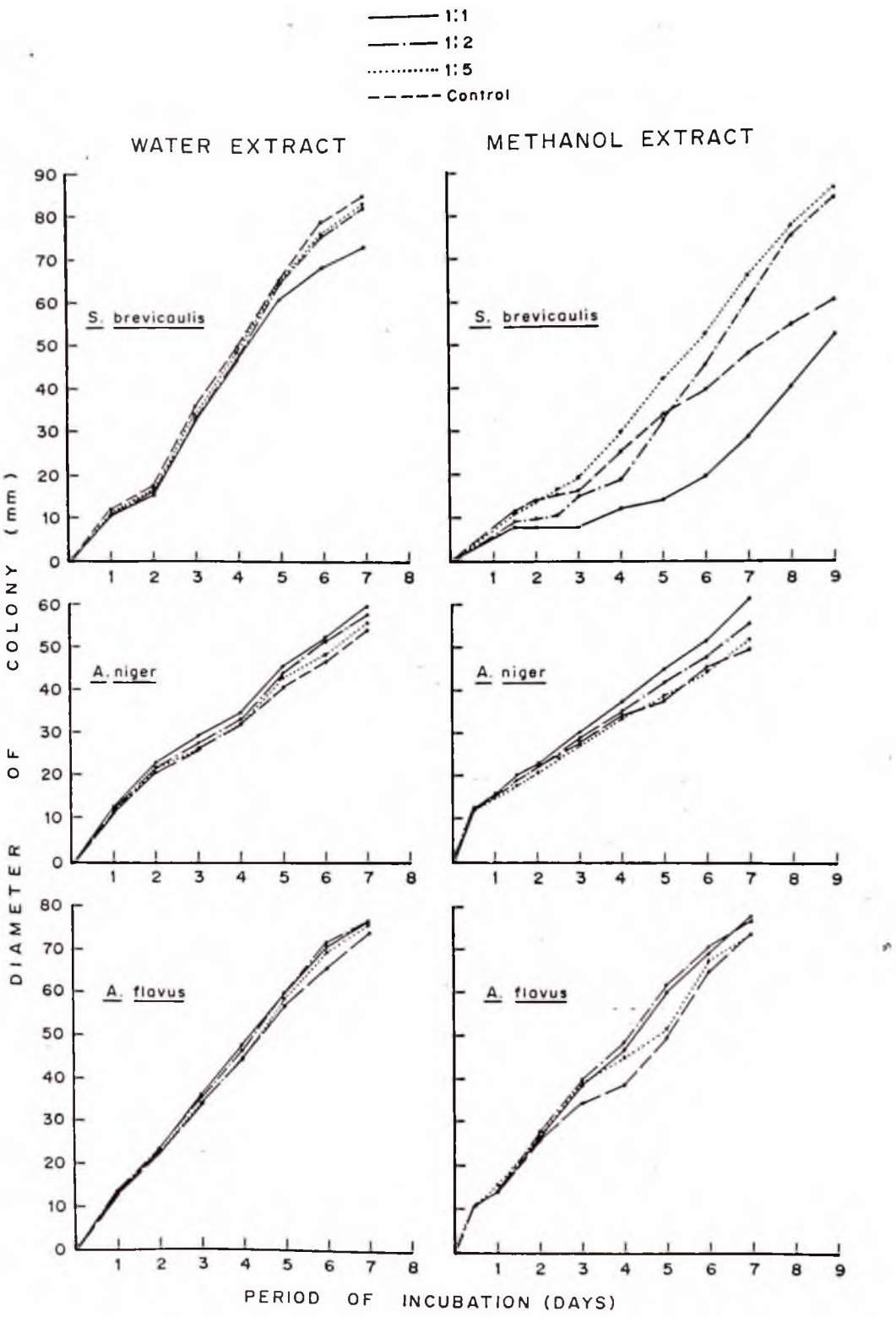
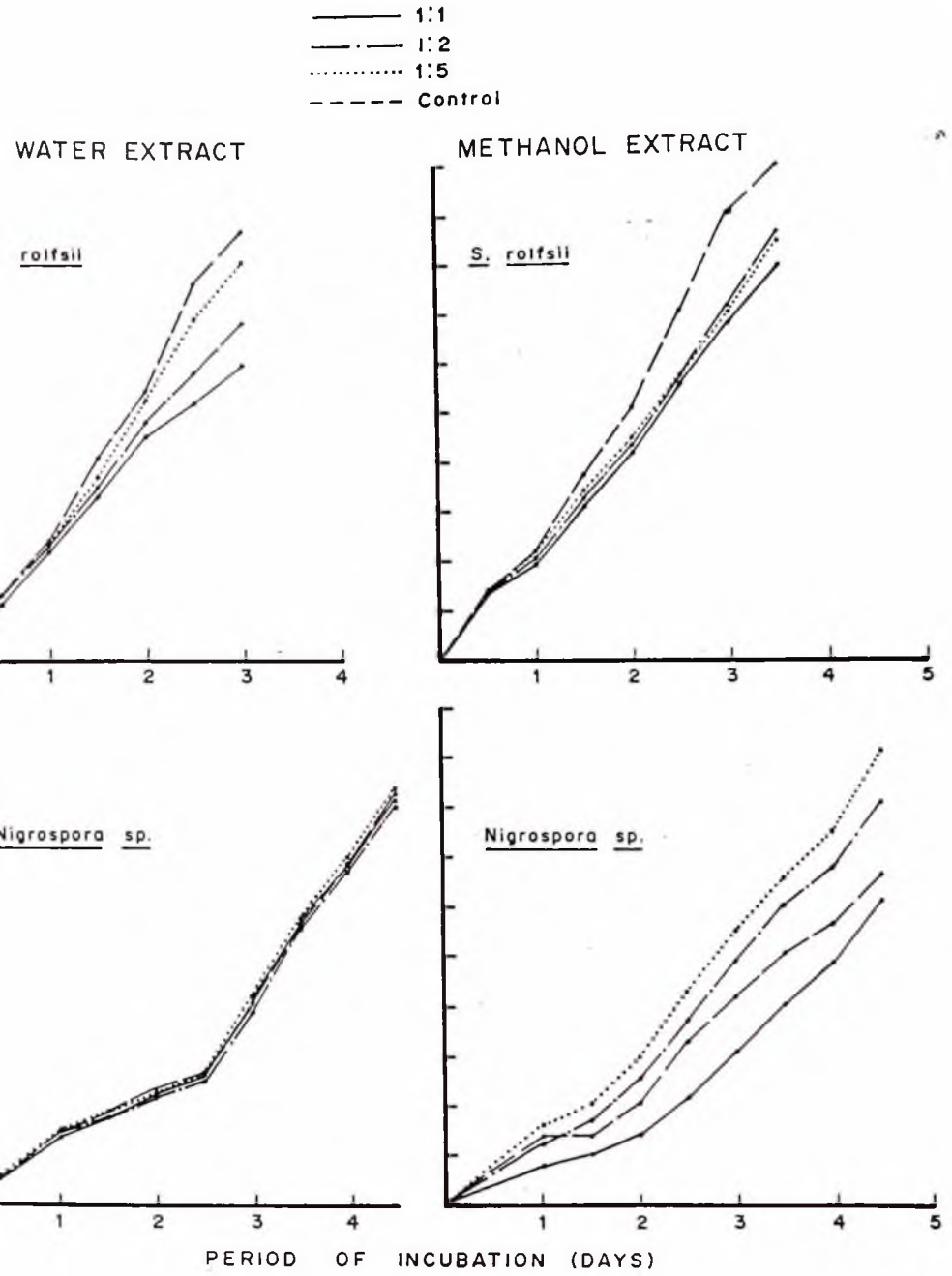


Fig.15. Effect of varying dilutions of water and methanol extracts of Sida acuta on vegetative growth of indicated fungi.



15 (Cont'd). Effect of varying dilutions of water and methanol extracts of Sida acuta on vegetative growth of indicated fungi.

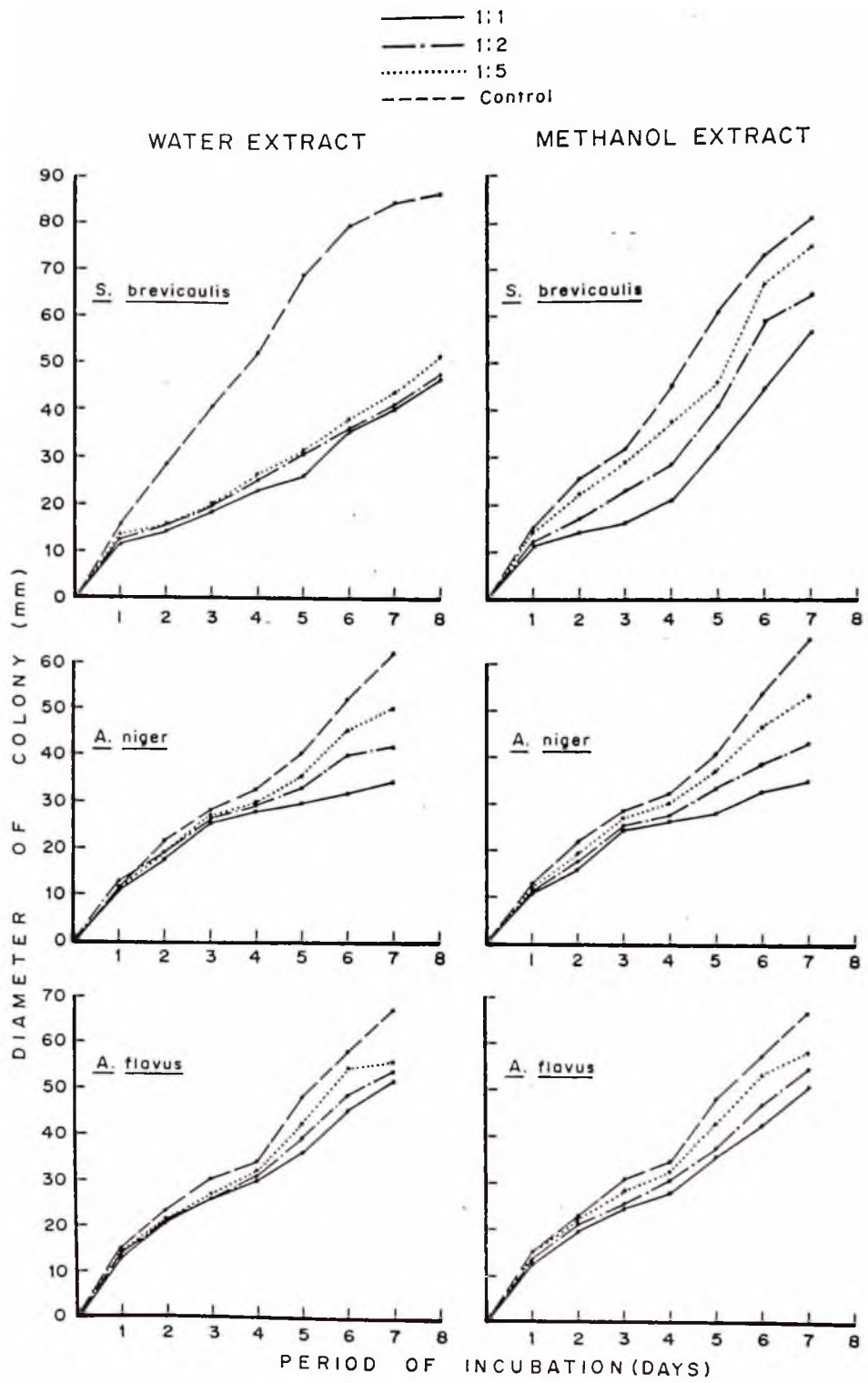


Fig.16. Effect of varying dilutions of water and methanol extracts of Alternanthera pungens on vegetative growth of indicated fungi.

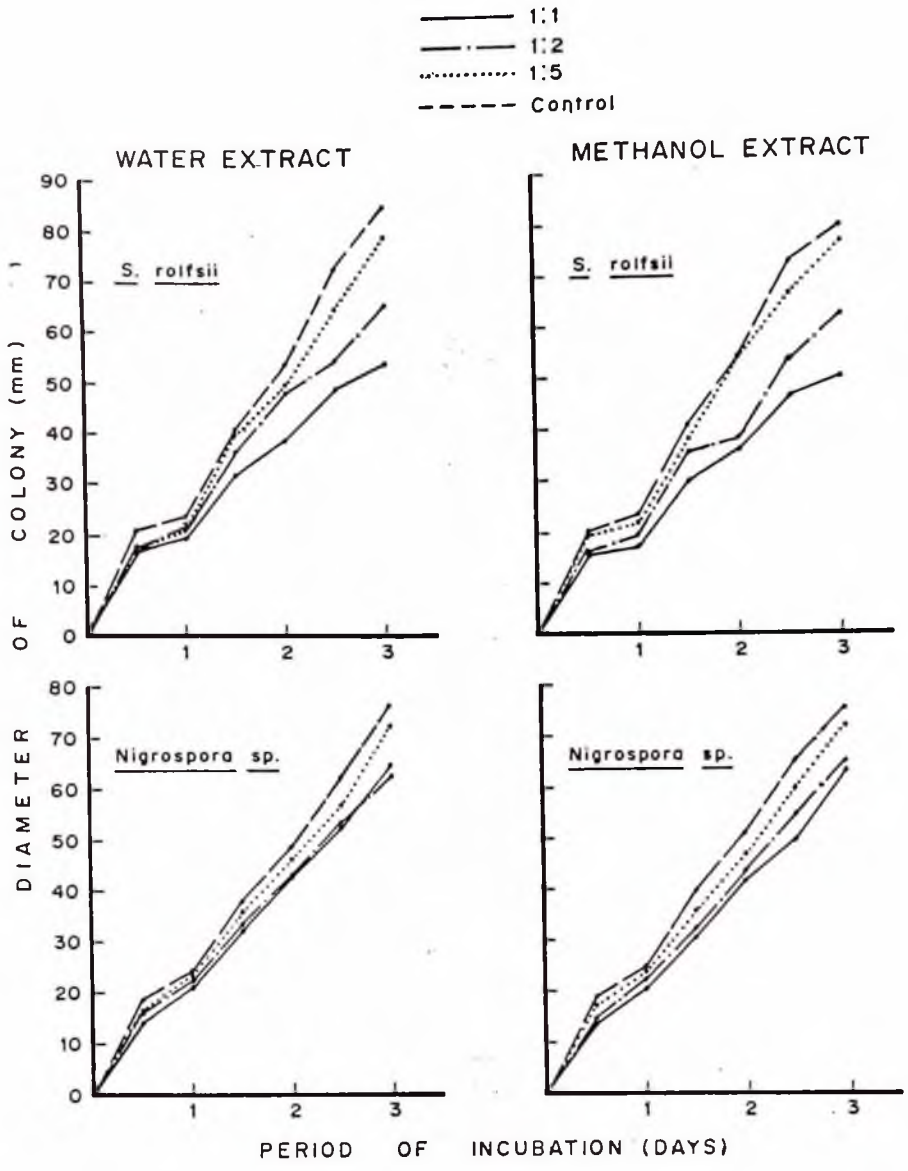


Fig.16 (Cont'd). Effect of varying dilutions of water and methanol extracts of Alternathera pungens on vegetative growth of indicated fungi.

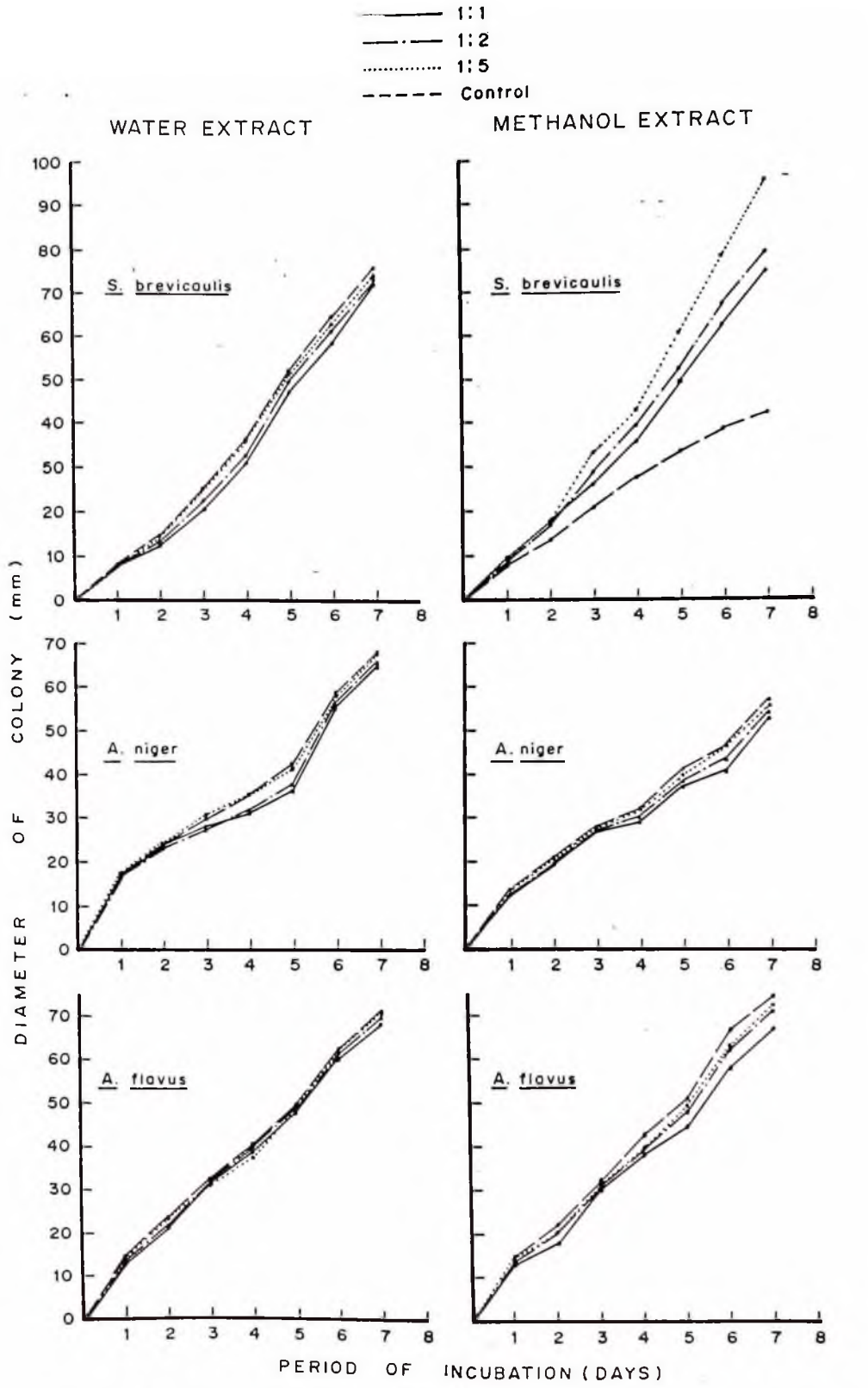


Fig.17. Effect of varying dilutions of water and methanol extracts of Boerhavia diffusa on vegetative growth of indicated fungi.

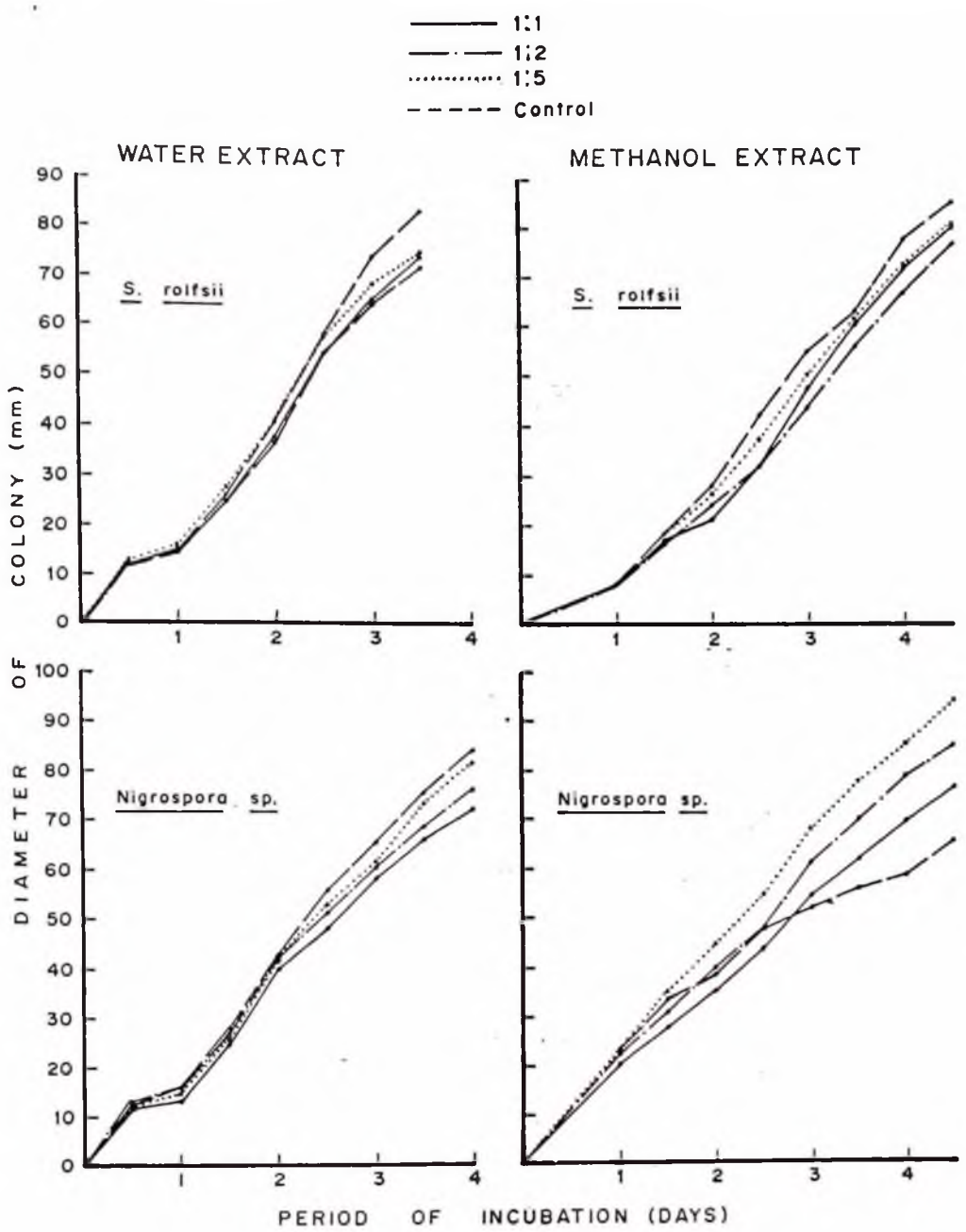


Fig.17 (Cont'd). Effect of varying dilutions of water and methanol extracts of Boerhavia diffusa on vegetative growth of indicated fungi.

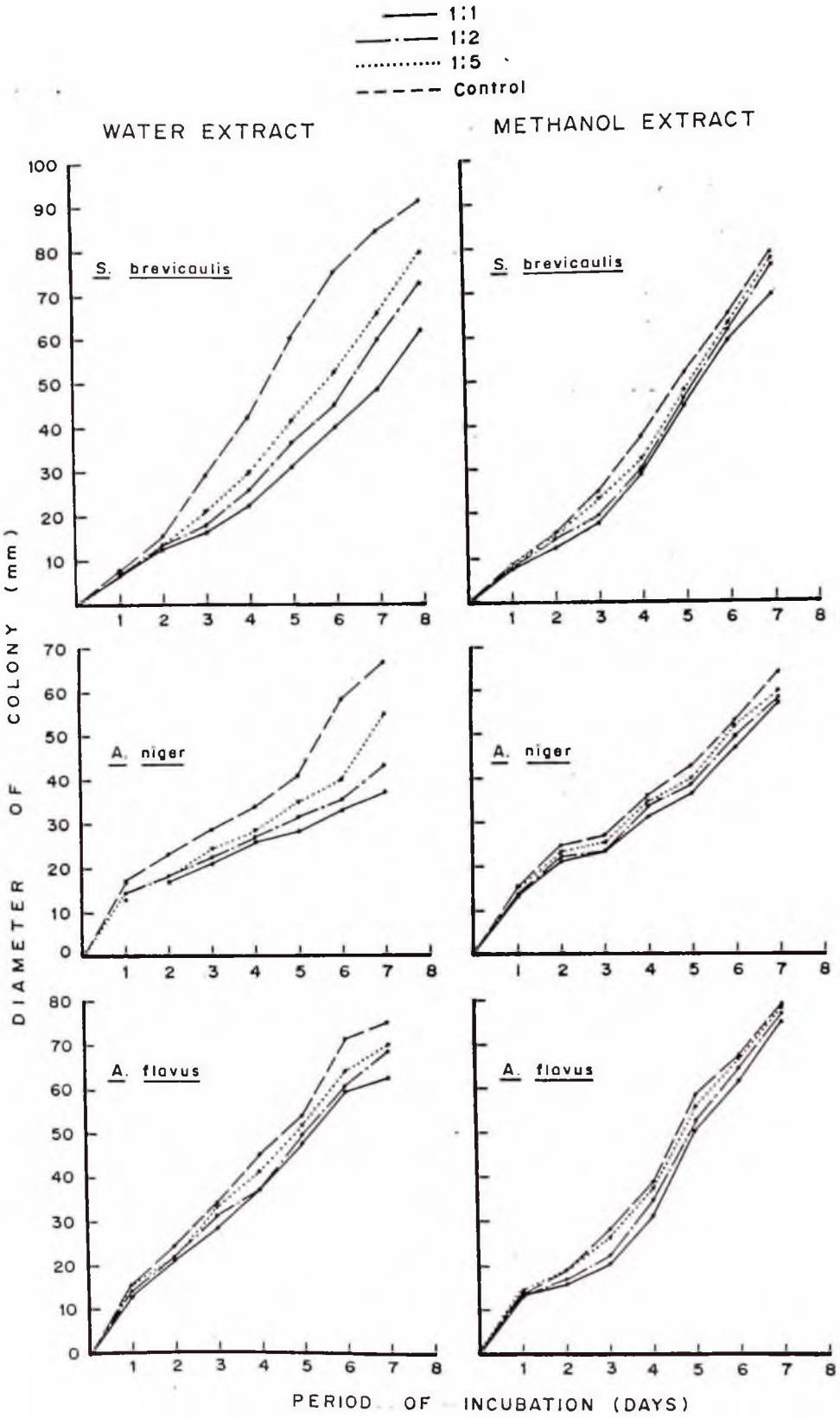


Fig.18. Effect of varying dilutions of water and methanol extracts of Oxalis corniculata on vegetative growth of indicated fungi.

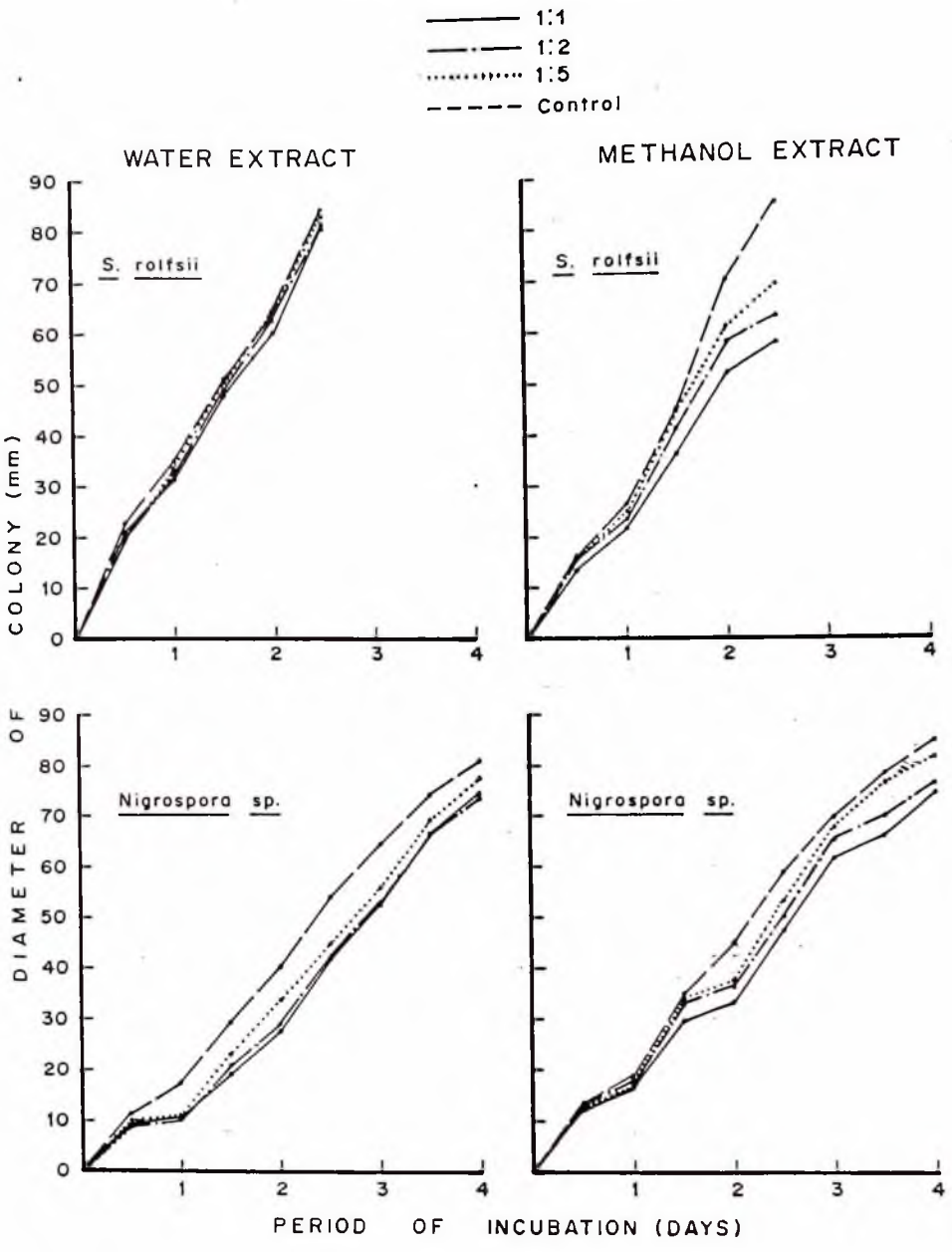


Fig.18 (Cont'd). Effect of varying dilutions of water and methanol extracts of Oxalis corniculata on vegetative growth of indicated fungi.

TABLE 12a

anol extract of *Sida acuta* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	39	21153.69		
	9	17355.76	1928.417	36.62
ct	3	2376.27	792.090	15.04
	27	1421.67	52.654	
	1	860.55	860.555	39.87
	26	561.11	21.581	
	Table F-value at	p = 0.05 is 2.96 p = 0.01 is 4.60		

TABLE 12b

anol extract of *Sida acuta* on vegetative growth of *Aspergillus niger* at 35°C.

	Degrees of freedom	Sum of squares	Mean square	F-value
	39	7365.98		
	9	7207.35	800.817	269.60
act	3	78.43	26.142	8.80
	27	80.20	2.970	
y	1	65.90	65.904	119.86
	26	14.30	0.550	
	Table F-value at	p = 0.05 is 2.96 p = 0.01 is 4.60		

TABLE 12c

anol extract of *Sida acuta* on vegetative growth of Aspergillus flavus at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	39	18320.47		
	9	18127.72	2015.192	476.11
act	3	78.52	26.175	6.19
	27	114.23	4.231	
y	1	33·47	33·472	10·78
	26	80·75	3·106	
	Table F-value at	p = 0.05 is 2.96 p = 0.01 is 4.60		

TABLE 12d

thanol extract of *Sida acuta* on vegetative growth of *Sclerotium rolfsii* at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	23	11318.24		
	5	10802.68	2160.535	142.96
ract	3	288.86	96.288	6.37
	15	226.70	15.113	
ty	1	217.09	217.092	316.40
	14	9.61	0.686	
	Table F-value at	p = 0.05 is 3.29 p = 0.01 is 5.42		

TABLE 12e

thanol extract of *Sida acuta* on vegetative growth of *Nigrospora sp.* at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	31	16669.43		
	7	14533.49	2076.213	127.26
tract	3	1793.34	597.779	36.64
	21	342.60	16.314	
ity	1	278.54	278.544	86.97
	20	64.06	3.203	
	Table F-value at	p = 0.05 is 3.07 p = 0.01 is 4.87		

TABLE 13a

ter extract of *Alternanthera pungens* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	10314.24		
	6	5245.43	874.238	14.10
tract	3	3952.53	1317.509	21.24
	18	1116.29	62.016	
ity	1	1046.68	1046.678	255.63
	17	69.61	4.095	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 13b

ater extract of *Alternanthera pungens* on vegetative growth of *Aspergillus niger* at 35°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	4535.03		
	6	3767.21	627.869	30.78
tract	3	400.60	133.533	6.55
	18	367.21	20.401	
ity	1	300.06	300.064	75.97
	17	67.15	3.950	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 13c

ater extract of *Alternanthera pungens* on vegetative growth of Aspergillus flavus at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	6319.17		
	6	5964.23	994.039	154.65
xtract	3	239.24	79.747	12.41
	18	115.70	6.428	
vity	1	94.72	94.718	76.75
	17	20.98	1.234	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 13d

er extract of *Alternanthera pungens* on vegetative growth of *Sclerotium rolfsii* at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	23	9850.49		
	5	8741.68	1748.335	63.76
ract	3	697.53	232.510	8.48
	15	411.28	27.419	
ty	1	365.67	365.673	112.25
	14	45.61	3.258	

Table F-value at p = 0.05 is 3.29
p = 0.01 is 5.42

TABLE 13e

ter extract of *Alternanthera pungens* on vegetative growth of *Nigrospora sp.* at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	23	8299.74		
	5	8045.68	1609.135	326.04
ract	3	180.03	60.010	12.16
	15	74.03	4.935	
ty	1	55.89	55.891	43.13
	14	18.14	1.296	

Table F-value at p = 0.05 is 3.29
p = 0.01 is 5.42

TABLE 14a

thanol extract of *Alternanthera pungens* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	12770.03		
	6	10844.21	1807.369	90.98
tract	3	1568.24	522.747	26.31
	18	357.57	19.865	
ity	1	238.70	238.699	34.14
	17	118.87	6.992	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 14b

ethanol extract of *Alternanthera pungens* on vegetative growth of *Aspergillus niger* at 35°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	5104.96		
	6	4177.46	696.244	33.54
tract	3	553.89	184.631	8.90
	18	373.61	20.756	
ity	1	316.74	316.742	94.69
	17	56.87	3.345	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 14c

ethanol extract of Alternanthera pungens on vegetative growth of Aspergillus flavus at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	6401.11		
	6	5953.23	992.205	157.48
tract	3	334.46	111.488	17.69
	18	113.41	6.301	
ity	1	96.90	96.901	99.78
	17	16.51	0.971	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 14d

ethanol extract of *Alternanthera pungens* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	23	9889.50		
	5	8464.63	1692.925	56.67
tract	3	976.75	325.583	10.90
	15	448.13	29.875	
ity	1	403.64	403.640	127.03
	14	44.48	3.177	

Table F-value at p = 0.05 is 3.29
p = 0.01 is 5.42

TABLE 14e

ethanol extract of *Alternanthera pungens* on vegetative growth of *Nigrospora sp.* at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	23	8592.96		
	5	8218.21	1643.642	415.82
xtract	3	315.46	105.153	26.60
	15	59.29	3.953	
vity	1	46.44	46.440	50.59
	14	12.85	0.918	

Table F-value at p = 0.05 is 3.29
p = 0.01 is 5.42

TABLE 15a

r extract of *Oxalis corniculata* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	23	10025.33		
	5	7728.46	1545.692	45.57
act	3	1788.08	596.028	17.57
	15	508.79	33.919	
y	1	443.70	443.699	95.43
	14	65.09	4.649	
	Table F-value at	p = 0.05 is 3.29 p = 0.01 is 5.42		

TABLE 15b

er extract of *Oxalis corniculata* on vegetative growth of *Aspergillus niger* at 35°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	4940.03		
	6	3841.84	640.307	30.41
ract	3	719.24	239.747	11.39
	18	378.95	21.053	
ty	1	307.43	307.430	73.08
	17	71.52	4.207	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 15c

ter extract of *Oxalis corniculata* on vegetative growth of *Aspergillus flavus* at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	10491.93		
	6	10236.80	1706.134	479.98
ract	3	191.14	63.714	17.92
	18	63.98	3.555	
ty	1	41.78	41.779	31.99
	17	22.20	1.306	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 15d

vater extract of *Oxalis corniculata* on vegetative growth of *Sclerotium rolfsii* at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	19	9423.24		
	4	9398.68	2349.669	5197.42
xtract	3	19.14	6.379	14.11
	12	5.43	0.452	
ivity	1	0.01	0.009	0.02
	11	5.42	0.492	

Table F-value at p = 0.05 is 3.49
p = 0.01 is 5.95

TABLE 15e

water extract of *Oxalis corniculata* on vegetative growth of *Nigrospora sp.* at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	31	18411.80		
	7	17934.87	2562.124	948.49
extract	3	420.21	140.070	51.85
	21	56.73	2.701	
ivity	1	5.26	5.262	2.09
	20	51.47	2.573	

Table F-value at p = 0.05 is 3.07
p = 0.01 is 4.87

TABLE 16a

nethanol extract of *Oxalis corniculata* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	14937.81		
	6	14756.25	2459.375	789.00
extract	3	125.46	41.818	13.42
	18	56.11	3.117	
ivity	1	14.77	14.773	6.08
	17	41.33	2.431	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 16b

methanol extract of *Oxalis corniculata* on vegetative growth of *Aspergillus niger* at 35°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	6189.21		
	6	6099.46	1016.577	1006.59
extract	3	71.57	23.857	23.62
	18	18.18	1.010	
ivity	1	11.21	11.213	27.37
	17	6.97	0.410	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 16c

methanol extract of *Oxalis corniculata* on vegetative growth of *Aspergillus flavus* at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	27	14734.86		
s	6	14581.73	2430.289	1377.03
extract	3	121.36	40.452	22.92
	18	31.77	1.765	
tivity	1	2.55	2.553	1.49
	17	29.22	1.719	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 16d

methanol extract of *Oxalis corniculata* on vegetative growth of *Sclerotium rolfsii* at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	19	9006.45		
	4	8371.70	2092.925	94.52
extract	3	369.05	123.017	5.56
	12	265.70	22.142	
ivity	1	227.41	227.407	65.32
	11	38.29	3.481	

Table F-value at p = 0.05 is 3.49
p = 0.01 is 5.95

TABLE 16e

methanol extract of *Oxalis corniculata* on vegetative growth of *Nigrospora sp.* at 30°C

	Degrees of freedom	Sum of squares	Mean square	F-value
	31	18200.30		
s	7	17828.99	2546.999	480.61
extract	3	260.02	86.674	16.36
	21	111.29	5.299	
tivity	1	57.71	57.706	21.54
	20	53.58	2.679	

Table F-value at p = 0.05 is 3.07
p = 0.01 is 4.87

G. STUDIES ON THE VEGETATIVE GROWTH OF FIVE FUNGI ON SOLID MEDIUM AMENDED WITH WATER AND METHANOL EXTRACTS OF PLANTS FROM THE FAMILY APOCYNACEAE, ASCLEPIADACEAE AND EUPHORBIACEAE

A summary of the results is as follows:

1. *Euphorbia heterophylla* (Euphorbiaceae)

(a) Water Extract.

The only inhibitory effect of significance of the extract on the test fungi was that on *Scopulariopsis brevicaulis* (Fig. 19). Vegetative growth of *S. brevicaulis* was inhibited by 37.5 per cent when cultured in the 1:1v/v dilution of the extract. Growth in all the dilutions (1:1-1:5v/v) were close to those in the controls in the remaining test fungi namely *Aspergillus niger, A. flavus, Scelerotium rolfsii* and *Nigrospora sp.*

(b) Methanol Extract

The extract had no significant inhibitory effect on *A. niger*, *A. flavus* and *Nigrospora sp.* (Fig. 19). On the other hand, radial diameter of *S. brevicaulis and S. rolfsii* in the presence of 1:1 v/v dilution of the extract was depressed by 35.2 and 21.2 per cent respectively.

2. *Pergularia daemia* (Asclepiadaceae)

(a) Water Extract

Vegetative growth of all test fungi was significantly depressed by this water extract (Fig. 20; Tables 17a-17e). Radial diameter of *S. brevicanlis* was depressed by 47.6 per cent in 1:1v/v dilution whilst the same extract depressed dry matter accumulation of *A. niger* by 40.2

per cent. Vegetative growth of *Nigrospora sp.* was inhibited by 15.5 per cent while that of *A. flavus* was by 13.8 per cent.

(b) Methanol Extract.

This extract also significantly ($p \leq 0.05$) suppressed vegetative growth of all the test fungi (Fig. 20; Tables 18a-18e). Growth of *S. brevicaulis* was depressed by 37.7 per cent and that of *A. niger* by 34.3 per cent, in the 1:1v/v dilution of extract. Vegetative growth of *S. rolfsii* and *A. flavus* was depressed by 16.1 per cent and 10.0 per cent respectively whilst that of *Nigrospora sp.* was depressed by 19.5 per cent.

3. *Voacanga africana* (Apocynaceae)

(a) Water Extract

Growth of *S. rolfsii* and *Nigrospora sp.* were very significantly depressed in the water extract of *V. africana* (Fig. 21; Tables 19a-19e). The depression of growth of *A. niger* and *A. flavus* by this extract can be described as marginal in all dilutions (1:1-1:5v/v). Growth of *S. rolfsii* was depressed by 37.2 per cent followed by 28.4 per cent inhibition of growth by *Nigrospora sp.* in the 1:1v/v dilution. Vegetative growth of *S. brevicaulis* was depressed by 22.8 per cent.

(b) Methanol Extract

The methanol extract was more potent against *S. brevicaulis*, *S. rolfsii* and *Nigrospora sp.* (Fig. 21; Tables 20a-20e). The effect of this methanol extract on *A . niger* and *A. flavus* was only marginally significant. Interestingly, vegetative growth of *Nigrospora sp.*, *S. rolfsii* and *S. brevicaulis* was inhibited by 44.0, 33.3 and 32.7 per cent respectively by 1:1v/v dilution of this extract.

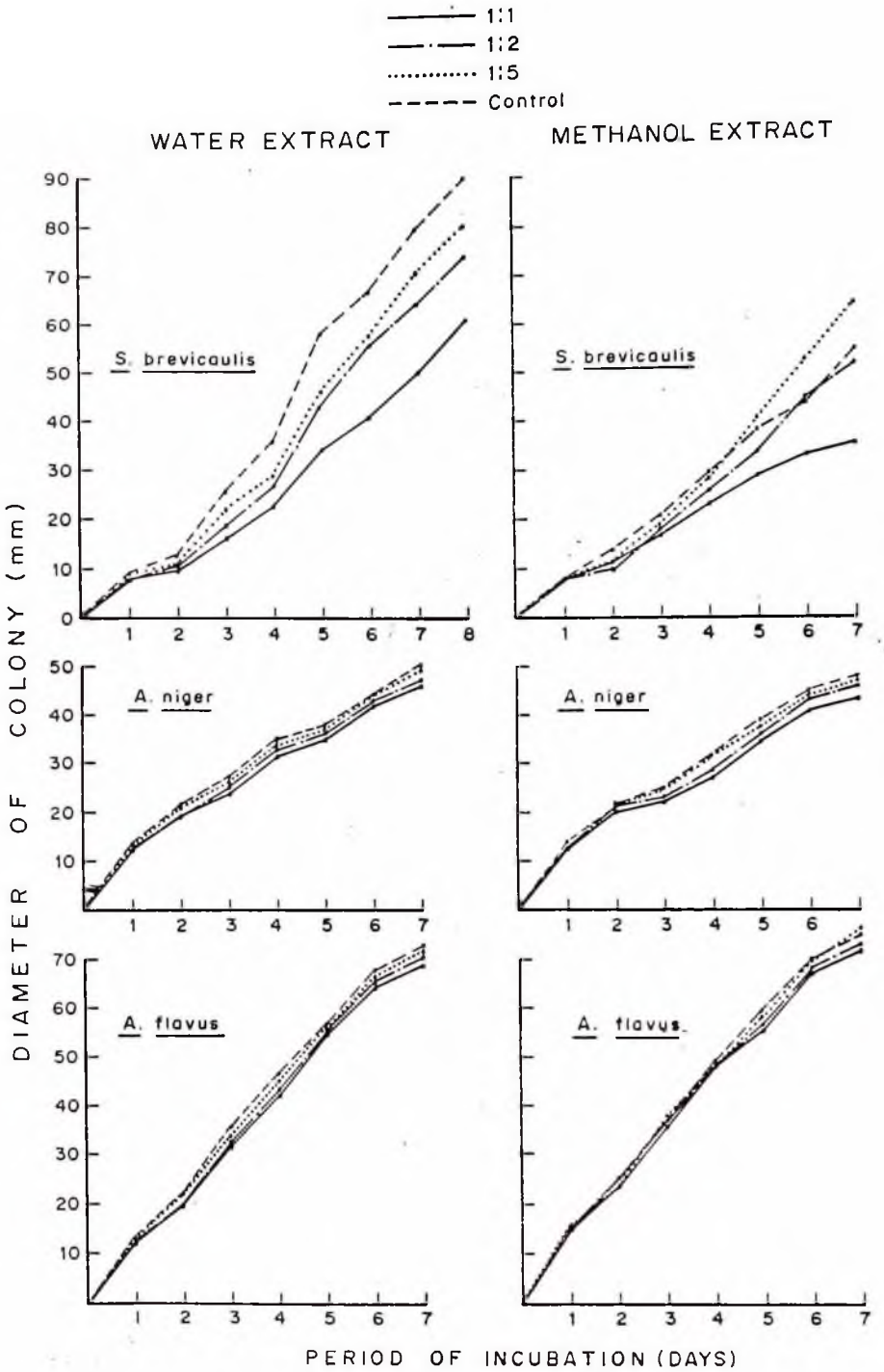


Fig.19. Effect of varying dilutions of water and methanol extracts of Euphorbia heterophylla on vegetative growth of indicated fungi.

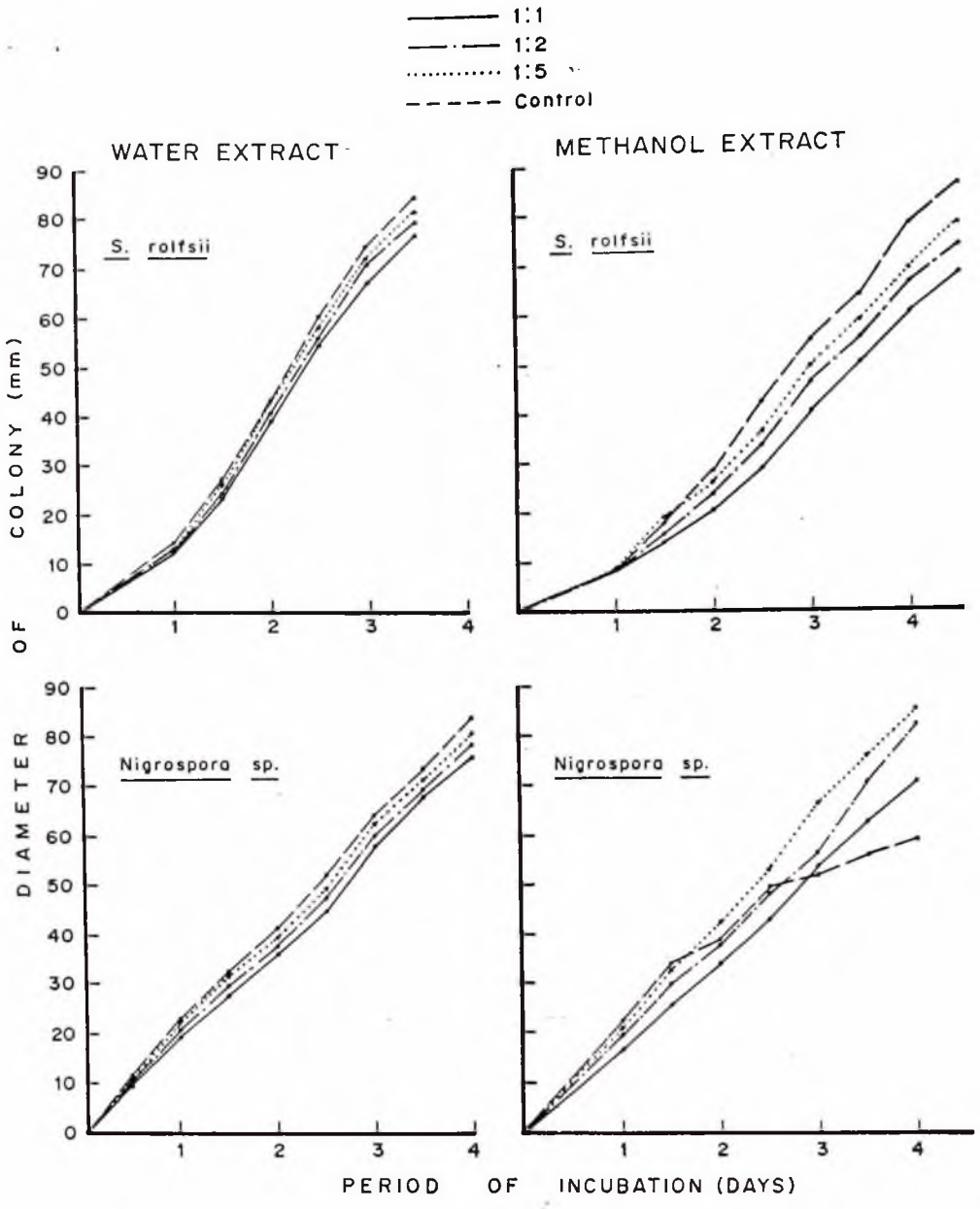


Fig.19 (Cont'd). Effect of varying dilutions of water and methanol extracts of Euphorbia heterophylla on vegetative growth of indicated fungi.

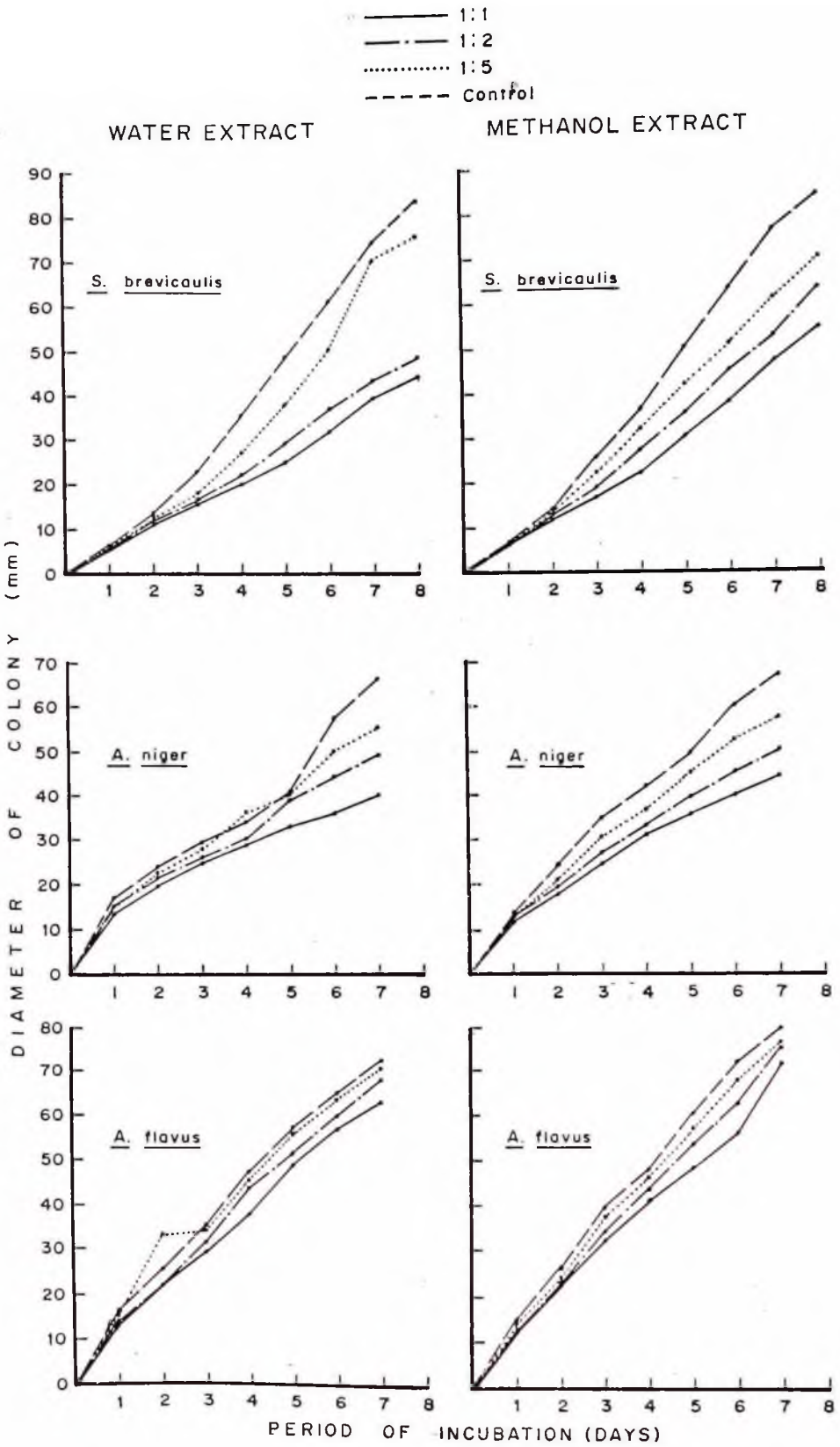


Fig.20. Effect of varying dilutions of water and methanol extracts of Pergularia daemia on vegetative growth of indicated fungi.

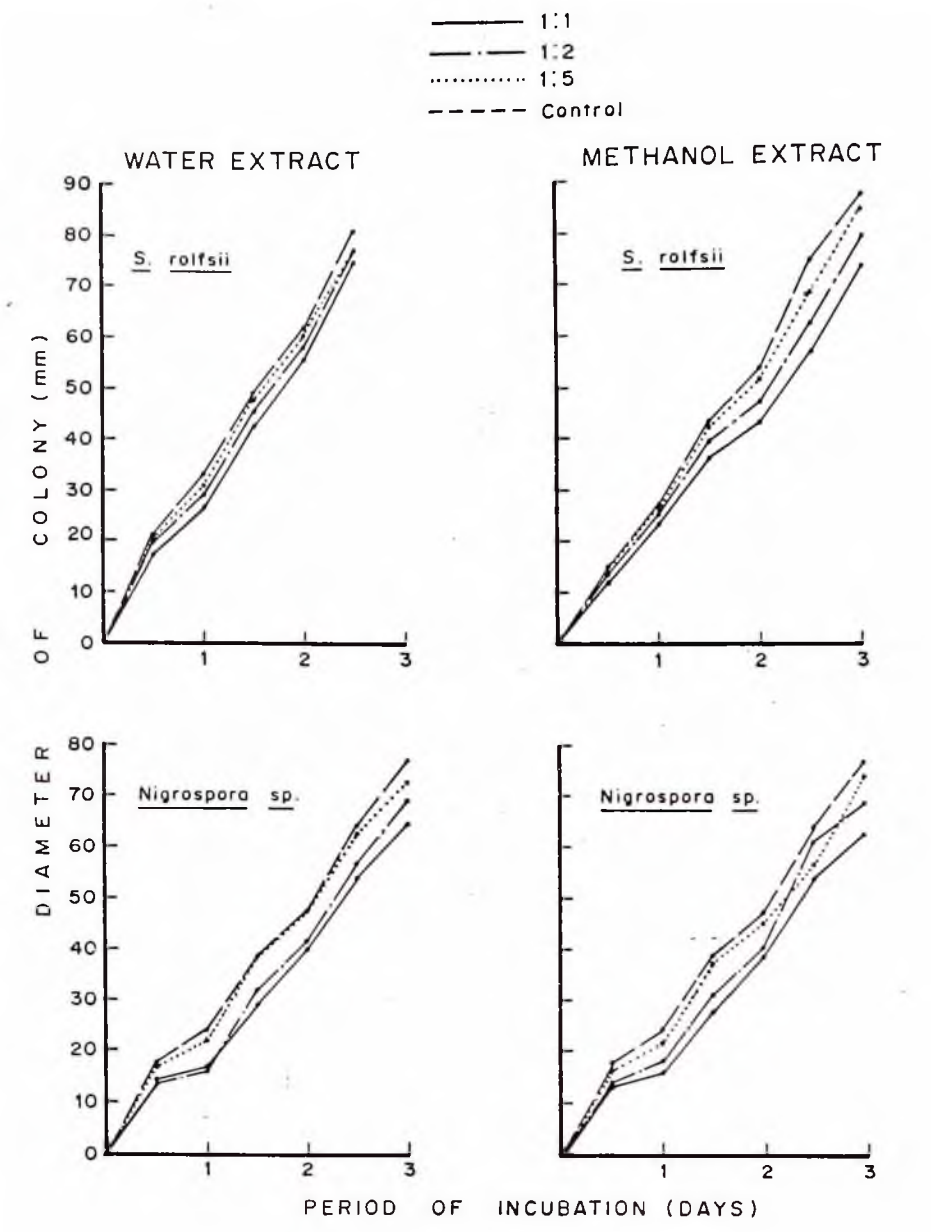


Fig.20 (Cont'd). Effect of varying dilutions of water and methanol extracts of Pergularia daemia on vegetative growth of indicated fungi.

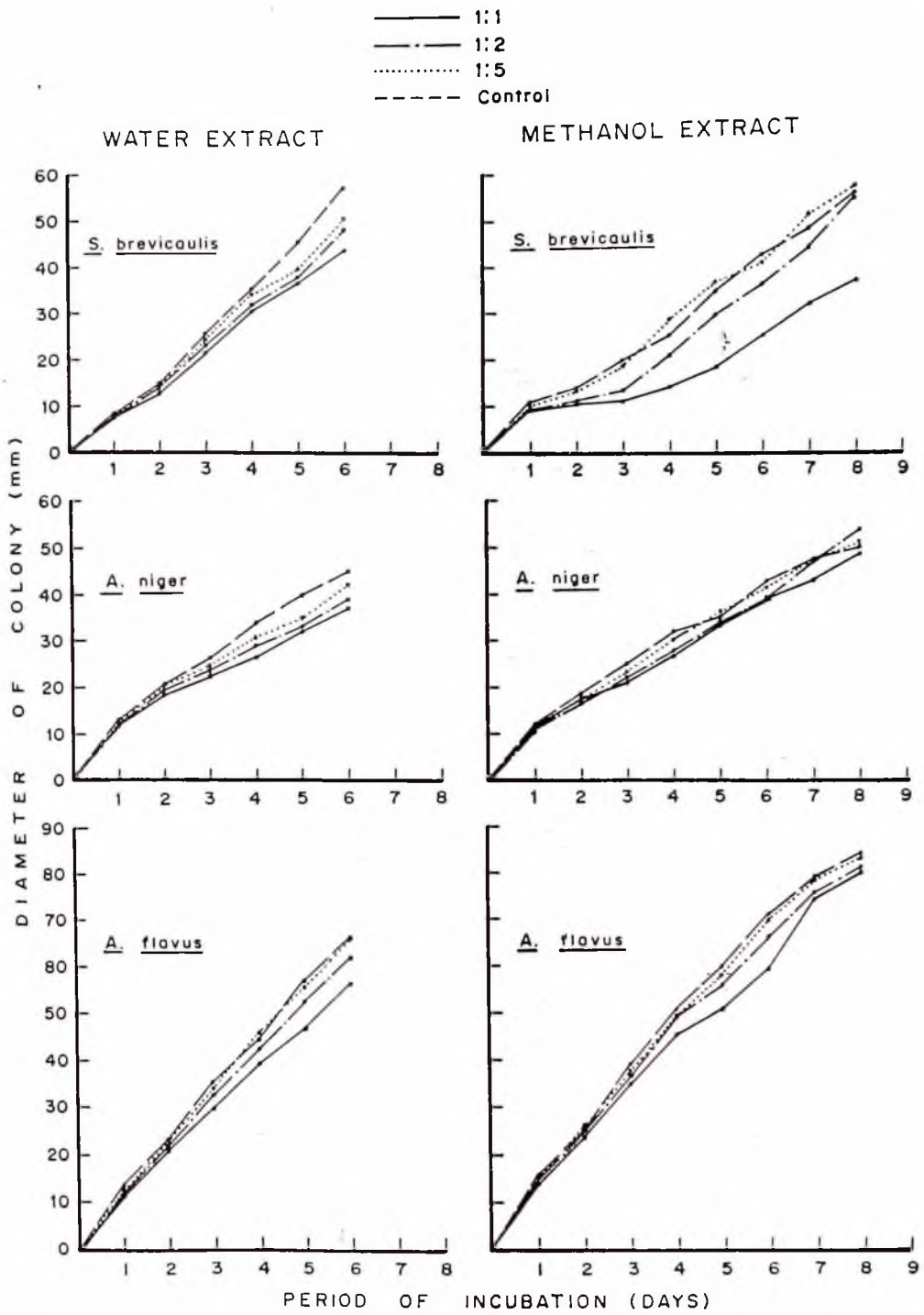


Fig.21. Effect of varying dilutions of water and methanol extracts of Voacanga africana on vegetative growth of indicated fungi.

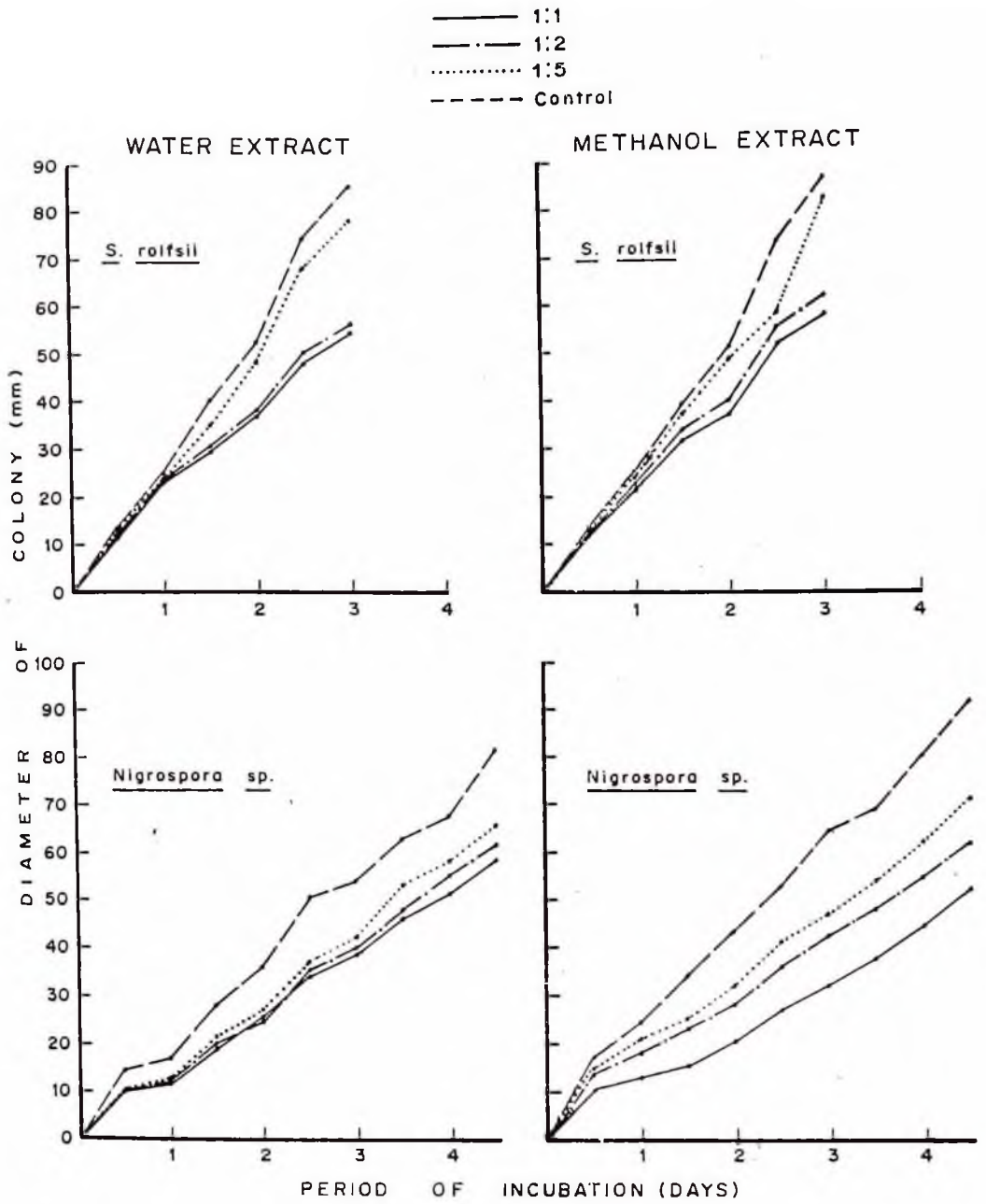


Fig.21 (Cont'd). Effect of varying dilutions of water and methanol extracts of Voacanga africana on vegetative growth of indicated fungi.

TABLE 17a

Effect of water extract of *Pergularia daemia* on vegetative growth of *S. brevicaulis* at 30°C

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	27	12107.24		
Replicates	6	8919.68	1486.613	27.43
Conc. of extract	3	2212.10	737.366	13.61
Error	18	975.46	54.192	
Non-additivity	1	897.13	897.135	194.71
Residual	17	78.33	4.608	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 17b

Effect of water extract of *Pergularia daemia* on vegetative growth of *Aspergillus niger* at 35°C.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	27	5105.96		
Replicates	6	4387.96	731.327	41.86
Conc. of extract	3	403.54	134.512	7.70
Error	18	314.46	17.470	
Non-additivity	1	243.03	243.024	57.84
Residual	17	71.43	4.202	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 17c

Effect of water extract of *Pergularia daemia* on vegetative growth of *Aspergillus flavus* at 30°C

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	27	9763.037		
Replicates	6	9550.59	1591.765	624.08
Conc. of extract	3	166.53	55.509	21.76
Error	18	45.91	2.551	
Non-additivity	1	33.08	33.083	43.84
Residual	17	12.83	0.755	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 17d

Effect of water extract of *Pergularia daemia* on vegetative growth of *Sclerotium rolfsii* at 30°C

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	15	8562.77		
Replicates	4	8505.00	2126.251	5260.83
Conc. of extract	3	54.53	18.178	44.98
Error	8	3.23	0.404	
Non-additivity	1	1.05	1.057	3.40
Residual	7	2.18	0.311	

Table F-value at p = 0.05 is 4.07
p = 0.01 is 7.59

TABLE 17e

Effect of water extract of *Pergularia daemia* on vegetative growth of *Nigrospora sp.* at 30oC

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	23	9670.244		
Replicates	5	9344.93	1868.985	823.80
Conc. of extract	3	291.28	97.094	42.80
Error	15	34.03	2.269	
Non-additivity	1	13.02	13.019	8.67
Residual	14	21.01	1.501	

Table F-value at p = 0.05 is 3.29
p = 0.01 is 5.42

TABLE 18a

Effect of methanol extract of *Pergularia daemia* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	27	10678.68		
Replicates	6	8612.18	1435.363	41.39
Conc. of extract	3	1442.32	480.774	13.86
Error	18	624.18	34.677	
Non-additivity	1	211.92	211.921	8.74
Residual	17	412.26	24.250	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 18b

Effect of methanol extract of *Pergularia daemia* on vegetative growth of *Aspergillus niger* at 35°C

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	27	6284.50		
Replicates	6	5496.25	916.042	85.48
Conc. of extract	3	595.36	198.452	18.52
Error	18	192.89	10.716	
Non-additivity	1	183.76	183.765	342.24
Residual	17	9.13	0.537	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 18c

Effect of methanol extract of *Pergularia daemia* on vegetative growth of *Aspergillus flavus* at 30°C

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	27	12202.50		
Replicates	6	11873.00	1978.885	387.03
Conc. of extract	3	239.79	70.929	16.04
Error	18	89.71	4.984	
Non-additivity	1	47.67	47.670	19.27
Residual	17	42.05	2.473	
	Table F-value at	p = 0.05 is 3.16 p = 0.01 is 5.09		

TABLE 18d

Effect of methanol extract of *Pergularia daemia* on vegetative growth of *Sclerotium rolfsii* at 30°C

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	23	12868.49		
Replicates	5	12485.05	2497.010	371.49
Conc. of extract	3	282.61	94.205	14.02
Error	15	100.82	6.722	
Non-additivity	1	83.76	83.757	68.71
Residual	14	17.07	1.219	
	Table F-value at	p = 0.05 is 3.29 p = 0.01 is 5.42		

TABLE 18e

Effect of methanol extract of *Pergularia daemia* on vegetative growth of *Nigrospora sp.* at 30°C

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	23	9400.74		
Replicates	5	8982.55	1796.510	449.83
Conc. of extract	3	358.28	119.427	29.90
Error	15	59.91	3.994	
Non-additivity	1	22.99	22.987	8.72
Residual	14	36.92	2.637	
	Table F-value at	p = 0.05 is 3.29 p = 0.01 is 5.42		

TABLE 19a

Effect of water extract of *Voacanga africana* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	23	5635.83		
Replicates	5	5414.33	1082.867	179.48
Conc. of extract	3	131.00	43.667	7.24
Error	15	90.50	6.033	
Non-additivity	1	23.39	23.387	4.88
Residual	14	67.11	4.794	
	Table F-value at	p = 0.05 is 3.29 p = 0.01 is 5.42		

TABLE 19b

Effect of water extract of *Voacanga africana* on vegetative growth of *Aspergillus niger* at 35°C

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	23	2246.99		
Replicates	5	2135.80	427.160	175.20
Conc. of extract	3	74.61	24.872	10.20
Error	15	36.57	2.438	
Non-additivity	1	30.99	30.991	77.74
Residual	14	5.58	0.399	
	Table F-value at	p = 0.05 is 3.29 p = 0.01 is 5.42		

TABLE 19c

Effect of water extract of *Voacanga africana* on vegetative growth of *Aspergillus flavus* at 30°C

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	23	7305.50		
Replicates	5	7153.00	1430.600	486.78
Conc. of extract	3	108.42	36.139	12.30
Error	15	44.08	2.939	
Non-additivity	1	41.23	41.230	202.28
Residual	14	2.85	0.204	
	Table F-value at	p = 0.05 is 3.29 p = 0.01 is 5.42		

TABLE 19d

Effect of water extract of *Voacanga africana* on vegetative growth of *Sclerotium rolfsii* at 30°C

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	23	10861.46		
Replicates	5	9311.83	1862.367	44.80
Conc. of extract	3	926.04	308.681	7.43
Error	15	623.58	41.572	
Non-additivity	1	599.85	599.852	353.87
Residual	14	23.73	1.695	

Table F-value at p = 0.05 is 3.29
p = 0.01 is 5.42

TABLE 19e

Effect of water extract of *Voacanga africana* on vegetative growth of *Nigrospora sp.* at 30°C

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	38	18125.93		
Replicates	9	16725.66	1858.406	210.02
Conc. of extract	3	1170.21	390.071	44.08
Error	26	230.06	8.849	
Non-additivity	1	151.01	151.013	47.76
Residual	25	79.05	3.162	

Table F-value at p = 0.05 is 2.98
p = 0.01 is 4.64

TABLE 20a

Effect of methanol extract of *Voacanga africana* on vegetative growth of *Scopulariopsis brevicaulis* at 30°C

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	31	7500.00		
Replicates	7	6483.38	926.196	69.82
Conc. of extract	3	738.06	246.012	18.55
Error	21	278.56	13.265	
Non-additivity	1	194.33	194.333	46.14
Residual	20	84.23	4.211	
	Table F-value at	p = 0.05 is 3.07 p = 0.01 is 4.87		

TABLE 20b

Effect of methanol extract of *Voacanga africana* on vegetative growth of *Aspergillus niger* at 35°C

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	31	5370.38		
Replicates	7	5319.76	759.964	515.85
Conc. of extract	3	19.69	6.563	4.45
Error	21	30.94	1.473	
Non-additivity	1	2.71	2.709	1.92
Residual	20	28.23	1.411	
	Table F-value at	p = 0.05 is 3.07 p = 0.01 is 4.87		

TABLE 20c

Effect of methanol extract of *Voacanga africana* on vegetative growth of *Aspergillus flavus* at 30°C

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	31	16735.47		
Replicates	7	16575.47	2367.924	859.67
Conc. of extract	3	102.16	34.052	12.36
Error	21	57.84	2.754	
Non-additivity	1	17.87	17.870	8.94
Residual	20	39.97	1.999	
	Table F-value at	p = 0.05 is 3.07 p = 0.01 is 4.87		

TABLE 20d

Effect of methanol extract of *Voacanga africana* on vegetative growth of *Sclerotium rolfsii* at 30°C

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	23	11494.66		
Replicates	5	10367.59	2073.519	64.47
Conc. of extract	3	644.61	214.872	6.68
Error	15	482.45	32.163	
Non-additivity	1	454.30	454.296	225.92
Residual	14	28.15	2.011	

Table F-value at p = 0.05 is 3.29
p = 0.01 is 5.42

TABLE 20e

Effect of methanol extract of *Voacanga africana* on vegetative growth of *Nigrospora sp.* at 30°C

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Total	35	14917.64		
Replicates	8	11397.39	1424.674	61.99
Conc. of extract	3	2968.69	989.565	43.06
Error	24	551.56	22.981	
Non-additivity	1	509.18	509.179	276.36
Residual	23	42.38	1.842	

Table F-value at p = 0.05 is 3.01
p = 0.01 is 4.72

H. COMPARATIVE FUNGISTATIC ACTIVITY OF EXTRACTS OF NINETEEN PLANTS ON VEGETATIVE GROWTH OF FIVE SELECTED FUNGI

Results obtained are presented in Tables 21-24.

Fungistatic activity of the plant extracts on each fungus varied from plant to plant. There was no relationship between the effect of extracts from plants from the same family on any of the test fungi. There were differences in the activity of the water and methanol extracts from each plant. None of the plant extracts exhibited a broad spectrum activity over all the five selected test fungi.

The highest fungistatic activity of 7.7 was obtained with the water extract of *Cassia rotundifolia* on *Scopulariopsis brevicaulis* (Table 22). This was followed by 2.6 and 2.2 by *Alternanthera pungens* and *Tridax procumbens* respectively on *S. brevicaulis* (Tables 23 and 22). *Pergularia daemia* and *Oxalis corniculata* each exerted fungistatic activity of 2.0 on *S. brevicaulis*.

The water extracts of *Launaea taraxacifolia, Aspilia africana, Emilia sonchifolia, Synedrella nodiflora, Zanthoxylum xanthoxyloides* and *Boerhavia diffusa* all exerted fungistatic activities that were below 1.5 on any of the test fungi.

The most susceptible fungus to the water extracts was *S. brevicaulis* whilst the most resistant was *Aspergillus flavus*.

FUNGISTATIC ACTIVITY OF WATER AND METHANOL EXTRACTS OF SIX PLANTS IN FAMILY COMPOSITAE ON INDICATED FUNGI

PLANT	FUNGUS	WATER EXTRACT			METHANOL EXTRACT		
		Diameter of colony (mm)		Fungistatic	Diameter of colony (mm)		Fungistatic
		Control	1:1 v/v dilution	activity E/C	Control	1:1 v/v dilution	activity E/C
Launaea (Lactuca) taraxacifolia	*Scopulariopsis brevicaulis*	30.0	25.0	1.2	25.0	10.5	2.4
	Aspergillus niger	21.0	20.0	1.1	12.3	13.0	0.9
	Aspergillus flavus	23.5	20.0	1.2	67.5	45.0	1.5
	Sclerotium rolfsii	25.0	21.0	1.2	90.0	82.0	1.1
	Nigrospora sp.	11.5	9.0	1.3	42.0	17.0	2.5
Tridax procumbens	*Scopulariopsis brevicaulis*	33.0	15.0	2.2	14.0	11.0	1.3
	Aspergillus niger	43.0	41.0	1.1	16.0	16.0	1.0
	Aspergillus flavus	55.0	47.0	1.2	77.5	65.5	1.2
	Sclerotium rolfsii	47.5	44.5	1.2	90.0	61.5	1.5
	Nigrospora sp.	15.5	14.5	1.1	13.5	14.5	0.9
Aspilia africana	*Scopulariopsis brevicaulis*	11.5	14.0	0.8	11.0	11.5	1.0
	Aspergillus niger	15.5	15.5	1.0	16.0	14.5	1.1
	Aspergillus flavus	16.0	17.0	0.9	15.5	14.0	1.1
	Sclerotium rolfsii	14.0	13.5	1.2	15.5	12.0	1.3
	Nigrospora sp.	43.5	37.5	1.2	39.5	31.0	1.3
Emilia sonchifolia	~~*Scopulariopsis brevicaulis*~~	13.0	14.5	0.9	18.0	14.0	0.9
	Aspergillus niger	17.0	17.0	1.0	60.5	62.0	1.0
	Aspergillus flavus	61.5	64.0	1.0	15.0	17.0	0.9
	Sclerotium rolfsii	24.0	21.0	1.1	15.0	11.0	1.4
	Nigrospora sp.	11.0	10.0	1.1	30.5	29.0	1.1
Synedrella nodiflora	*Scopulariopsis brevicaulis*	33.5	39.5	0.9	16.0	18.5	0.9
	Aspergillus niger	34.5	30.0	1.2	40.0	33.0	1.2
	Aspergillus flavus	23.5	22.0	1.1	35.0	31.5	1.1
	Sclerotium rolfsii	24.0	24.0	1.0	53.0	35.5	1.5
	Nigrospora sp.	23.0	19.0	1.2	21.0	14.5	1.5
Chromolaena odorata	*Scopulariopsis brevicaulis*	19.5	22.0	0.9	25.0	21.0	1.2
	Aspergillus niger	37.0	34.0	1.2	54.5	46.0	1.2
	Aspergillus flavus	21.5	19.0	1.1	22.0	18.0	1.2
	Sclerotium rolfsii	43.0	41.0	1.1	23.0	18.0	1.3
	Nigrospora sp.	23.0	15.5	1.5	35.0	26.0	1.4

TABLE 22
FUNGISTATIC ACTIVITY OF WATER AND METHANOL EXTRACTS OF SIX PLANTS ON INDICATED FUNGI

PLANT	FUNGUS	WATER EXTRACT			METHANOL EXTRACT		
		Diameter of colony (mm)		Fungistatic	Diameter of colony (mm)		Fungistatic
		Control	1:1 %/v dilution	activity E/C	Control	1:1%/v dilution	activity E/C
Crotalaria retusa (Papilionaceae)	*Scopulariopsis brevicaulis*	46.5	30.0	1.6	40.0	22.0	1.8
	Aspergillus niger	19.5	17.0	1.1	31.0	28.0	1.2
	Aspergillus flavus	62.0	48.0	1.3	30.0	27.5	1.2
	Sclerotium rolfsii	27.0	24.5	1.1	23.0	20.0	1.2
	Nigrospora sp.	26.5	23.0	1.2	22.5	18.0	1.3
Desmodium triflorum (Papilionaceae)	*Scopulariopsis brevicaulis*	14.5	11.5	1.3	13.5	10.5	1.3
	Aspergillus niger	58.0	39.0	1.5	56.5	37.5	1.5
	Aspergillus flavus	70.0	40.5	1.7	44.0	32.0	1.4
	Sclerotium rolfsii	22.5	16.0	1.4	42.5	27.0	1.6
	Nigrospora sp.	18.0	12.0	1.5	24.5	16.0	1.5
Cassia rotundifolia (Caesalpinaceae)	*Scopulariopsis brevicaulis*	84.5	11.0	7.7	26.0	19.5	1.3
	Aspergillus niger	65.0	51.0	1.3	63.0	42.0	1.5
	Aspergillus flavus	45.5	34.5	1.3	41.0	28.5	1.4
	Sclerotium rolfsii	54.0	43.0	1.3	39.0	25.5	1.5
	Nigrospora sp.	55.0	32.5	1.7	33.5	18.0	1.9
Griffonia simplicifolia (Caesalpinaceae)	*Scopulariopsis brevicaulis*	45.5	35.0	1.3	25.0	14.0	1.8
	Aspergillus niger	12.0	12.5	1.0	21.5	17.5	1.2
	Aspergillus flavus	35.0	35.5	1.0	50.5	42.5	1.2
	Sclerotium rolfsii	24.0	16.5	1.5	23.5	18.5	1.3
	Nigrospora sp.	28.0	24.0	1.2	17.0	8.0	2.1
Zanthoxylum xanthoxyloides (Rutaceae)	*Scopulariopsis brevicaulis*	67.0	53.0	1.3	15.5	10.5	1.5
	Aspergillus niger	42.0	36.5	1.2	21.0	18.0	1.2
	Aspergillus flavus	31.0	27.0	1.2	67.0	57.0	1.2
	Sclerotium rolfsii	25.0	19.0	1.3	27.5	20.0	1.4
	Nigrospora sp.	59.5	51.0	1.2	10.0	7.5	1.3
Azadirachta indica (Meliaceae)	*Scopulariopsis brevicaulis*	8.0	8.0	1.0	34.0	28.0	1.2
	Aspergillus niger	28.5	20.0	1.4	28.0	18.5	1.2
	Aspergillus flavus	36.5	29.5	1.2	42.5	35.5	1.2
	Sclerotium rolfsii	44.5	38.5	1.2	27.5	18.0	1.5
	Nigrospora sp.	27.5	16.5	1.7	13.5	7.0	1.9

TABLE 23

FUNGISTATIC ACTIVITY OF WATER AND METHANOL EXTRACTS OF FOUR PLANTS ON INDICATED TEST FUNGI

PLANT	FUNGUS	WATER EXTRACT			METHANOL EXTRACT		
		Diameter of colony (mm)		Fungistatic	Diameter of colony (mm)		Fungistatic
		Control	1:1 %/v dilution	activity E/C	Control	1:1%/v dilution	activity E/C
Sida acuta (Malvaceae)	*Scopulariopsis brevicaulis*	79.0	68.5	1.2	19.0	8.0	2.4
	Aspergillus niger	12.5	12.5	1.0	15.0	15.5	1.0
	Aspergillus flavus	13.0	13.0	1.0	14.5	14.0	1.0
	Sclerotium rolfsii	76.5	52.0	1.5	70.0	15.5	1.3
	Nigrozpora sp.	14.0	13.5	1.0	13.5	8.0	1.7
Alternanthera pungens (Amaranthaceae)	*Scopulariopsis brevicaulis*	69.0	26.5	2.6	45.0	21.0	2.1
	Aspergillus niger	63.0	34.5	1.8	65.5	35.0	1.9
	Aspergillus flavus	48.5	36.0	1.3	48.5	35.5	1.4
	Sclerotium rolfsii	84.5	53.5	1.6	84.5	50.0	1.7
	Nigrospora sp.	19.0	14.5	1.3	18.5	13.5	1.4
Boerhavia diffusa (Nyctaginaceae)	*Scopulariopsis brevicaulis*	25.0	20.0	1.3	8.0	9.0	0.9
	Aspergillus niger	35.5	31.0	1.2	47.0	41.0	1.2
	Aspergillus flavus	14.0	13.0	1.1	21.5	18.0	1.2
	Sclerotium rolfsii	27.0	25.0	1.1	28.0	21.0	1.3
	Nigrospora sp.	15.0	13.0	1.2	23.0	20.0	1.2
Oxalis corniculata (Oxalidaceae)	*Scopulariopsis brevicaulis*	61.0	31.0	2.0	24.5	18.0	1.4
	Aspergillus niger	66.5	37.5	1.8	42.5	36.5	1.2
	Aspergillus flavus	15.5	13.0	1.2	28.0	20.5	1.4
	Sclerotium rolfsii	23.0	21.0	1.1	84.5	57.5	1.5
	Nigrospora sp.	17.5	10.5	1.7	45.0	33.0	1.4

TABLE 24

FUNGISTATIC ACTIVITY OF WATER AND METHANOL EXTRACTS OF THREE PLANTS ON INDICATED FUNGI

PLANT	FUNGUS	WATER EXTRACT			METHANOL EXTRACT		
		Diameter of colony (mm)		Fungistatic activity E/C	Diameter of colony (mm)		Fungistatic activity E/C
		Control	1:1 %/v dilution		Control	1:1%/v dilution	
Euphorbia heterophylla (Euphorbiaceae)	*Scopulariopsis brevicaulis*	58.5	34.5	1.7	54.0	35.0	1.5
	Aspergillus niger	20.5	18.5	1.1	31.5	27.0	1.2
	Aspergillus flavus	22.0	19.0	1.2	58.5	55.0	1.1
	Sclerotium rolfsii	14.0	12.0	1.2	42.0	29.0	1.5
	Nigrospora sp.	22.5	19.5	1.2	23.0	17.0	1.4
Pergularia daemia (Asclepiadaceae)	*Scopulariopsis brevicaulis*	49.0	25.0	2.0	36.5	22.0	1.7
	Aspergillus niger	66.5	40.0	1.7	60.0	40.0	1.5
	Aspergillus flavus	47.5	38.0	1.3	72.5	56.0	1.3
	Scierotium rolfsii	21.0	17.0	1.2	74.0	57.0	1.3
	Nigrospora sp.	24.5	17.5	1.4	24.5	16.0	1.5
Voacanga africana (Apocynaceae)	*Scopulariopsis brevicaulis*	57.5	44.5	1.3	25.0	13.5	1.9
	Aspergillus niger	33.5	26.5	1.3	24.0	21.0	1.1
	Aspergillus flavus	35.0	30.0	1.2	59.0	50.5	1.2
	Scierotium rolfsii	75.0	48.0	1.6	86.5	57.5	1.5
	Nigrospora sp.	14.5	10.0	1.5	34.5	15.0	2.3

I. GROWTH OF FIVE FUNGI STORED IN WATER AND METHANOL EXTRACTS OF NINE PLANTS.

Results obtained are presented in Figs. 22-26.

In all cases mycelia of the fungi resumed growth when placed in Potato Dextrose Broth (PDB) medium after immersion in the water or methanol extract of the plants for the varying periods (15 minutes to 48 hours). The longer the period of immersion in the extract the severer the decline in dry matter accumulation by the fungus. The only exception was with the water extract of *Griffonia simplicifolia* (Fig.26) where the extract appeared to have stimulated growth of *Aspergillus niger* and *A. flavus* because of the increase in their dry matter accumlation.

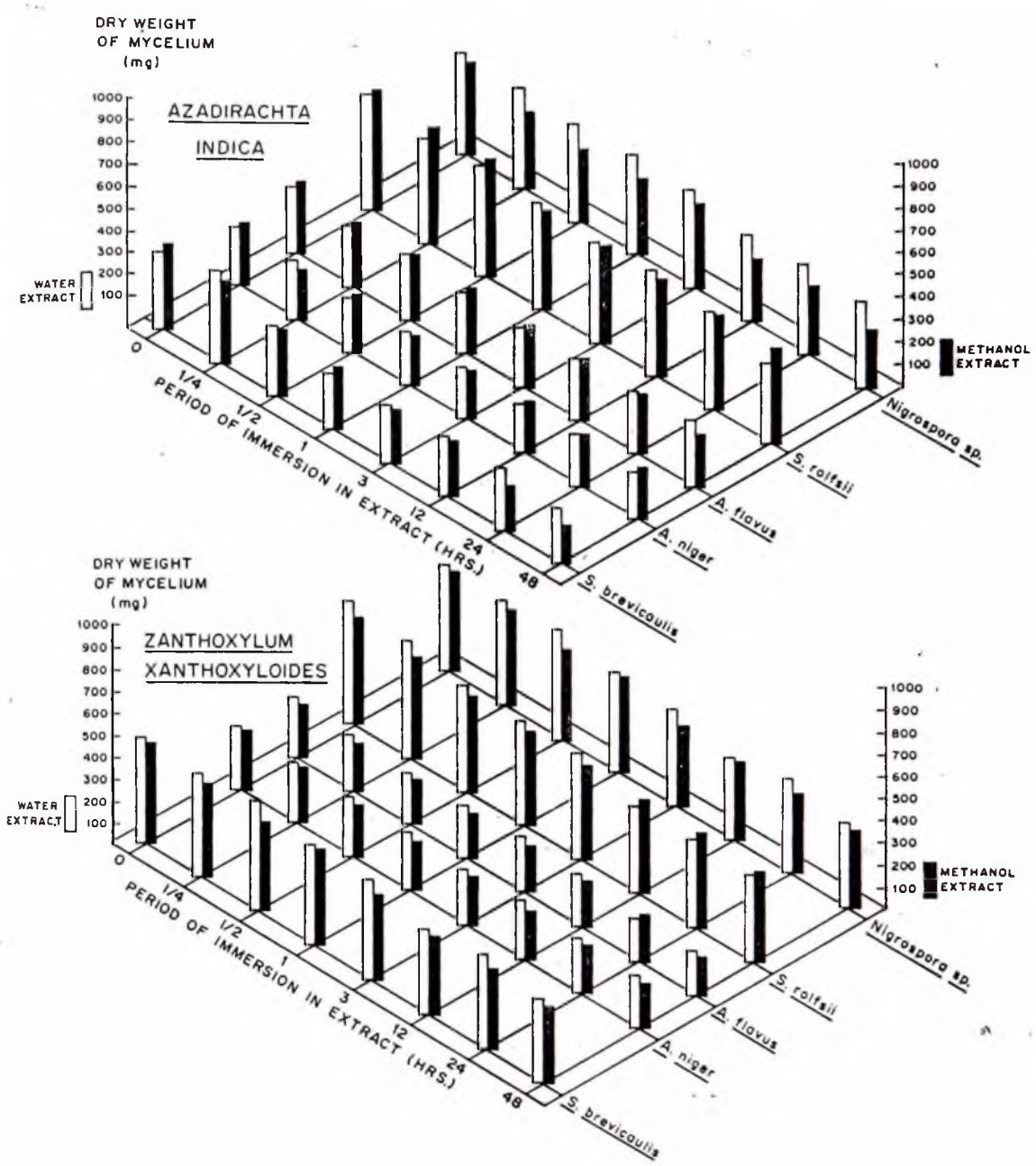


Fig.22. Vegetative growth of fungi stored in 1:1 v/v dilution of water and methanol extracts of plants for indicated periods and then transferred to Potato Dextrose Broth for 10 days at 30°C.

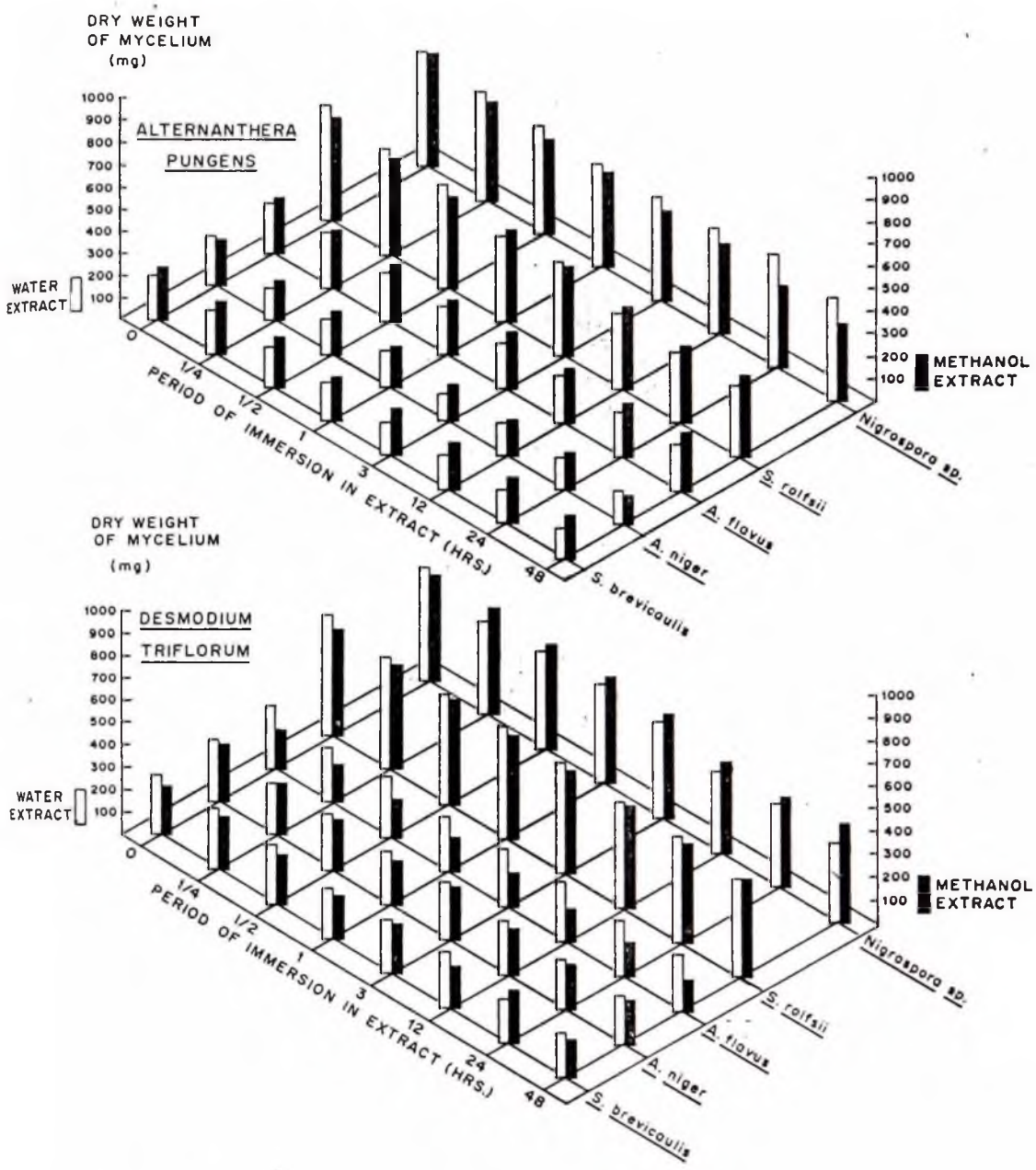


Fig. 23. Vegetative growth of fungi stored in 1:1 v/v dilution of water and methanol extracts of plants for indicated periods and then transferred to Potato Dextrose Broth for 10 days at 30°C.

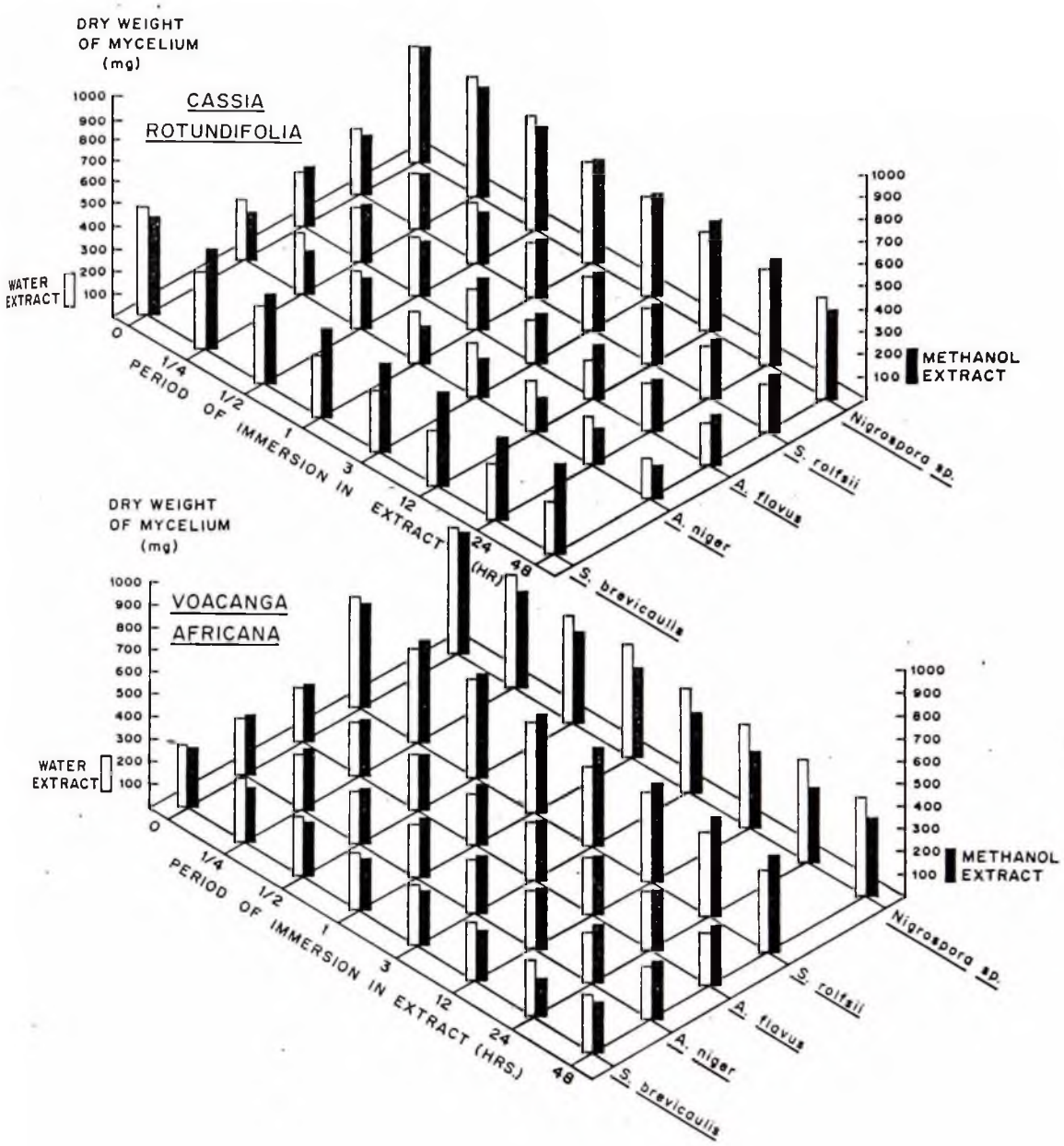


Fig. 24. Vegetative growth of fungi stored in 1:1 v/v dilution of water and methanol extracts of plants for indicated periods and then transferred to Potato Dextrose Broth for 10 days at 30°C.

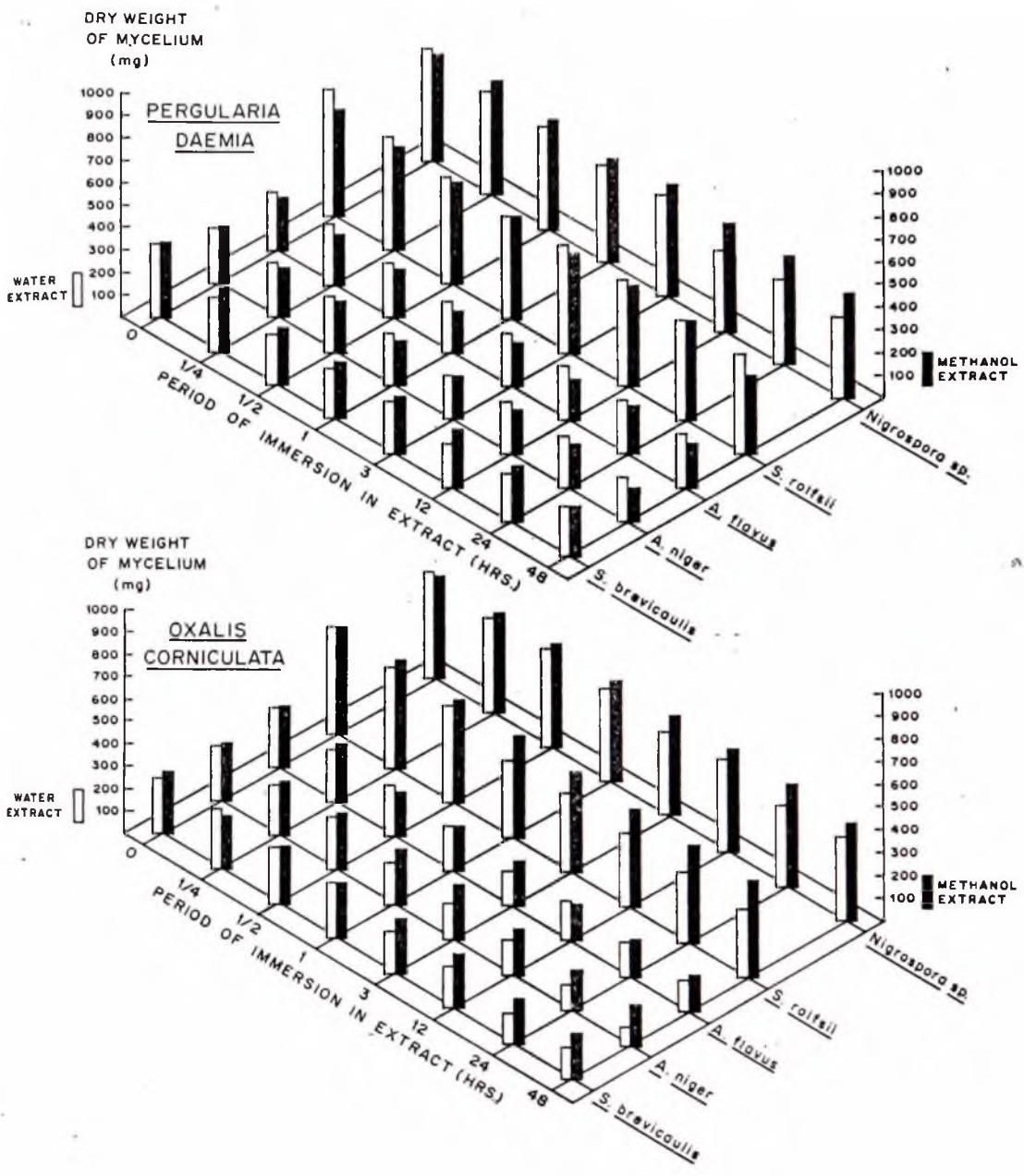


Fig. 25. Vegetative growth of fungi stored in 1:1 v/v dilution of water and methanol extracts of plants for indicated periods and then transferred to Potato Dextrose Broth for 10 days at 30°C.

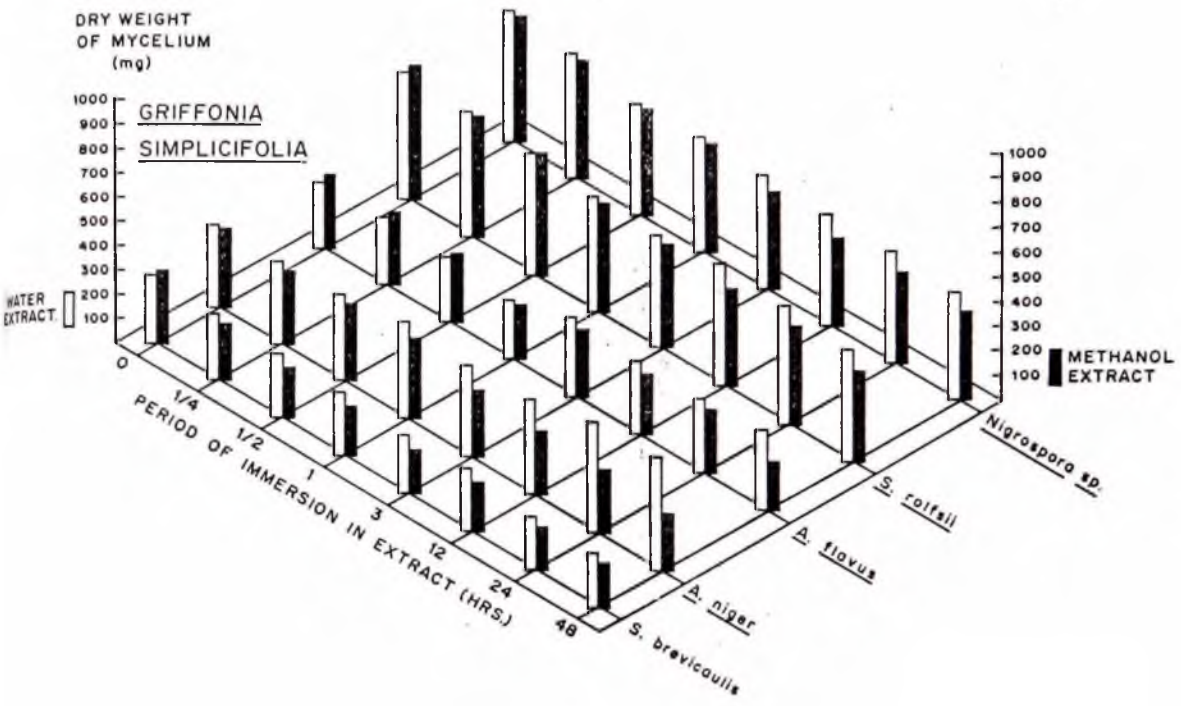


Fig.26. Vegetative growth of fungi stored in 1:1 v/v dilution of water and methanol extracts of Griffonia simplicifolia for indicated periods and then transferred to Potato Dextrose Broth for 10 days at 30°C.

J. ANTIBACTERIAL ACTIVITY OF EIGHT SELECTED PLANTS

The results are presented in Table 25.

Most of the plant extracts tested did not have any significant antimicrobial activity against the test microorganisms. *Oxalis corniculata* had the highest antimicrobial activity amongst the eight plants tested. Its water extract in most instances produced wider diameter of zones of inhibition than those of the standard antibiotics. The methanol extract of this plant however, failed to exert any significant inhibitory effect as compared to the water extract (Table 25).

Inhibition of growth of test microorganisms was related to the type of antibiotic used. Oxytetracycline was not effective against *Staphylococcus aureus*, *Salmonella* (Group C_1) and *Escherichia coli* (ETEC OK5). The water extract of *O. corniculata* was more inhibitory to *Salmonella* (Group C_1) than was Streptomycin but the inhibition of *E. coli* by *O. corniculata* was about the same as obtained for Streptomycin. The inhibitory effect of Chloramphenicol on *Pseudomonas aeruginosa* (1.0mm diameter) was significantly inferior to what existed in *O. corniculata* water extract (3.8mm diameter). However, *O. corniculata* did not have any inhibitory effect on *S. aureus*. The same water extract of *O. corniculata* could adversely affect growth of *E. coli* (ETEC OK5).

ANTIBACTERIAL ACTIVITY OF EIGHT GHANAIAN PLANTS ON INDICATED MICROORGANISMS

MICROORGANISM	ANTIBIOTIC			PLANT EXTRACT							
	Streptomycin 35μg/ml	Chloramphenicol 5μg/ml	Oxytetracycline 5μg/ml	*Oxalis corniculata*		*Pergularia daemia*		*Desmodium triflorum*		*Alternanthera pungens*	
				W	M	W	M	W	M	W	M
	DIAMETER OF ZONE OF INHIBITION IN mm										
Pseudomonas aeruginosa	4.6	1.0	2.4	3.8	0.0	0.5	0.2	0.0	0.0	1.2	0.0
Staphylococcus aureus	10.6	11.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0
Salmonella (Group C_1)	3.4	5.2	0.0	4.0	0.0	0.2	0.0	0.0	0.0	1.4	0.0
Escherichia coli (EPEC 0:43)	4.8	3.2	2.4	4.0	2.0	0.0	0.4	0.0	1.8	0.0	0.0
Escherichia coli (ETEC OK5)	2.6	1.6	0.5	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0

W = Water extract
M = Methanol extract

TABLE 25 Cont'd

ANTIBACTERIAL ACTIVITY OF EIGHT GHANAIAN PLANTS ON INDICATED MICROORGANISMS

MICROORGANISM	ANTIBIOTIC			PLANT EXTRACT							
	Streptomycin 35μg/ml	Chloramp-henicol 5μg/ml	Oxytetracycline 5μg/ml	*Voacanga africana*		*Cassia rotundifolia*		*Zanthoxylum xanthoxyloides*		*Azadirachta indica*	
				W	M	W	M	W	M	W	M
	DIAMETER OF ZONE OF INHIBITION IN mm										
Pseudomonas aeruginosa	4.6	1.0	2.4	0.5	0.0	0.0	0.6	1.0	0.0	1.0	1.2
Staphylococcus aureus	10.6	11.0	0.0	0.0	0.0	0.2	0.0	1.0	0.0	0.0	0.0
Salmonella (Group C_1)	3.4	5.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Escherichia coli (EPEC 0:43)	4.8	3.2	2.4	1.0	1.4	0.0	0.8	0.0	0.0	0.0	1.2
Escherichia coli (ETEC OK5)	2.6	1.6	0.5	1.0	1.2	0.0	0.0	0.5	1.0	0.0	0.0

W = Water extract
M = Methanol extract

VI GENERAL DISCUSSION

In recent years a number of studies dealing with antimicrobial activity of plant extracts have been reported (Almagboul *et al.*, 1985 b, c; Tomes *et al.*, 1986; Rashan, 1990; Cosar and Çubukçu, 1990; Salako *et al.*, 1990; Diallo *et al.*, 1991; Obasi and Igboechi, 1991). A wide variety of plants belonging to more than fifty families have been shown to have potentially interesting activity against a wide variety of microorganisms including fungi.

The fungus *Scopulariopsis brevicaulis* has been isolated from soil for the first time in this country and it grew best between 25-30°C (Procedure A). This confirms the findings of Morton and McMillan (1954). The annual temperature in Ghana makes it a potential pathogen under which the host plant tomato and the pathogen will thrive. Rather curiously, vegetative growth of *S. brevicaulis* in liquid medium amended with water extract of *Alternanthera pungens, Sida acuta, Euphorbia heterophylla, Crotalaria retusa* and *Tridax procumbens* was improved. Although the phytochemical content of leaf extract of *A. pungens, S. acuta, C. retusa* and *T. procumbens* have not been extensively studied, *E. heterophylla* contains alkaloids, coumarins, flavonoids, sterols and/or terpenes (Rizk, 1982). Presumably inhibitory effect of these compounds are impaired in the presence of nutrients in the vicinity of *S. brevicaulis*. The fact that *Oxalis corniculata* water extract inhibited growth of *S. brevicaulis* confirms the variation in antifungal compounds in different species and families of plants used.

Data from Procedures C to H show some interesting results although they are not surprising. The antifungal activity of the water and methanol extracts of the nineteen plants used varied from one species to another and from family to family. Within the same family, the inhibitory effect was variable depending on the test fungus.

Measurable antifungal activity of water extract of leaf of *Cassia rotundifolia* (Caesalpinaceae), *Alternanthera pungens*, (Amaranthaceae) and *Pergularia daemia* (Asclepiadaceae) were recorded on vegetative growth of *S. brevicaulis* (Figs. 11, 16, 20). Radial diameter of *Aspergillus niger* was depressed by water extract of leaf of *A. pungens*, *Oxalis corniculata* (Oxalidaceae) and *P. daemia* (Figs. 16, 18, 20) whilst that of *A. flavus* was depressed by *Desmodium triflorum* (Papilionaceae) (Fig. 10). Water extract of leaf of *Voacanga africana* (Apocynaceae), *Cassia rotundifolia* (Caesalpinaceae) and *Zanthoxylum xanthoxyloides* (Rutaceae) had high antifungal properties against *Nigrospora sp.* (Figs. 11, 13, 21). *Z. xanthoxyloides* also depressed growth of *Sclerotium rolfsii.*

Vegetative growth of *S. brevicaulis* was depressed by methanol extract of *Launaea taraxacifolia* (Compositae), *Crotalaria retusa* (Papilionaceae), *Pergularia daemia* (Asclepiadeaceae) and *Euphorbia heterophylla* (Euphorbiaceae) (Figs. 3, 9, 19, 20); growth of *A. niger* was depressed to different extent by methanol extract of *Alternanthera pungens* (Amaranthaceae), *Pergularia daemia* (Asclepiadaceae), *Cassia rotundifolia* (Caesalpinaceae) and *Tridax procumbens* (Compositae) (Figs. 4, 11, 16, 20). Methanol extract of *T. procumbens*, *A. pungens* and *Voacanga africana* were inhibitory to growth of *A. flavus* (Figs. 4, 16, 21), while methanol extract of *L. taraxacifolia*, *V. africana*, *Azadirachta indica* (Meliaceae) and *C. rotundifolia* depressed vegetative growth of *Nigrospora sp.* and *S. rolfsii* (Figs. 3, 11, 14, 21.)

Comparatively higher fungistatic effect were found in both the water and methanol extracts of leaves of *C. rotundifolia*, *P. daemia*, *A. pungens*, *V. africana*, *L. taraxacifolia*, *T. procumbens*, *Z. xanthoxyloides*, *O. corniculata*, *A. indica*, *Desmodium triflorum*, *E.*

heterophylla and *Crotalaria retusa* (in decreasing order). However, whilst water extract of *L. taraxacifolia* was ineffective, methanol extract of this plant depressed vegetative growth of *S. brevicaulis* by 67.0 per cent, *A. flavus* by 34.0 per cent and *Nigrospora sp.* by 51.5 per cent (Table 9a-9e).

The yield of the active ingredients presumably differed depending on the type of solvent used in extracting the fungistatic principle from the respective plants. Secondly, there was variation in the effect of the plant extracts on each fungus. This may be attributed to differences in quality, quantity and nature of the chemical compounds in each species and their mode of action on the metabolism of the fungus. In future studies a wider range of polar and non-polar solvents will be used as the yield of the active ingredients may differ depending on the chemical nature of the secondary metabolites in the plant species. It will also be interesting for chemists to identify the chemical nature of the compounds from some of the plants which have been found to exert fungistatic effect on the test fungi in this thesis.

The pertinent literature, however, indicates that species of the genus *Cassia* contain quinone (Githens, 1949). Leaves of more than 20 species of *Cassia* contain emodin (Githens, 1949). Many cardenolides (eg. calactin, calothropagenin, uzarin, coroglaucigenin), methyl sterols (α-amyrin, ß-amyrin and lupeol) and ß-sitosterol are found in various parts of *Pergularia daemia* including the leaf, stem and roots (Mishuhashi and Sasaki, 1973; Rhakit *et al.*, 1959; Pattabiram and Baru, 1958).

Voacanga africana contains many alkaloids including voacamine (major), voacangine, voacangrine, voacorine and vobtusine (Oliver, 1960), raubasine and vincane (Sofowora, 1982). Tannins and flavonoids have also been isolated from this plant (Kerharo and Adam, 1974;

William and Li, 1970; Thomas and Bieman, 1968; Watt and Breyer-Brandwijk, 1962).

Many alkaloids have been isolated from *Zanthoxylum xanthoxyloides* including furoquinoline, L-benzytetrahydroisoquinolines, ortho-coupled aporphines, para-coupled benzophenanthridines, protoberberines, amides, by-cyclic coumarins, furanocoumarines and pyranocoumarins, lignans and simple cinnamic acid derivatives (Thoms, 1911, 1912; Carmalm *et al*; 1955). Other alkaloids like fagaridine, skinmianine, chelerythrine, dihydrochelerythrine and artarine (9-ethoxychelerythrine) have also been isolated from *Z. xanthoxyloides* (Torto *et al.*, 1969).

Azadirachta indica contains nimbolin, tannin and various glucosides (Ayitey-Smith, 1989). A toxic alkaloid monocrataline is present in many species of *Crotalaria* (Githens, 1949). *Euphorbia heterophylla* contains alkaloids, coumarins, flavonoids, sterols and/or terpenes (Rizk, 1982). Latex from *E. heterophylla* contains acrid resins and euphorbon (Githens, 1949). *Desmodium triflorum* contains tannins and *Tridax procumbens* has essential oils (Pathak and Dexit, 1988; Githens, 1949). *Launaea taraxacifolia* contains alkaloids, saponins and cathecol-type tannins (Gyamfi, 1991).

The active ingredient of *Alternanthera pungens* is not known although it is used extensively in traditional medicinal practice (Dokosi, 1969; Dalziel, 1936; Ampofo, 1983; Abbiw, 1990). Future studies are needed to isolate and identify the phytochemical content of the remaining plants.

The importance of aromatic compounds in plants in the biological control of plant pathogens have long been recognised. For example Saksena and Tripathi (1986) reported that fifteen aromatic plants (*Lantana camara*, *Ruta sp.*, *Cuminum cyminium*, *Eucalyptus citriodora*,

Clerodendron sp., *Ocimum sanctum*, *Biota sp.*, *Cycas rumphii*, *Artemisia nilgiri*, *Ferula jaeschkeana*, *Angelica archangelica*, *Chenopodium album*, *Cymbopogon flexuosus*, *Thespisia populea* and *Lagerstroemia speciosa*) showed remarkable inhibition of spore germination of the test pathogen. *L. camara*, *Biota sp;* *C. runphii* and *C. album* inhibited germination of spores of *Aspergillus fumigatus*. Thus they could be usefully planted to check the prevalence of this fungus. *L. camara*, *C. cyminum* and *A. nilgiri* showed absolute inhibition of *A. niger* spores. *E. citriodora*, *C. album*, *C. flexuosus* and *T. populea* showed absolute inhibition of *Helminthosporium oryzae* which is known to cause disease in rice. Absolute suppression of germination of *Mucor mucedo* was induced by *L. camara*, *E. citriodora*, *Clerodendron sp.*, *Biota sp.*, *Ocimum santum and T. populea*. *Alternaria alternata*, another plant pathogen was completely suppressed by *Ruta sp.*, *C. rumphii*, *A. nilgiri* and *F. jaeschkeana*.

Future studies should aim at using more solvents in order to cover the range of compounds found in the extracts of plants.

An information of practical importance is the period for which viability of the mycelium would be sustained in the presence of the fungistatic principle in the extract. The shorter the period to 'inactivate' the mycelium, the greater the usefulness of the extract as a control agent for the fungi used in this thesis namely *Scopulariopsis brevicaulis*, *Aspergillus niger*, *A. flavus*, *Sclerotium rolfsii* and *Nigrospora sp.* Discs of the mycelium of the listed fungi were immersed for various periods (15 minutes to 48 hours) and later transferred to extract-free Potato Dextrose Broth (PDB) (Procedure I). Fungal mycelial discs immersed in extracts for varying periods were still viable and resumed growth on transfer to PDB medium. This connotes that the extracts did not permanently inhibit the fungal metabolism. Vegetative growth was

however, slower and mycelial dry weights obtained were reduced compared with growth in the control. The longer the period of immersion in the plant extract the lower the dry weight obtained on transfer to the extract-free PDB medium. The extracts were therefore fungistatic and not fungicidal in their action on the mycelium of the test fungi.

The quiescent mycelium of the fungus under forced dormancy in the soil faces other hazards. Both organic and inorganic ions in the soil, when present at high levels are likely to impose plasmolytic problems which would later shorten longevity. If the mycelium is capable of sufficient metabolism under soil conditions, it is possible that metabolites of the fungus could exert inhibitory influences on other microorganisms close to them and could at least delay destruction. Future studies could examine the possible changes in phenology of the microbial propagules among pathogens following application of extracts containing phytotoxins from the test plants used in this thesis.

In Procedure J of this thesis the antibacterial activity of eight plants were examined. *Oxalis corniculata* showed the strongest antibacterial activity among the plants used. The water extract of *O. corniculata* showed the strongest antibacterial activity among the plants used. The water extract of *O. corniculata* exhibited activities which compared favourably with corresponding standard antibiotics (35μg/ml Streptomycin, 5μg/ml Chloramphenicol, 5μg/ml Oxytetracycline) used in the inhibition of *Pseudomonas aeruginosa*, *Salmonella* (Group C_1), *Escherichia coli* (EPEC 0:43) and *E. coli* (ETEC OK5). The results suggest that the water extract of *O. corniculata* possibly contains potent antibacterial principles.

There is no known local use of *O corniculata* in traditional medicine and nothing is known about its phytochemical content. It would therefore be of interest to carry out detailed phytochemical studies on this plant to isolate and characterise the active component(s) in the extract.

Rather curiously, methanol extract of *Alternanthera pungens* did not exhibit any antibacterial activity against any of the microorganisms under investigation. The variation in the antibacterial activity of the plants could be attributed to either differences in the quantities and/or quality of the compounds present in the extracts.

The concentration of the content of a particular active principle in a plant may have a seasonal or diurnal variation. For example, the volatile oil-containing plant *Chromolaena odorata* loses its oil content, probably due to evaporation in bright sunlight, but the concentration is at a peak from sunset to midnight (Agu, 1980). Plants for phytochemical analysis would have to be collected at various times and growing stages for a maximum yield.

With regard to the antibacterial activities, the water extract was generally more superior to the methanol extract. Present data cannot fully explain this phenomenon.

It is concluded that the water and the methanol extracts of the plants investigated contain certain antifungal and antibacterial principles of varying extents which inhibited growth of the fungi and bacteria. The severity of the water or the methanol extract in suppressing a particular fungus or bacterium is an indication of the potency of the principle(s) contained in the plant and the effectiveness of the solvent in extracting the principles(s).

Since the wealth of medicinal plants is one of vital resources, having important bearing on human health and a regions economy, plants identified with potential antifungal and/or antibacterial properties can be developed to form the basis of drug, fungicide and pesticide industry in the country. Success in these studies may lead to the development of naturally occurring antifungal and antibacterial compounds that may not cause any upheavals to the environment. If such naturally occurring compounds in plants are eventually extracted, characterized and found active against many of the plant pathogens and human diseases which take a heavy toll of our crops and human lives, this thesis would have provided the spring board for future indepth studies.

VII. SUMMARY

1. Best vegetative growth (60 mg) of *Scopulariopsis brevicaulis* was obtained at a temperature of 30°C after 12 days. Growth at a temperature of 25°C (52.5mg) was comparably good.
2. Growth of *S. brevicaulis* at 35°C (25.0 mg) and 40°C (10.0 mg) was inferior to vegetative growth at optimum temperature of 30°C.
3. The pH of the liquid medium in which *S. brevicaulis* was cultured drifted from 5.2 to 6.1 in 15 days at 30°C.
4. Vegetative growth of *S. brevicaulis* in liquid medium amended with water extract of *Alternanthera pungens, Sida acuta, Euphorbia heterophylla, Crotalaria retusa* and *Tridax procumbens* was improved. The highest dry weight of 87.5 mg was recorded in medium amended with 1:1 v/v dilution of water extract of *T. procumbens*.
5. Liquid medium amended with water extract of *Oxalis corniculata* (1:1 v/v dilution) depressed vegetative growth of *S. brevicaulis* by 41.7 per cent in 15 days; the same extract prevented sporulation of the fungus. The inhibitory effect was gradually removed with increasing dilution of the extract.
6. Vegetative growth of the test fungi on basal nutrient agar amended with either water or methanol extract of plants in the family Compositae varied considerably and can be summarised as follows:

Plant	Water extract	Methanol extract
Launaea taraxacifolia	No difference in vegetative growth of any of the test fungi as compared to control.	1:1 v/v dilution of extract depressed vegetative growth of *S. brevicaulis* by 67.0%, *A. flavus* by 34.0% and *Nigrospora sp.* by 51.5%; no effect on *S. rolfsii.*
Tridax procumbens	No effect on *A. niger, S. rolfsii, Nigrospora sp. and A. flavus*, but 1:1 v/v dilution depressed growth of *S. brevicaulis* by 36.5%.	1:1 v/v dilution of extract depressed growth of *S. brevicaulis* (by 25.0%), *A. Niger* (by 28.6%) and, *S. rolfsii* by 38.0%. No effect on *A. flavus*. Enhanced growth of *Nigrospora sp.*
Aspilia africana	No significant inhibitory effect on any of the test fungi.	No significant inhibitory effect on any of the test fungi.
Emilia sonchifolia	No significant inhibitory effect on *A. niger, A.flavus, S. rolfsii* and *Nigrospora sp.* 1:1 v/v dilution depressed vegetative growth of *S. brevicaulis* by 23.2%.	No significant inhibitory effect on *A. niger, A. flavus, S. rolfsii and Nigrospora sp.* 1:1 v/v dilution depressed vegetative growth of *S. brevicaulis* by 11.9%.
Synedrella nodiflora	No significant inhibitory effect on vegetative growth of any of the test fungi.	1:1 v/v dilution of extract depressed vegetative growth of *S. rolfsii* by 31.2%.
Chromolaena odorata	Depressed vegetative growth of *Nigrospora sp.*(by 14.1%), *A. niger* (by 10.3%) and *A. flavus*(by 13.5%)	Depressed vegetative growth of *A. flavus* (by 19.6%), *S. rolfsii* (by 12.5%), *Nigrospora sp.* (by 12.1%) and *S. brevicaulis* (by 11.8%).

7. Vegetative growth of the test fungi on basal nutrient agar amended with either water or methanol extract of plants in the family Leguminosae can be summarised as follows:

Plant	Water extract	Methanol extract
Crotalaria retusa (Tribe Papilionoideae)	1:1 v/v dilution depressed vegetative growth of *S. brevicaulis* (by 20.0%), *A. flavus* (22.6%) and *Nigrospora sp.* (by 10.1%). No significant effect was observed on *A. niger* and *S. rolfsii.*	Vegetative growth of *S. brevicaulis* and *A. Niger* was depressed by 1:1 v/v dilution of extract. No effect on *A. flavus, S. rolfsii* and *Nigrospora sp.*
Desmodium triflorum (Tribe Papilionoideae)	Significant depression of vegetative growth of *A. flavus*(41.4%), *A. niger* (17.3%), *S. rolfsii* (17.3%) and *Nigrospora sp.*(12.9%).	Depressed vegetative growth of *A. flavus* (27.9%), *S. rolfsii* (27.1%), *A. niger* (26.9%) and, *Nigrospora sp.*(16.5%).

Plant	Water extract	Methanol extract
Cassia rotundifolia (Tribe Caesalpinioideae)	Vegetative growth of *S. brevicaulis* depressed by 86.9% in 1:1 v/v dilution, *A. niger* by 20.0%, *Nigrospora sp.* by 19.0%, *A. flavus* by 15.6% and *S. rolfsii* by 10.6%.	Extract (1:1 v/v dilution) depressed vegetative growth of *Nigrospora sp.* by 41.1% and *A. niger* by 32.8%.
Griffonia simplicifolia (Tribe Caesalpinioideae)	Vegetative growth of *A. flavus* *S. brevicaulis*, *S. rolfsii* and *Nigrospora sp.* was only marginally depressed as compared to the control.	Inhibition of growth of *A. niger*, *S. rolfsii*, and *A. flavus*, was negligible. *Nigrospora sp.* was inhibited by 28.6% and *S. brevicaulis* by 20.8%.

8. Dry matter accumulation of test fungi cultured on basal nutrient agar amended with water and methanol extracts of plants in the family Rutaceae and Meliaceae was also variably affected and can be summarised as below:

Plant	Water extract	Methanol extract
Zanthoxylum xanthoxyloides (Rutaceae)	All dilutions of the extract (1:1-1:5 v/v) decreased vegetative growth of all the test fungi.	1:1 v/v dilution of extract depressed vegetative growth of *S. rolfsii* (28.4%), *S. brevicaulis* (26.2%), *Nigrospora sp.* (22.4%) and *A. flavus* (14.9%).
Azadirachta indica (Meliaceae)	No effect on vegetative growth of *S. brevicaulis*, *S. rolfsii*, *A. niger* and *A. flavus*.	Depressed vegetative growth of *Nigrospora sp.* (41.8%) and *S. rolfsii* (by 22.4%),

9. Vegetative growth of the five test fungi on basal nutrient agar amended with either water or methanol extract of plants in the family Malvaceae, Amaranthaceae, Nyctaginaceae and Oxalidaceae also varied considerably and is summarised as below:

Plant	Water extract	Methanol extract
Sida acuta (Malvaceae)	Significant depression of vegetative growth of *S. rolfsii*. Growth of *S. brevicaulis*, *A. niger*, *A. flavus* and *Nigrospora sp.* was only marginally depressed as compared to the control.	Vegetative growth of *S. rolfsii* inhibited by 24.4% in 1:1 v/v dilution. No significant effect on *S. brevicaulis* and *Nigrospora sp.* Enhanced growth of *A. niger* and *A. flavus*.
Alternanthera pungens (Amaranthaceae)	Depressed vegetative growth of *S. brevicaulis* (52.9%), *A. niger* (45.2%), *S. rolfsii* (36.5%) and *A. flavus* (23.9%)	Depressed vegetative growth of *A. Niger* (47.0%), *S. rolfsii* (36.7%), *S. brevicaulis* (30.0%) and *A. flavus* (23.9%).
Boerhavia diffusa (Nyctaginaceae)	No significant inhibitory effect on any of the test fungi.	No inhibitory effect on any of the test fungi. Vegetative growth of *S. brevicaulis* and *Nigrospora sp.* was improved.
Oxalis corniculata (Oxalidaceae)	Significant inhibitory effect on vegetative growth of *A. niger*, (43.1%) and *S. brevicaulis*(41.7%) Growth of *A. flavus* , *S. rolfsii* and *Nigrospora sp.* was also depressed.	1:1 v/v dilution depressed vegetative growth of *S. rolfsii (32.9%), and Nigrospora sp.* (12.9%). Vegetative growth of *S. brevicaulis*, *A. niger* and *A. flavus* was close to that in the control.

10. The effect of basal nutrient agar amended with water and methanol extracts of plants in the family Apocynaceae, Asclepiadaceae and Euphorbiaceae on vegetative growth of the test fungi is summarised as follows:

Plant	Water extract	Methanol extract
Euphorbia heterophylla (Euphorbiaceae)	Vegetative growth *S. brevicaulis* was the only one significantly inhibited (37.5%).	No significant effect on *A. niger*, *A. flavus*, and *Nigrospora sp.* Vegetative growth of *S. brevicaulis* and *S. rolfsii* depressed by 35.2% and 21.2% respectively.
Pergularia daemia (Asclepiadaceae)	Vegetative growth of all test fungi significantly depressed	Vegetative growth of all test fungi significantly depressed.
Voacanga africana (Apocynaceae)	Vegetative growth of *S. rolfsii* and *Nigrospora sp.* was significantly depressed. Growth of *A. niger* and *A. flavus* was only marginally depressed as compared to the control.	Depressd vegetative growth of *S. brevicaulis* (44.0%) *S. rolfsii* (33.3%) and *Nigrospora sp.* (32.7%) in the 1:1 v/v dilution.

11. The most susceptible test fungus to the water extracts was *Scopulariopsis brevicaulis* whilst the most resistant was *Aspergillus flavus*.
12. The most susceptible test fungus to the methanol extracts was *Nigrospora sp.*, followed by *S. brevicaulis* and *Sclerotium rolfsii* in that order; the most resistant was *A. flavus*.
13. Mycelial discs of fungi immersed in 1:1 v/v dilution of plant extracts for varying periods (1/4, 1/2, 1, 3, 12, 24, 48h) were viable and resumed growth on transfer to extract-free (Potato Dextrose Broth) medium. The longer the period of immersion in the plant extract the lower the dry weight of mycelium obtained on transfer to the extract-free medium.
14. The leaf extracts were fungistatic and not fungicidal in their action on the mycelium of the test fungi.
15. *Oxalis corniculata* showed the highest antibacterial activity among the eight plants (*Oxalis corniculata, Pergularia daemia, Desmodium triflorum, Alternanthera pungens, Voacanga africana, Cassia rotundifolia, Zanthoxylum xanthoxyloides, Azadirachta indica)* tested.
16. The water extract of *Oxalis corniculata* exhibited activity which compared favourably with activities of corresponding standard antibiotics (35 μg/ml Streptomycin, 5 μg/ml Chloramphenicol, 5 μg/ml Oxytetracycline) used against *Pseudomonas aeruginosa, Staphylococcus aureus, Salmonella* (Group C_1), *Escherichia coli* (EPEC O:43) and *E. coli* (ETEC OK5).
17. Methanol extract of *Alternanthera pungens* did not exhibit any antibacterial activity against any of the microorganisms used.
18. The water extract was generally more superior to the methanol extract with regard to the antibacterial activities.
19. The antifungal and antibacterial activities of the water and methanol extracts of the plants used varied from family to family and from one species to another.
20. Within the same plant family the inhibitory effect depended on the solvent used in the extraction and the test fungus or bacterium the extract was tested against.

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APPENDICES

APPENDIX A

Effect of temperature on growth of *Scopulariopsis brevicaulis* incubated in Basal medium for 15 days.

Temperature of incubation (°C)	Period of incubation (Days)	pH of medium Initial	pH of medium Mean Final	Mean dry weight of mycelium (mg)± S.E.
15	2	5.2	4.8	20.0 ± 2.4
	4		4.8	20.0 ± 1.0
	8		7.3	32.5 ± 1.4
	12		7.4	32.5 ± 0.6
	15		7.5	35.0 + 1.8
20	2	5.2	5.2	20.0 ± 0.5
	4		4.7	22.0 ± 1.9
	8		5.1	37.5 ± 1.4
	12		5.8	55.5 ± 1.2
	15		6.8	55.0 + 1.5
25	2	5.2	5.5	25.0 ± 0.3
	4		6.7	32.5 ± 1.5
	8		6.8	42.5 ± 1.2
	12		6.7	52.5 ± 1.2
	15		6.6	50.0 + 0.4
30	2	5.2	5.1	30.0 ± 1.4
	4		4.6	37.5 ± 1.8
	8		5.2	45.0 ± 2.1
	12		5.9	60.0 ± 2.3
	15		6.1	40.0 + 1.5
35	2	5.2	5.9	12.5 ± 1.6
	4		5.2	10.0 ± 1.3
	8		5.5	12.5 ± 1.2
	12		6.4	25.0 ± 0.8
	15		5.8	20.0 + 2.0
40	2	5.2	4.5	5.0 ± 1.2
	4		4.3	7.5 ± 1.4
	8		4.7	7.5 ± 1.9
	12		4.8	10.0 ± 2.0
	15		4.7	7.5 + 0.8

APPENDIX B

Vegetative growth of *S. brevicaulis* at 30°C in basal medium ammended with different concentrations of water extract of *Alternanthera pungens*.

Period of incubation (Days)	Concentration of extract	pH of medium Initial	pH of medium Mean Final	Mean dry weight of mycelium (mg) ± S.E.
2	1:1	4.5	5.6	52.5 ± 1.2
	1:2	4.4	5.2	45.0 ± 1.6
	1:5	4.4	5.4	35.0 ± 2.0
	CONTROL	4.2	4.8	32.5 ± 0.8
4	1:1	4.5	6.9	67.5 ± 1.8
	1:2	4.4	5.5	60.0 ± 1.5
	1:5	4.4	5.6	50.0 ± 1.4
	CONTROL	4.2	4.6	47.5 ± 0.5
8	1:1	4.5	7.8	77.5 ± 2.1
	1:2	4.4	6.9	65.0 ± 0.6
	1:5	4.4	6.8	70.0 ± 0.8
	CONTROL	4.2	6.0	62.5 ± 1.9
12	1:1	4.5	7.9	70.0 ± 1.4
	1:2	4.4	7.5	80.0 ± 0.8
	1:5	4.4	7.3	72.5 ± 1.3
	CONTROL	4.2	6.0	75.0 ± 0.5
15	1:1	4.5	7.9	75.0 ± 1.4
	1:2	4.4	7.7	77.5 ± 1.8
	1:5	4.4	7.8	72.5 ± 0.9
	CONTROL	4.2	6.0	76.0 ± 1.1

APPENDIX C

Vegetative growth of *S. brevicaulis* at 30°C in basal medium ammended with different concentrations of water extract of *Euphorbia heterophylla*.

Period of incubation (Days)	Concentration of extract	pH of medium Initial	pH of medium Mean Final	Mean dry weight of mycelium (mg)± S.E.
2	1:1	4.4	4.6	25.0 ± 1.3
	1:2	5.7	6.1	37.5 ± 2.0
	1:5	5.6	5.3	42.5 ± 2.1
	CONTROL	4.4	4.2	17.5 ± 2.4
4	1:1	4.4	6.2	52.5 ± 1.1
	1:2	5.7	6.0	50.0 ± 0.8
	1:5	5.6	6.6	47.5 ± 0.4
	CONTROL	4.4	5.3	37.5 ± 2.2
8	1:1	4.4	7.3	57.5 ± 2.2
	1:2	5.7	7.5	80.0 ± 2.5
	1:5	5.6	7.1	80.0 ± 1.7
	CONTROL	4.4	6.1	40.0 ± 2.5
12	1:1	4.4	7.7	72.5 ± 1.8
	1:2	5.7	7.7	85.0 ± 1.6
	1:5	5.6	7.1	77.5 ± 2.0
	CONTROL	4.4	6.1	57.5 ± 1.6
15	1:1	4.4	7.4	75.0 ± 2.3
	1:2	5.7	7.6	77.5 ± 2.1
	1:5	5.6	7.0	70.0 ± 2.0
	CONTROL	4.4	6.4	50.0 ± 1.5

APPENDIX D

Vegetative growth of *S. brevicaulis* at 30°C in basal medium ammended with different concentrations of water extract of *Oxalis corniculata*.

Period of incubation (Days)	Concentration of extract	pH of medium Initial	pH of medium Mean Final	Mean dry weight of mycelium (mg) ± S.E.
2	1:1	3.0	3.5	15.0 ± 2.5
	1:2	3.5	4.7	12.5 ± 2.0
	1:5	4.1	5.0	22.5 ± 1.6
	CONTROL	5.2	5.1	17.5 ± 2.3
4	1:1	3.0	6.6	20.0 ± 1.2
	1:2	3.5	6.9	15.0 ± 1.0
	1:5	4.1	7.5	27.5 ± 0.8
	CONTROL	5.2	5.6	32.5 ± 1.4
8	1:1	3.0	7.6	30.0 ± 2.4
	1:2	3.5	7.2	35.0 ± 2.6
	1:5	4.1	7.1	42.5 ± 1.8
	CONTROL	5.2	5.4	52.5 ± 0.6
12	1:1	3.0	8.0	27.5 ± 2.0
	1:2	3.5	7.8	37.5 ± 1.5
	1:5	4.1	7.9	45.0 ± 1.8
	CONTROL	5.2	5.8	60.0 ± 1.4
15	1:1	3.0	7.7	32.5 ± 0.7
	1:2	3.5	7.5	50.0 ± 2.4
	1:5	4.1	7.2	65.0 ± 1.5
	CONTROL	5.2	5.9	57.5 ± 1.2

APPENDIX E

Vegetative growth of *S. brevicaulis* at 30°C in basal medium ammended with different concentrations of water extract of *Sida acuta*.

Period of incubation (Days)	Concentration of extract	pH of medium Initial	pH of medium Mean Final	Mean dry weight of mycelium (mg) ± S.E.
2	1:1	4.7	4.8	25.0 ± 1.3
	1:2	4.7	4.8	27.5 ± 1.8
	1:5	4.9	5.2	30.0 ± 0.3
	CONTROL	5.2	5.1	25.0 ± 0.7
4	1:1	4.7	6.5	37.5 ± 2.4
	1:2	4.7	4.6	47.5 ± 2.1
	1:5	4.9	4.7	35.0 ± 2.1
	CONTROL	5.2	4.6	32.5 ± 1.7
8	1:1	4.7	7.3	75.0 ± 1.2
	1:2	4.7	7.3	70.0 ± 0.4
	1:5	4.9	5.1	50.0 ± 0.5
	CONTROL	5.2	5.2	42.5 ± 1.0
12	1:1	4.7	7.4	77.5 ± 1.3
	1:2	4.7	4.4	75.0 ± 0.8
	1:5	4.9	5.8	70.0 ± 0.5
	CONTROL	5.2	5.9	62.5 ± 0.6
15	1:1	4.7	7.5	80.0 ± 2.3
	1:2	4.7	7.5	50.0 ± 1.6
	1:5	4.9	6.1	72.5 ± 1.4
	CONTROL	5.2	6.1	62.5 ± 1.8

APPENDIX F

Vegetative growth of *S. brevicaulis* at 30°C in basal medium ammended with different concentrations of water extract of *Sida acuta*.

Period of incubation (Days)	Concentration of extract	pH of medium Initial	pH of medium Mean Final	Mean dry weight of mycelium (mg) ± S.E.
2	1:1	5.1	6.4	22.5 ± 1.3
	1:2	5.6	6.9	30.0 ± 1.5
	1:5	5.8	7.0	17.5 ± 2.0
	CONTROL	4.7	4.9	25.0 ± 1.8
4	1:1	5.1	7.0	55.0 ± 2.0
	1:2	5.6	7.5	57.5 ± 2.6
	1:5	5.8	7.2	52.5 ± 0.8
	CONTROL	4.7	5.0	37.5 ± 0.6
8	1:1	5.1	7.3	75.5 ± 1.0
	1:2	5.6	7.2	65.0 ± 1.2
	1:5	5.8	7.9	55.0 ± 0.5
	CONTROL	4.7	5.7	52.5 ± 1.6
12	1:1	5.1	7.2	70.0 ± 1.7
	1:2	5.6	7.3	57.5 ± 0.3
	1:5	5.8	8.1	60.0 ± 0.5
	CONTROL	4.7	6.1	50.0 ± 2.0
15	1:1	5.1	7.4	75.0 ± 1.5
	1:2	5.6	7.4	80.0 ± 0.4
	1:5	5.8	7.3	60.0 ± 2.1
	CONTROL	4.7	6.1	52.5 ± 2.4

APPENDIX G

Vegetative growth of *S. brevicaulis* at 30°C in basal medium ammended with different concentrations of water extract of *Tridax pocumbens*.

Period of incubation (Days)	Concentration of extract	pH of medium Initial	pH of medium Mean Final	Mean dry weight of mycelium (mg)± S.E.
2	1:1	5.3	7.1	15.0 ± 2.9
	1:2	5.3	6.4	32.5 ± 2.4
	1:5	5.2	5.5	17.5 ± 1.8
	CONTROL	5.1	4.3	30.0 ± 1.5
4	1:1	5.3	7.4	57.5 ± 1.8
	1:2	5.3	6.7	38.0 ± 0.9
	1:5	5.2	6.0	35.0 ± 0.6
	CONTROL	5.1	5.1	37.5 ± 1.3
8	1:1	5.3	7.4	72.5 ± 1.8
	1:2	5.3	6.9	70.0 ± 2.2
	1:5	5.2	6.0	57.5 ± 1.8
	CONTROL	5.1	5.6	45.0 ± 2.0
12	1:1	5.3	8.0	80.0 ± 1.7
	1:2	5.3	6.9	75.0 ± 2.6
	1:5	5.2	6.1	75.0 ± 2.3
	CONTROL	5.1	5.8	62.5 ± 0.8
15	1:1	5.3	8.1	87.5 ± 0.7
	1:2	5.3	7.1	70.0 ± 1.3
	1:5	5.2	5.5	65.0 ± 2.1
	CONTROL	5.1	6.1	40.0 ± 0.7