Studies on the mycoflora of Okra (*Abelmoschus esculentus* L. Moench), Onion (*Allium cepa* L. var *cepa*), Pepper (*Capsicum annuum* L.) and Tomato (*Lycopersicon esculentum* Mill.) plants and their stored products.

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From: Department of Botany,
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DECLARATION

I, the undersigned, MARY MAMLE TEYE, do hereby declare that with the exception of references cited, this work was done entirely by me and no part of it has been presented for any other degree of this University or elsewhere.

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Dedicated to the Glory of the Lord Jesus Christ, who, from of old no one has heard or perceived by the ear,no eye has seen a God besides Him, who works for those who wait for Him.

Isaiah 64:4

ABSTRACT

The mycoflora of four vegetables, okra, onion, pepper and tomato, have been extensively studied. The crops were grown at Legon at three sites, namely Experimental Plot at the Department of Botany, the University Farm and a Private Farm, using one variety of pepper, two varieties of okra (Clemson spineless and Local), two varieties of onion (Red Creole and Texas Grano) and three varieties of tomato (Heinz, Roma and Wosowoso). The fructiplane, phylloplane and rhizosphere fungi of the growing plants and fungi of fruits of okra and pepper and bulbs of onion variously treated and stored were studied.

There were more species of Aspergillus and Penicillium than species of other genera of the flora on the surfaces of the fruits, but the dominant species on okra fruits were Aspergillus niger, Cladosporium herbarum, Fusarium oxysporum; those of the pepper fruits were Aspergillus flavus, Cladosporium herbarum, and Rhizopus sp. and those of tomato fruits were Cladosporium herbarum and Fusarium oxysporum. Fungal species occurring on freshly harvested bulbs of Red Creole and Texas Grano were Fusarium oxysporum in the dry season and Aspergillus niger and Penicillium cyclopium in the rainy season.

In experimental inoculation tests, Alternaria alternata, Aspergillus terreus, Corynespora casiicola, Curvularia lunata, Fusarium oxysporum and Scopulariopsis brevicaulis caused considerable rot of tomato fruits, but other species such as Aspergillus glaucus, Cladosporium herbarum, Helminthosporium sp., Penicillium citrinum, Penicillium funiculosum and Syncephalastrum racemosum did not cause any infection even when inoculated into wounds.

The dominant phylloplane fungi recorded on okra were Cladosporium herbarum, Fusarium oxysporum and Mycelia sterilia. Cladosporium herbarum, Curvularia lunata and Fusarium oxysporum were dominant on pepper leaves, Aspergillus niger on onion leaves and Cladosporium herbarum, Fusarium oxysporum and Penicillium cyclopium on tomato leaves.

There was a direct relationship between the airspora and fungi from the surfaces of fruits and leaves. However, even though the three sites where the airspora were trapped were quite close, the patterns of occurrence of the fungal species were different and did not show the same relationship with the climatic conditions. Over a period of January, 1989 to December, 1990, airspora of the Experimental Plot, and University Farm showed peaks in January and February 1989, and three peaks in January, 1989, and February and April, 1990 and June, 1990, respectively.

Following the traditional methods of preservation, ripe pepper fruits were boiled and then dried while okra fruits were cut into chips before drying. Air dried chips of okra fruits were more heavily contaminated than the solar dried chips in the rainy season. The predominant fungus of both dried pepper fruits and okra fruit chips was Aspergillus niger.

There was no consistent effect of irradiation of onion bulbs with Gamma rays at dosages of 0.05 and 0.10 Gy before storage on fungal infection. In all cases, Aspergillus niger thrived very well on bulbs stored over 90 days.

Corynespora casiicola which was being studied for the first time on tomato plants in Ghana grew better in Sweet Potato Dextrose Broth than in Potato Dextrose Broth, used Galactose

better as a carbon-source than Glucose and grew best in media containing Asparagine, Potassium nitrate and Sodium nitrate among the various nitrogen-sources tested. C. casiicola required an external supply of thiamine for good growth at an optimum concentration of 100 ug per litre, and the optimum concentration of $CaCl_2$. $2H_2O$, KCl, K_2SO_4, $MgCl_2$ and NaH_2. $2H_2O$ was 29.0 x 10^{-6}M, , 8.0 x 10^{-3}M, 11.0 x 10^{-3}M, 10.0 x 10^{-4}M and 65.0 x 10^{-4}M, respectively. The optimum temperature for growth was 30°C and C. casiicola grew better in either continuous darkness or under 12 hours dark/12 hours light condition than in continuous light.

CONTENTS

INTRODUCTION AND LITERATURE REVIEW

Many vegetable crops are cultivated in Ghana. Until recently, with the exception of cocoa, food crops were mostly produced for home consumption. They have been grown on small holdings and production levels had been relatively low. Lately, there has been an upsurge in productivity and non-traditional export food items are being exported, some at considerably high levels. There could be three reasons for this.

First, the natural impulse to raise productivity as the peasant farmers faced alarming escalation cost of living. Secondly, the adoption of modern agriculture by the new breed of farmers which entered the food production enterprise. Modern agriculture depends on the four technologies: mechanisation, irrigation, fertilizer application, and the control of parasites and pests. Thirdly, it is a result of the enormous interest aroused among member nations of the Food and Agriculture Organisation of the United Nations (FAO) by the organization's World Plan for Agriculture. In this plan, the FAO developed an integrated programme to close the gap between the curves for food production and population growth by 1985 and also made possible for developing countries to get access to aid for expansion of agricultural endeavours. The history of the plan began in 1963.

The first World Food Congress was convened in Washington D.C., United States of America (USA), under the Freedom from Hunger Campaign, a private group that raises funds and provides other support for the FAO. It was

decided that the FAO should be asked to prepare a survey of the world food situation in relation to population and overall economic development, together with a plan for action that would indicate the long-term prospects for closing the food gap. The scope of the proposed survey was widened by the FAO's governing conference of member states so that the study would become a "World plan for agricultural production, trade and development" highlighting the national and international actions needed to redress the alarming imbalance between food and population. The findings, projections and policy recommendations of this study, which became known as 'Indicative World Plan for Agricultural Development' were submitted to the FAO'S 15th Conference in November, 1969 (FAO 1970). The Plan was intended to provide a framework within which national and regional programmes could be developed. It was hoped that governments would be able to use the plan to create and implement agricultural policies. Moreover, it should serve as a guide to both donors and recipients of international aid. Judging from the subsequent improved agricultural output of many countries, it could be fairly concluded that the Plan has succeeded in achieving its main objective.

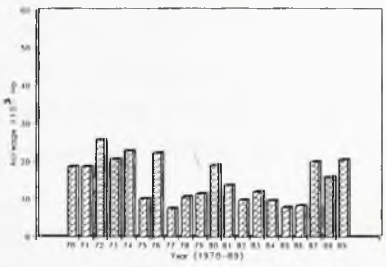
In Ghana, vegetables which are abundantly cultivated include okra (Abelmoschus esculentus L. Moench), onions (Allium cepa L. var cepa), pepper (Capsicum annuum L.) and tomato (Lycopersicon esculentum Mill). The acreages under cultivation recorded by the Ministry of Agriculture for the

period 1970-1989 are shown in Fig. 1

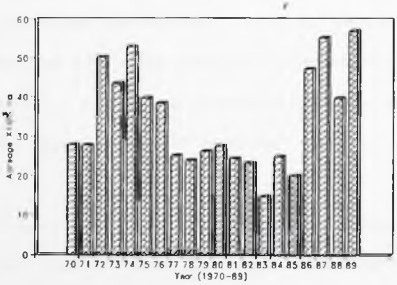
Okra is widely cultivated in the tropical regions. It can grow on any type of soil but does best on well drained fertile soils with adequate organic matter. Most cultivars are adapted to high temperatures throughout the growing season with little diurnal or seasonal fluctuations. Okra is tolerant to a wide range of rainfall although supplementary irrigation may be required up to the fruiting period (Purseglove, 1968). It is one of the most popular tropical vegetables cultivated primarily for its mucilaginous fruits. The fruit, when required as a vegetable, is harvested while it is relatively tender just 3-4 days old after attaining full size, when the seeds are still immature (Thompson and Kelly, 1957).

The important measure of quality in okra fruit as a green vegetable, is its sliminess. The slimier, the better (Uzo and Ojiako, 1980). The high mucilage content helps thicken soups and stews. The green tender fruits are also dried and ground into powder which is used for salad dressing, soups and ice creams. In West Africa a considerable proportion of the okra crop is preserved by cutting the fruits into small pieces and sun-dried. In Northern Ghana, the pieces are mixed with wood ash before sun-drying. The most reliable method of preservation is either canning or pickling with salt or sugar solutions (Dei-Tutu, 1972; Doty, 1980; UNIFEM, 1988). The fruit is rich in vitamin C (Akinsoyoye, 1979; Phillips, 1974) and

Tomato



Pepper



Okra

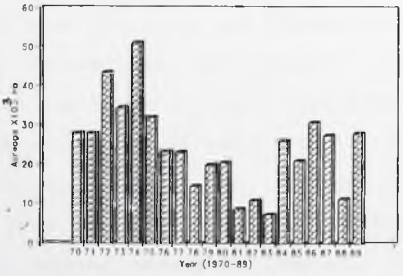


Fig.1 Acreage of cultivation of okra, pepper and tomato in Ghana from 1970 to 1989.

(Data provided by the Statistical Division of the Ministry of Agriculture, Accra).

contains high levels of calcium. Niacin, riboflavin and thiamine are the notable vitamins of the fruit (FAO, 1968, 1972; Grubben, 1977). The leaves of okra are also rich in vitamins A and C and in some parts of the world are cooked as a pot-herb like spinach (Martin et al., 1981; Martin, 1982).

The matured seeds of okra are gradually attracting interest as source of vegetable oil. For oil production, the fruits are allowed to dry on the plants before they are harvested and the seeds extracted yielding vegetable oil of about 20 per cent of the seed weight. The major components are linoleic, fatty, oleic and palmitic acids with cupric and lauric acids occurring in smaller quantities (Oyolu, 1982).

The plant has other uses. Okra has medicinal uses. The mucilage of fresh fruits is used in the treatment of ulcers and for relief of haemorrhoids. It is also used as a clarifying agent in the production of sugar from sugar cane and for sizing paper in China and Malaysia (Akilade and Adesiyan, 1982; Purseglove, 1977; Sackette, 1975). The stems and leaves are fodder for goats and sheep.

Clemson Spineless, Labadi Dwarf and Local are the most common among a large number of cultivars in Ghana - Accra,Akatsi, Akim Oda, Asutem Red, Asutem White, Bawku, Ho, Kade, Likpe, Madina, Mole short, Patasi, Sunu, Sunyani and Tafo. The cultivars vary mainly in colour of plant parts, fruit shape and fruit size. For example Labadi Dwarf and Local fruits may be long or short, ridged with

spines, pointed and pyramidal. The fruits may be green, reddish green or pale green to yellow (Sinnadurai, 1977; Tindall, 1987). The fruits of Clemson spineless are long, cylindrical, smooth and pale green.

Okra is grown in many regions of the country as shown in Fig. 2, but flourishes best in Ada, Agbogba, Ashiaman-Michelle Camp, Kokrobite, Larsibi-Bleku, Ningo and Weija in the Greater Accra Region; Akim Oda, Akorle, Huhunya, Nkurakan and Okuenya districts in the Eastern Region and Agogo (Ashanti Akim) district in the Ashanti Region. Production in the various regions is seasonal (Fig. 2) with the exception of Ashanti which lies in the Tropical rain forest belt, where the crop is cultivated practically throughout the year.

As a perishable, endogenous physiological processes in the presence of the high water content cause rapid storage deterioration. Also the harvested fruit under normal atmospheric humidity conditions lose water quite rapidly, and become shrivelled, discoloured and hardened (Labios, 1984). When fruits of 'Smooth Green' okra variety were kept on shelves in polyethylene bags with or without diffusion holes, the visual quality of the fruits remained good for 5 days while pods without polyethylene covers became progressively flaccid within that period (Labios, 1984).

Onion is grown mainly in the northern areas of tropical West Africa particularly by the Hausas of Northern Nigeria, Mali and Niger (Irvine, 1969). Prior to the

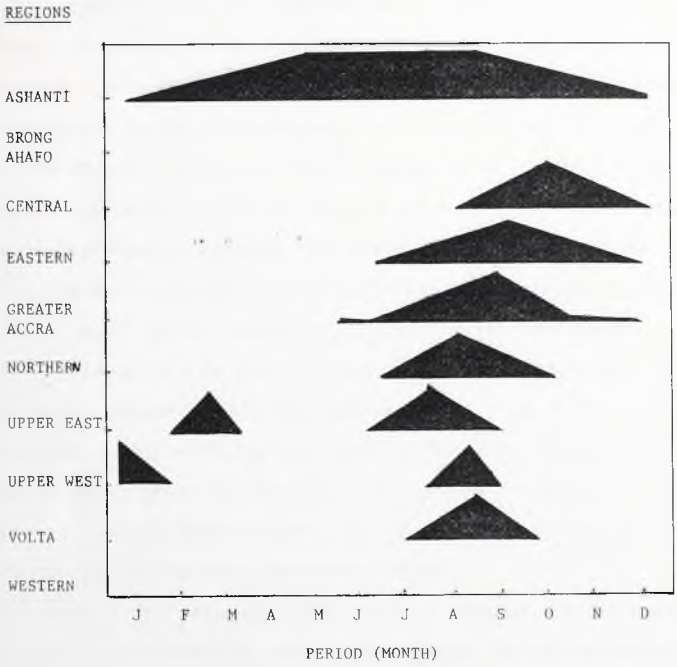


Fig. 2: Harvesting periods of Okra in the different okra-growing regions of Ghana (Data provided by the Ministry of Agric., Accra)

introduction of onion into Ghana in the 1930's, shallot (Allium cepa var aggregatum) was the only alliaceous crop cultivated and this was done mainly in the sandy areas of Anloga in the Volta Region (Adomako, 1959). According to Adomako (op. cit.) the Bawku variety of onion was first introduced in 1930 from Benlengu in Burkina Faso to Bugri in the Kusasi district of the Upper East Region. From there its cultivation spread southwards. However, the Upper East Region remains the major area of production.

The major varieties cultivated in Ghana are Bawku, Red Creole and Texas Grano. These varieties can be distinguished on the basis of size, colour and pungency of the bulb. Bawku variety has medium sized, firm-fleshed and globular bulbs with purple skin. Red Creole bulbs are semi-globes, small to medium in size, firm fleshed and red skinned. Texas Grano bulbs are large, shaped like a top with straw yellow skin and white flesh.

Onion is characterised by a pungent alliaceous compound, allyl-propyl disulphide ($C_6H_{12}S_2$) which is formed when the plant is cut, bruised or injured. The bulb is rich in Vitamin C (Jones and Mann 1963), and all the other vitamins found in okra. It is eaten as salad and cooked in curries, fried, boiled, baked, used in soup and as flavouring agents. Onion bulbs repel snakes when planted around houses. They have a disinfecting action in the intestines and prevent thrombosis in arteries (Abbiw, 1990; Bendre and Kumar, 1980).

Onion is a cold season crop but it thrives over a wide

range of temperatures. It grows best in rich well drained soil especially when animal or poultry manure is applied (Irvine, 1969). An adequate soil moisture is required throughout the growing period and particularly important at the time of bulb formation. Thereafter, a long dry period is required for bulb ripening. The aerial leaves shrivel when the bulb has fully matured. In Ghana, onion is harvested in the harmattan season from December to March.

After lifting the bulbs from the soil, they are left in rows in the field to allow the neck and the outer scale leaves to dry. In certain countries, drying is done by tying the bulbs into bunches of up to 20 by their tops and hanging on railings in shade to dry. It is also possible to dry the bulbs artificially in special driers. In Great Britain, for example, drying is carried out at 30-35^{0}C and at less than 75% RH in driers with an airflow at 7cm^{3}/tonne/min (Shipway, 1978).

According to Sinnadurai and Abu (1977) the Bawku variety is inherently more compact than the Texas Early Grano, Red Creole and other foreign cultivars. Balkema (1977) noted that Texas Early Grano varieties yield better than the Red Creole variety but its bulbs have inferior keeping quality. Giza 6 variety of Egypt can withstand rough handling and long distant shipment; and bulbs of the cultivar Wad Ramli cultivated in Sudan, is stored for several months under normal atmospheric conditions (Musa et al., 1973).

In Sudan, onions are stored on slates in mud or straw

cottages, piling the bulbs up to about one meter high. Under that condition, long storage of about four to five months could lead to a loss of 40-50 per cent (Musa et al., 1973). In Korea, square straw cottages are built on stilts in which bunches of onions plaited together by their tops are hung on nails.

In Ghana, onions are spread on jute sacs, zanna mats in sheds, on sand or floors in rooms or on platforms in shade until they are sent to the market (Adomako, 1959).

If financial resources allow, storage under refrigeration is the best. A temperature of 0^0C and atmospheric humidity of 70-75% RH are presumed to be ideal (Thompson, 1982). Storage at temperatures between 1^0C and about 25^0C results in sprouting (Stow, 1975).

Sprouting is a serious constraint in storage of onion bulbs. The major factors which influence the rate of sprouting are type of cultivar, improper curing and storage temperature and humidity (Jones and Mann, 1963). Wright et al. (1935) working on stored Yellow Globe storage-type onions at 0^0C, 4.5^0C and 10^0C and at relative humidities of approximately 65, 80 and 90% respectively found that sprouting in storage was influenced very little by humidity, but increased with increase in temperature, whereas rooting increased with humidity and was little influenced by temperature. Karmarkar and Joshi (1941) conducted storage tests with a red cultivar grown in Bombay region, India, using eight different temperatures between 0^0C and 35^0C. Sprouting occurred in the second month in

onions stored at 8.8, 11 and 20°C, in the third month at 4.4°C, in the fourth month at 1.6°C and finally in the seventh month at 0°C. There was no sprouting after nine months at 24 to 29.5°C and after 10 months at 32 to 35°C. They also showed that bulbs stored at °C for varying periods of 1,2,3,5 and 7 months, and then transferred to 11°C and 20°C sprouted much sooner than those kept at an initial temperature of 32-35°C. According to Martin et al., (1985) when Taherpur and Jhitka onion varieties were stored for 8 months at a precooler zone of 15-18°C and 70-90% RH in a commercial cold storage, all the bulbs sprouted heavily and rotted. Onion bulbs stored at 20-37°C and 70-90% RH with natural aeration dehydrated and rotted without sprouting. Yellow Grannex variety had been found to be storable at 2-5°C and 70-75% RH. They could be stored for a maximum period of 3-4 months after which losses due to sprouting rotting and loss in weight set in (Singson et al, 1977).

Various chemical treatments and gamma irradiation have been shown to prevent sprouting of onions in storage (Thompson et al., 1972). The most commonly used chemical is maleic hydrazide which is applied as a foliar spray in the field before harvest (Thompson et al., op cit).

Radiation is used to extend shelf life of certain fruits and vegetables. It is used to control sprouting in potatoes, onions and garlic and it is superior to other techniques (Diehl, 1974; Nair, 1973; Roushdy et al., 1973). It has been recommended that irradiation should be done

soon after harvest (Roushdy et al., 1973; Sparenberg, 1974). Irradiation of onions at rate of 10krad completely inhibited sprouting of onion bulbs stored at atmospheric humidity and at low temperatures for as long as 150 days. According to Khan and Wahid (1977), irradiation and their storage at 14-16^{0}C is the optimum condition of storing onions and garlic in tropical countries like Pakistan.

Pepper is widely grown throughout the country and it is perhaps the most common vegetable garden plant. Yanney Ewusie (1960) studied extensively pepper species and varieties in West Africa. He identified 80 varieties belonging to three species Capsicum annuum L., Capsicum frutescence L. and Capsicum sinense L. The major varieties cultivated in Ghana belong to the species, Capsicum annuum L. and Capsicum frutescence L. Varieties of Capsicum annuum vary widely in form, from the long slender fruits of Legon Red to the large, inflated, bell shaped fruits with thick pericarp. Capsicum frutescence L. are small fruited peppers which could be conical or taper at the ends. They are often dispersed by birds. Capsicum sinense L. fruits are small and rounded and with firm flesh.

The peppers are usually grown as a rain-fed crop in areas with an annual rainfall of 600-1200mm. Excessive rainfall is detrimental as it affects flowering and fruit set and encourages fruit rot. The plants cannot withstand water-logging even for a short time causing premature leaf shedding. They grow best on light loamy soil rich in lime but they can also be grown on a variety of soils provided

they are well drained. Capsicum species are adapted to high temperature but infertile pollen and poor fruit set may be caused by excessively hot weather (Pursegloves, 1968; Rice et al., 1987; Tindall, 1987).

Pepper is cultivated in all the regions of Ghana on large scale except in the Western Region. Peak harvesting periods for the different regions occur at different times between May and November as shown in Fig. 3. Some varieties can be preserved by sun-drying the ripe fruits to form what is called chillies. Chillies are also milled and stored in powdered form. Fresh pepper can also be milled into paste or puree and canned. The fresh fruits, the chilies and the powder are used for culinary purposes and for seasoning. The extract of the fruit is also an ingredient of ginger beer and other beverages (Tindall, 1987). It is also an ingredient in many local medicinal preparations.

Pepper fruits also contain the vitamins ascorbic acid, niacin, riboflavin and thiamine (FAO, 1968).

Tomato is cultivated in eight out of the ten regions of Ghana. The major cultivars grown are Asante, Derma, Heinz, Improved Zuarungu, Local, Money maker, Pearson, Roma VF and Wosowoso. The morphological characters are presented in Table 1.

In the tropics, tomato plants thrive best where there are long sunny periods with light evenly distributed rainfall. Very wet weather with low sunshine conditions and high night temperatures result in excessive vegetative

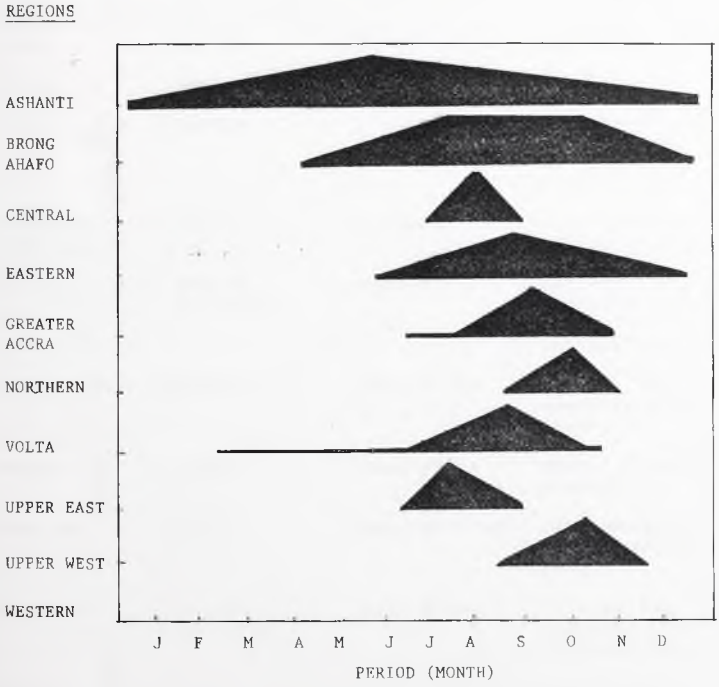


Fig. 3: Harvesting periods of pepper in the different pepper-growing regions of Ghana. (Data provided by the Ministry of Agriculture, Accra).

TABLE 1: General characteristics of fruits of Tomato varieties grown in Ghana (Apte et al., 1969; Norman, 1974).

Cultivar	Fruit size	Fruit shape	Other features
Asante	Medium	Globe	2-3 lobes
Derma	Medium	Globe	Few lobes
Heinz, 1350 1370	Medium	Flattened Globe	Thick mesocarp with smooth skin which is firm
Improved Zuarungu	Small	Globular	Thick fleshy mesocarp
Local	Medium to large	Semi-globe	Thin-walled mesocarp with irregular corrugations
Moneymaker	Medium	Semi-globe	Very firm mesocarp with lobes
Pearson	Large	Deep globe	Thick fleshy mesocarp
Roma VF	Small	Pear to plum	Thick mesocarp with smooth skin
Wosowoso	Medium to large	Semi-globe	Thin-walled mesocarp with corrugations.

growth at the expense of fruiting and increase in leaf disease (Tindall,1983, Rice et al; 1987).

The ideal soil condition is a light free - draining loam soil with a pH of 5 - 7 (Tindall 1983; Rice et al.,1987). In Ghana the crop flourishes best in Baru, Nania, Paga, Vea and Wuru in the Tono district in the Upper East Region; Northern Region; Ashalley Botwe, Ada, Kokrobitey and Sege districts in the Greater Accra Region; Wenchi district in Brong Ahafo; Mankessim and Swedru districts in the Central Region; Akorwu-Bana, Amanfrom-Kwahu at the Afram Plains, Asamankese, Nkurakan, Nsawam and Oda in the Eastern Region; and Agogo (Ashanti Akim) and Akumadan districts in the Ashanti Region.

The building of the two dams in Northern Ghana under the management of the Irrigation Company of Upper Region (ICOUR) has led to a remarkable increase in tomato cultivation in the region. Tomato production in the Vea irrigated area in Bolgatanga District of Upper East Region of Ghana started in 1965 (Anonymous, 1990).

Figure 4 shows the periods of tomato harvesting in the different regions. There are three canneries- Ghana Industrial Holding Corporation (GIHOC) Cannery at Nsawam in the Eastern Region, the cannery at Wenchi in Brong Ahafo and Tomato Cannery at Pwalugu in the Upper East Region- which can the excess product. The fruit can also be crushed and then dehydrated into powder for preservation (Anonymous 1990).

According to Norman (1972) the shelf-life of Improved

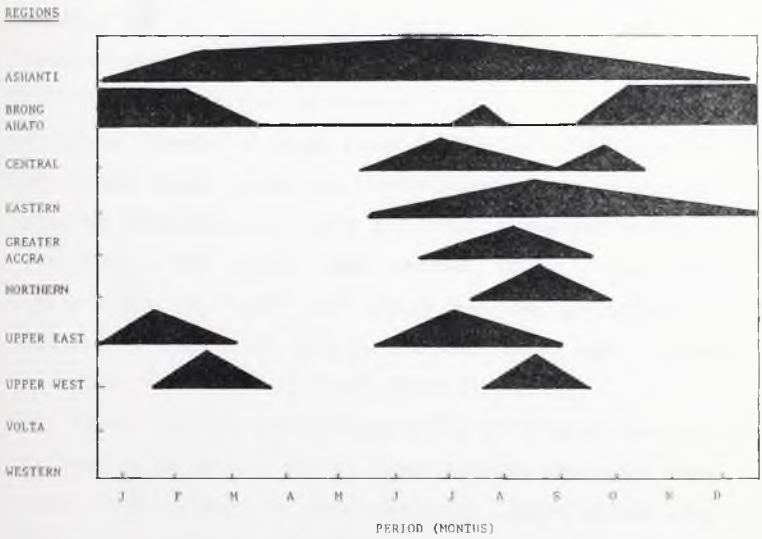


Fig. 4 : Harvesting period of tomato in the different tomato growing regions of Ghana (Data provided by the Ministry of Agriculture, Accra).

Zuarungu fruits could be extended. Fruits treated with succinic acid 2,2-dimethyl hydrazide (Alar-85) and harvested at mature green stage was kept in open boxes at room temperature (27^0C). Fruits from treated plants were firmer and had a longer shelf life of 17 days. Untreated fruits showed a shorter shelf life of 11 days. Fruits from plants treated with Alar-85 at 1000ppm and 2000ppm had shelf-lives of 17 and 18 days, respectively,and the intensity of colour was even for all fruits.

The fruit is rich in Vitamin C, niacin, riboflavin and thiamine. Tomato is eaten fresh or used in the preparation of sauces, soups, stews and tomato ketchup. The juice can also be fermented into wine and other fermented products (Dei-Tutu, 1972; King, 1980; UNIFEM, 1988). The seeds contain 24 per cent oil which can be extracted in commercial quantities, and the residual press cake is used as animal feed and fertilizer (Tindall, 1987).

Under the best cultural conditions it is never possible to achieve maximum yield of crops because pathogens take their toll in large or small measures. Associations with the pathogens and pests extend from the field into storage. The pathogens are bacteria, fungi, nematodes and viruses. Viruses hardly pose any problem at the post-harvest stage and the destructive activities of nematodes at this stage are confined mainly to the tubers. Apart from the tubers the other major plant food products are the cereal grains and seeds on the one hand, and the vegetables and fruits on the other. Cereal grains and seeds are stored in

the dried state and they, therefore, do not support bacterial growth and are attacked mainly by fungi . Perishables made up of the tubers, corms, rhizomes, fruits and vegetables with their high water content form good substrates for both fungi and bacteria and these two groups of pathogens thrive well on them in the field and on their products after harvest. Their influence on the production of okra, onion, pepper, and tomato in Ghana, and indeed elsewhere is, therefore, considerable.

Although okra is attacked by a number of fungal pathogens the effects of infection have not been overly serious. Sooty mould of the leaves caused by Irenopsis aciculosa is very common in Ghana (Leather, 1958). Another black leaf mould, Cercospora abelmoschii may induce premature leaf fall. Pre-harvest fruit diseases are few. Ascochyta abelmoschii causes pod spot (Irvine, 1969; Pursegloves, 1968). Macrophomina phaseolina causes dry rot of the fruit (Pursegloves, 1968).

A succession of mycoflora is a common feature of chips of any kind exposed to drying. The early period of drying is characterised by fast growing moisture -loving fungal species. They are mainly members of the sub-division Zygomycotina which are able to use only sugars and simple carbon compounds as energy source. These species are followed by members of the sub-divisions Ascomycotina and Deuteromycotina which have the ability to use cellulose and other complex carbon compounds (Barton, 1960). As the drying material loses much of its moisture many fungi are

eliminated leaving only the xerophilic species. The Aspergillus and Penicillium species in particular belong to this category and in the tropics they are the predominant flora of dry products. Thus, studies by Udeobi (1987) have revealed that fresh okra fruit chips are heavily invaded by Neurospora crassa and Rhizopus oryzae while Christensen and Kaufman (1974) recorded Aspergillus candidus, Aspergillus flavus, Aspergillus glaucus, Aspergillus halophilucus, Aspergillus ochraceus, Aspergillus restrictus and Wallemia sebi on dry okra fruit chips.

The effects of these contaminants are as serious as that of the pathogens. For example, Udeobi (1987) noted that Rhizopus oryzae caused a loss of 40 per cent in dry weight within 4 days, a shift of pH from 5.3 to 7.1 and a decrease in the level of fructose, glucose, maltose and also in the percentage of crude protein. Neurospora crassa-inoculated chips lost 20 per cent of the dry weight in 4 days. The pH rose from 5.3 to 5.7; fructose, glucose and sucrose concentrations fell and maltose was totally depleted. On the other hand, the percentage crude protein rose from an initial 4.4 per cent to 8.1 per cent.

The infections of onion fall into three groups namely, leaf infections, bulb field infections and bulb storage infections. Downy mildew of onions caused by Peronospora destructor is usually prevalent in areas of intensive onion production. Necrotic spots are found near the leaf tips (Hilderbrand and Sutton, 1984; Rice et al., 1987). There is die back of the leaves with consequent suppression

of the development of the bulb (Tindall, 1987).

Stemphylium vesicarium causes a leaf blight of onion in Texas, USA (Muller et al., 1978) and in India (Rao and Paugi, 1975). In experimental inoculations by Shishkoff and Lorbeer (1989), the fungus caused lesions on leaves of all ages.

A leaf disease characterised by elliptical white leaf blotches and die back in Great Britain appeared to be caused by a multiple infection. Although some of these symptoms were attributable to Alternaria porri and Cladosporium herbarum which were isolated from senescent leaf tissue or leaves scorched by herbicide, a few leaf tips revealed pycnidia of Ascochyta allii-cepae (Punithalingam et al., 1985).

Cladosporium allii-cepae and Cladosporium allii (Syn. Heterosporium allii) during experimental inoculation studies were found to cause leaf blotch of both onion and Japanese bunching onion (Allium fistulosum) (Jordan et al., 1984).

There are three major onion bulb field infections. The basal bulb rot caused by Fusarium oxysporum affects onions at any stage of development. It normally causes death of seedlings (Tindall, 1987). Bulbs infected at the last stage of development carry the fungus into storage and at room temperature quickly develop a soft semi-watery rot. The infected bulbs eventually become desiccated empty shells (Thompson, 1982).

Sclerotium cepivorum affects the bulbs in a different

way. It causes rapid watery rot of the onion bulb scales. The fungus produces oxalic acid in culture or in infected tissue which is partly responsible for maceration, and the symptoms of infected bulbs may be a synergistic action of the oxalic acid and Endogalacturonase of S. cepivorum (Stone and Armentrout, 1985).

Another soft rot disease is caused by Botrytis allii, Botrytis byssoidea and Botrytis squamose. The disease may, however, develop at any part of the bulb. The fungi mainly cause a neck rot of the bulbs. Affected areas develop a brown soft rot followed by a dense cover of grey or green powdery spores. The pathogens are seed borne and evidence suggests that there is no bulb to bulb transmission during storage (Maude and Presley, 1977), even though they cause serious storage bulb rot, especially in Great Britain. In experiments carried out a few years ago at Wellesbourne, Great Britain, Botrytis byssoidea was found to cause more severe neck rot than Botrytis allii in the field and in stored bulbs grown in areas where either onions or onions and leeks had been grown consistently for a number of years (Burchill, 1984).

Colletotrichum dematium f. sp. circinans infection is characterised by black lesions on the outer scales of maturing bulbs particularly under high temperature conditions (Rice et al., 1987; Tindall, 1987). The smut fungus, Urocystis cepulae, causes black soft rot. Only young plants are susceptible. The leaves develop black spots, collapse and the plant dies. The black spore masses

(chlamydospores) erupt near the base of bulb scales on surviving plants.

In storage, Aspergillus niger and Penicillium species are the main fungi always isolated from the bulbs. Penicillium species thrive along the main vertical ribs of the wrapper scales and sometimes the first fleshy scale of the bulb whereas Aspergillus niger often produces dense black powdery spore masses on the outer scales, beneath the wrapper scales and at the base of the neck downwards (Maude et al., 1983; Thompson, 1982). Aspergillus fumigatus also occurs occasionally, especially, at high storage temperature (30 - 40^{0}C). In 1984, the fungi were mainly responsible for post- harvest rotting in Great Britain (Maude et al., 1984).

Bacterial soft rot disease caused by Erwinia carotivora causes considerable loss in storage. The rot usually begins at the neck of the bulb and affects one or more scales. The bulb loses its firmness and an offensive - smelling exudate oozes through the neck when the onion is squeezed (Jones and Mann, 1963).

Pseudomonas cepa causes sour or slippery skin. This disease occasionally affects some of the outer fleshy scales of the bulb. The rot at first has a glazed appearance, then becomes slimy and yellow and gives off a characteristic vinegar-like odour (Jones and Mann, op.cit).

Extensive studies have been made in many countries to determine the keeping quality of various cultivars. Magruder et al., (1941) made a study of the principal onion

cultivars of the United States grown in many soils and climates, and stored under a variety of conditions. They were able to classify the cultivars which they studied into five storage groups as follows: very poor - Italian Red; poor -Crystal Wax, Yellow Bermuda, Early Grano; fair-White Sweet Spanish, Prizetaker, Sweet Spanish; good -Red Wethersfield, Mountain Danvers, Extra Early Yellow, Yellow Danvers Flat, Yellow Strasburg, Southport White Globe, Southport Yellow Globe, Southport Red Globe, Ohio Yellow Globe, White Portugal, Ebenezer, Yellow Globe Danvers; very good-White Creole, Red Creole, Australian Brown.

Pepper suffers from stem and collar rot diseases. Collar rot is caused by Sclerotium rolfsii and it is very serious during warm wet periods. Attack by Phytophthora capsici has similar effects on the plant. Infected plants are normally girdled at ground level causing wilting and ultimate death (Pursegloves et al., 1981). Heavy rainfalls bring about early onset and causes more rapid development of the disease (Ristaino, 1989). Another wilt disease, Fusarium wilt is caused by Fusarium annuum (Pursegloves et al., 1981). Finally, pepper suffers from a stem rot caused by Glomerella cingulata.

The major leaf fungal diseases are the pepper powdery mildew and the frog-eye leaf spot. Powdery mildew caused by Leveillula taurica occurs in great abundance in West Africa (Ayesu- Offei, 1966) and was first recorded in Ghana in 1958 (Leather, 1959). The mycelium of L. taurica is commonly endotrophic and conidiophores emerge through the

stomata to produce hyaline conidia of two types, a larger proportion of cylindrical conidia and a smaller proportion, approximately one-fifth of conical conidia. White patches indicating crops of conidiophores and their conidia are found principally on the abaxial surface of the leaf. The chloroplast in these localities degenerate and the infected areas are identified from the adaxial surface of the leaves as yellow patches. Diseased leaves fall prematurely. Brown (1976) found that during the dry season, infection by L. taurica was moderately high (21 per cent of the leaves were infected) in the large -fruited and long-fruited varieties whilst infection was very low (less than 5 per cent of the leaves were infected)in the medium-fruited, round-fruited and small-fruited varieties. The greatest infection was recorded on the long-fruited variety and the lowest infection on the small-fruited variety during the rainy season.

The frog-eye leaf spot is caused by two Cercospora species, C. capsici and C. unamumoi. The typical symptoms are large circular or oblong spots with dark brown margins and light-grey centres (Pursegloves et al., 1981).

Some pathogens attack both the leaves and the fruits. The stem-rot fungus Glomerella cingulata also causes fruit rot (Gollifer, 1973) and Xanthomonas vesicatoria causes a serious bacterial spot disease in both leaves and fruits. The spots on young leaves are yellowish-green but appear dark and water soaked on older leaves. Severely spotted leaves turn yellow and fall prematurely (McCarter, 1989).

Fungal attacks on the fruit causes diseased spots in many instances. Anthracnose caused by Gloesporium piperatum is particularly serious during wet weather. Infected fruits both green and ripe develop dark circular sunken spots. Another spotting of fruit is caused by Colletotrichum nigrum. The fungus commonly attacks over-ripe fruits producing dark sunken spots (Pursegloves et al., 1981). In Georgia, USA, Colletotrichum capsici causes small yellowish spots on the ripe fruit which, in damp weather, increase in size and become sunken and soft (Dempsey and Brantley, 1953).

Phomopsis sp. causes fruit rot (Gollifer, 1973) while Alternaria alternata causes an internal mould of ripe fruit without showing external signs of infection (Bremer, 1955; Leyendecker, 1950; Melikova, 1960). The fungus enters the ovary through the stigma and style and the fruit is therefore infected even before anthesis and compact sporulating masses of mycelia of the fungus are found on the seeds of the mature fruit. Such early infection of the floral parts causes damage to the flower and young fruit and the blossom-end of the fruit and the placenta tissue become necrotic (Meiri and Rylski, 1983). It is a common disease of various cultivars of sweet pepper in Israel (Rylski et al., 1975).

Powdered peppers can become highly contaminated. Hadlock (1969) and Walz (1956) recorded a total viable cell count of as high as 8.0-10.0 $X10^7$ $CFUg^{-1}$. Warm Brod and Fry (1968) found that total bacterial load of pepper ranged

from 3.0 X10^3 CFUg^{-1} to 2.8 X10^7 CFUg^{-1} while coliform were less than 100 CFUg^{-1}. Farkas et al.,(1982) stated that mould count in Nigerian pepper (Capsicum species) called 'Tatase' was low between 10.0 - 2.1 X10^2 CFUg^{-1}.

Mould and yeast counts on both whole and pulverised pepper fruits increased with rise in humidity within the range of 55 to 95 % RH. Whole pepper stored at 55% RH has mould and yeast population of about log 4.2 and this increased by about 4 log cycles at a storage of 75% RH (Afrim, 1986). Fungi contaminating pepper (whole and ground) stored at 28°C for 44 days were Aspergillus flavus, A. fumigatus, A. japonicus, A. parasiticus, A. sulphureus, Neurospora sitophila, Rhizopus oryzae. Aspergillus niger was encountered only on whole pepper. According to Farkas et al. (1966) during nine weeks test period the most frequent mould isolated from the pepper fruits belonged to the Alternaria, Cephalosporium, Fusarium and Stemphylium genera.

Tomato suffers from the greatest number of fungal and bacterial diseases. Phytophthora parasitica was found to be highly virulent to tomato seedlings causing stem lesions and usually seedling death (Matheron and Mejka, 1989).

Some of the pathogens of the seedlings could be seed-borne. Vartaman and Endo (1985) isolated Phytophthora infestans from freshly extracted wet tomato seeds, and seedlings became automatically diseased on emerging from wet seeds.

Fusarium oxysporum f. sp. lycopersici, the causal

agent of vascular wilt of tomato, is another example. It is both seed and soil-borne and it has been shown that long distance spread is by either infected seeds or by diseased transplants (Snyder and Hansen, 1941). The entire root system is affected, exhibiting a dry brown rot of the cortex and stele (Leary and Endo, 1971). Although plants infected at the vegetative stage do not die off, they become stunted, chlorotic and practically worthless. Infection after fruit set invariably causes plant wilt and death. Wilting and death also accompany Fusarium wilt caused by Fusarium bulbigenum var. lycopersici (Tindall, 1987). In Ghana, tomato vascular wilt caused by Fusarium oxysporum f. lycopersici and Verticillium albo-atrium is common. F. oxysporum f. lycopersici is very widespread and so persistent in soil that neither soil sterilization nor crop rotation is of much value (Clerk, 1974).

Furthermore, tomato suffers from a bacterial wilt. It is one of the most serious diseases of tomatoes in the wet tropics and is caused by Pseudomonas solanacearum. Infected plants never live long. They quickly wilt without yellowing and die soon after.

The soil facultative parasite Pyrenochaeta lycopersici causes the disease known as corky root. This is a cold region parasite. Lesion development was shown to be more severe at 16^0C than at 27^0C (Shishkoff, 1989).

Many fungal pathogens cause exclusively leaf diseases. The leaf mould Cladosporium fulvum is prevalent in wet weather and causes serious damage under warm moist

conditions. The fungus appears as brownish-grey patches on the underside of the leaves. The infected areas lose their chlorophyll content and appear as yellow patches when viewed from the upper surface (Clerk, 1974). Leveillula taurica causes powdery mildew of tomatoes whereby infections which are first visible as small light green lesions later became bright yellow and necrotic (Correl et al., 1985; Correl and Elliott, 1986). The disease is never as serious as powdery mildew caused by this fungus in pepper.

The leaf spot caused by Septoria lycopersici is common in forest areas and can be very serious. Small brown water-soaked spots with pale centre and yellow edges appear usually in wet weather on the leaves (Tindall, 1987). Infection may cause defoliation.

Corynespora cassicola causes target leaf of tomato, a dark brown patch with darker concentric rings. The disease severely reduces yield and causes peculiar branching of leaves. Stemphylium solani is known to cause grey leaf spot of tomato in the Panama, and is serious in warm wet weather (Cowling, 1980; Sanchez and Samaniego, 1984; Sherf and MacNab, 1986; Tindall, 1987). Another leaf spot pathogen is Cercospora canenscens which may attack the stem as well (Solheim and Stevens, 1931).

Alternaria solani is known to cause early blight of tomato in the Panama (Sanchez and Samaniego, 1984) and in many tomato growing countries.

Some of the pathogens affect both the vegetative

end-rot growth-cracks of skin or other causes (Anonymous, 1968; Ellis, 1971). Losses due to this disease can be substantial (Pearson and Hall, 1975).

The disease, buckeye rot of green tomato fruit is caused by Phytophthora parasitica (Criptopoulos, 1954; Satour, 1963). Lesions that develop on the surface of infected fruits have characteristic patterns of alternating light and dark brown concentric rings resembling a buckeye (Kendrick, 1923; Tompkin and Tucker, 1941). Buckeye rot occurs primarily on the fruit lying on or near moist soil (Barksdale, 1968; Batson, 1973; Tompkin and Tucker, 1941; Wilson, 1956). Rhizoctonia solani and Rhizoctonia cinerea also cause rot of tomato fruits touching the ground (Ayres et al., 1980, Barksdale, 1968; Batson, 1973).

Anthracnose of tomato caused by Colletotrichum coccoides is another important disease of tomato fruits (Dillard, 1989; Fulton, 1948; Kendrick and Walker, 1948; Ulman et al., 1959). Anthracnose appears as circular depressed lesions with darkened centres on ripe fruits. The lesions often merge and result in large rotten areas (Ayres et al., 1980; Gould, 1983). Severe outbreaks of tomato anthracnose are most often associated with high rainfall during the growing season (Barksdale et al., 1972; Dillard, 1988; 1989; Ulman et al., 1959).

Didymella lycopersicon is one of the most serious pathogens of tomatoes. Wounding and high humidity are reported to increase the chances of infection (Verhoeff, 1963). Pycnidiospores of D. lycopersicon were capable of

inducing stem lesions when experimentally inoculated into wounds (Fagg and Fletcher, 1987).

Other tomato fruit rot fungi identified in Trinidad by Baker (1939) are Bacillus aroideae, Phomopsis species and Botryodiplodia theobromae which caused soft rots and Phoma destructiva and Cladosporium fulvum which caused dark lesions on the fruits (Anonymous, 1981).

Many more fungi and bacteria associate with crops in other ways. The Rhizobium-legume mutualistic association is universally known and it is indispensable to the growth of the crop. Likewise numerous crops have endotrophic mycorrhiza association (Versicular-arbuscular-mycorrhiza (VAM)) which enhances the growth and yield of the crops. The fungal partner provides the crop principally with phosphorus. For example tomato plants inoculated with VAM fungi, Acaulospora laevis, Gigaspora gigantea and Gigaspora margarita yielded the respective vegetable dry weights of 13.3, 18.2 and 82.3 mg compared with a dry weight of only 6.9 mg of uninoculated plants, 7 weeks after inoculation (Fairweather and Parbery,1982).

Of far greater distribution and occurrence are the fungi and bacteria which occupy the surfaces of practically all organs of plants with varied consequences. Some are beneficial to the plant and some are not. These surface flora are encouraged and sustained by exudates of the organs. The exudates of aerial organs have been less studied than those of the subterranean organs. The subject of root exudates and mechanisms affecting root exudation

has been extensively reviewed in the last three decades (Hale et al., 1971; Hale and Moore, 1979; Rovira, 1969). According to Hale et al., (1971) both leakage and secretion have significant role in the release of root exudates.

It is almost a century ago that Hiltner (1904) first observed that micro-organisms were more abundant in soil near plant roots than in distant soil. His observation has stimulated numerous studies of this phenomenon and the existence of a rhizosphere or zone of root influence has become fully established. The rhizosphere varies in thickness with the kind of root and the nature and moisture conditions of the soil.

The products excreted by the roots of plants growing under aseptic conditions have been widely studied and the recorded compounds include amino acids, auxins, carbohydrates, enzymes, flavones, growth factors, nucleic acid derivatives and organic acid (Bhuvaneswari and Subba-Rao, 1957; Bhuvaneswari and Sulochana, 1955; Buxton, 1962; Kartznelson et al., 1955; Lundegardh and Stenlid, 1944; Riviere, 1959; 1960; Rovira, 1956; 1969; Rovira and Harris, 1961; Schroth and Snyder, 1961; Slankis, 1958; Sulochana, 1962 etc.).

Incidentally, Kalyanasundaram (1958) and Rovira (1959) identified amino acids such as α-alanine, Glutamic acid, Aspartic acid, Cystine/Cysteine, Glycine and Tyrosine in tomato root exudate. Melin and Rama Das (1954) also identified 'M' factor and Rovira and Harris (1961) found biotin, Pantothenate and Niacin in the tomato root exudate.

Among the microflora, the bacteria are the most abundant group in the rhizosphere and have apparently received the greatest attention. The Gram-negative, non-sporing, rod shaped bacteria predominate whereas Gram-positive non-sporing rods, pleomorphic rods and cocci are relatively less abundant (Lockhead, 1940; Rangaswani and Vasantharajan, 1962; Rouatt and Kartznelson, 1961; Sperber and Rovira, 1959; Vagnerova et al., 1960 a & b). The rhizosphere bacterial density is enormous. Viable plate counts often exceeded 10^9 per gram of soil (Rouatt and Kartznelson, 1961). The bacteria may cover up to 10 per cent of the root area (Rovira et al., 1974). An extensive report on the rhizosphere Actinomycetes by Venkatesan (1962) showed that aerobic, biochemically active, late-sporing and pigmented types and those requiring amino acids and vitamins were abundant in the rhizosphere.

There are similar reports relating to the physiology of rhizosphere fungi. Thrower (1954) found higher percentages of fungi capable of maximal growth in simple and in amino-acid supplemented media in rhizosphere than in non-rhizosphere soil, and lower proportions of those requiring more complex substances. Generally, there is always greater fungal population in the root zone than in the root-free soil (eg. Ebben, 1959; Goos and Timonin, 1962; Papavisas and Davey, 1961; Parkinson and Clarke, 1961 etc.).

There has been sustained interest in the rhizosphere phenomenon because the interaction between the plant and

the micro-organisms has a considerable significance for crop production and soil fertility. The plant roots create a unique subterranean habitat for the micro-orangnisms. The plant in turn is markedly affected by the populations it has stimulated around itself since the root is the site for the absorption of inorganic nutrients and through which many pathogens penetrate. The rhizosphere community may have, in the final analysis, either a favourable or a detrimental influence on plant development.

The rhizosphere microflora may favour plant development by various means. A high percentage of rhizosphere and rhizoplane bacteria is able to degrade organic phosphorus substrates making phosphorus available to the plant (Estermann and McLaren, 1961; Szember, 1960). Subba-Rao and Bajpai (1965) also found that the bacteria Bacillus megaterim, Bacillus circulans and fungal species belonging to the genera Alternaria, Aspergillus and Penicillium present on root nodules could solubilise phosphates.

Furthermore, deamination of nitrogenous compounds by the large rhizosphere bacterial population would liberate ammonia for the plants use. The process of the formation of root nodules by legumes has been fully worked out. The pre-penetration phase is characterised by an amazing interaction between the root and the bacteria in the rhizosphere. The process is triggered off by vitamin B_1 in the root exudate which stimulates growth of the Rhizobium population in the rhizosphere. The interaction can only

proceed when the Rhizobium cells convert Tryptophan in the exudate to Indole Acetic Acid and its slime polysaccharide stimulates the production of the enzyme Polygalacturonase by the legume root cells.

The microflora produce organic compounds such as amino acids, auxins, growth factors and vitamins which may exert great influence at the early stages of growth of the plant. An increased plant growth due to the production of auxin by soil organisms has been reported by McManus (1960) and Rishbeth (1957) and increased root hair development and mineral nutrient-transport induced by microbial substances have been demonstrated by Audus (1959) and Pecket (1960).

The activities of pathogens may be suppressed in two ways. First, the exudate may be inhibitory to the pathogen (Buxton, 1957b; 1962). Secondly, intense biological interactions among the flora of the rhizosphere may lead to the elimination or suppression of the pathogen through either parasitism, competition or antibiosis.

The harmful effect of some members of rhizosphere population could equally be considerable. Some organisms produce auxins which at very high concentrations retard root growth (Audus, 1959; Brian, 1957; Kartznelson and Sirois, 1961; McManus, 1960).

Root exudates stimulate germination of spores of plant fungal parasites and encourage the growth of both bacterial and fungal parasites while zoospores of zoosporic pathogenic fungi are strongly attracted to roots in response to particular compounds in the exudates.

Furthermore components of the exudates induce positive chemo-tropism in the germ-tubes of these fungi, thereby enhancing infection.

Some of these micro-organisms produce antibiotics and toxic compounds which suppress seed germination (Narain and Prakash, 1968; Leelavathy, 1969a & b) and cause malformations in, and retard growth of plant roots (Bowen and Rovira, 1981; Curtis, 1958 a & b).

In addition to root exudates, plant roots secrete root mucilage with clearly distinctive characteristics different from root exudates. Root mucilage can be classified into two types on the basis of their locations on the roots. The first is secreted by the outer root-cap cells and so referred to as 'root cap mucilage'. The second is a firm mucilaginous layer covering the epidermal cells and root hairs and called 'epidermal mucilage'. In addition to polysaccharides or their sugar residues (fructose, galactose, glucose, xylose etc.) other compounds have been detected in root mucilages. These include enzymes such as acid phosphatase (Felipe et al., 1979), esterase (Smith and O'Brien, 1979) and lecthins (Kato et al., 1981).

The mucilage population plays the same roles as rhizosphere population. According to Pauli (1980) the mucilage is a favourable matrix for the development of complex biological communities. According to various reviews (Chaboud and Rougier, 1984; Rougier and Chaboud,1985; Oades, 1978 etc) the mucilage has other

unique functions. The most important are reduction of friction between the growing root tips and the soil, protection of the root from desiccation and improvement of root-soil contact which facilitates nutrient diffusion to the roots. As mucilage is active in ion absorption it may exert some selectivity in the uptake of ions by plants (Rovira et al.,1983). The binding capacity of the mucilage may serve as a protective function. Thus it is able to immobilise certain toxic ions (Clarkson and Sanderson, 1969) and to retard the penetration of heavy metal cations towards the apical meristem (Barlow, 1975; Drew, 1979).

Because of the numerous roles played by microflora on surfaces of plant organs, the study of the population on plants is important in any investigation concerned with growth and productivity of plants. There are few reports on the microflora of the four vegetables studied in the present project.

Maude et al., (1983) found that Penicillium species and Aspergillus fumigatus were dominant on onion leaf surfaces followed by Aspergillus niger.

Sinha (1965) isolated a total of 55 species of fungi and bacteria from surfaces of leaves of pepper. The bacterium Actinomycetes sp. and the fungi Alternaria solani, Aspergillus niger, Cunninghamella sp, Curvularia siddiquii, Fusarium moniliforme, Fusidium sp., Mucor hiemalis and Penicillium janthinellum were present throughout the growing season. An Alternaria species and Cladosporium herbarum were confined to periods of

moderately cold and cold weather. Others, including an Actinomyces species and Alternaria tenuissinia, an Aspergillus species, Aspergillus flavus, Cladosporium cladosporioides, Heterosporium sp, Papulospora sp, Rhizopus nigricans and Trichoderma koningi occurred in abundance at one time or the other.

Preece and Dickinson (1971) and Sinha (1965) isolated different micro-organisms from the surface of tomato leaves at different times of the growing period. Alternaria solani, Alternaria tenuissinia, Aspergillus flavus, Aspergillus niger, Cladosporium cladosporioides, Fusarium moniliforme, Mucor, Spicaria and Streptomyces sp. were present throughout the growing season. Actinomyces sp., Aspergillus sp., Choanephora, Cladosporium herbarum, Curvularia siddiquii, Papulospora, Penicillium species, Penicillium ianthinellum, Sporotrichum and Trichoderma koningi were common in cooler weather. During this period Cladosporium herbarum was the most abundant. During warm periods Alternaria tenuissinia was the most abundant species.

An exhaustive search through literature revealed that no detailed study has ever been made in West Africa to establish the identity of the mycoflora of growing okra, onion, pepper and tomato plants, their possible succession and factors determining their occurrence and succession. Besides, the mycoflora of the products of these crops after harvest has hitherto received limited attention. The work described in this thesis was undertaken to provide the

relevant information that would be useful to plant cultivators in the Accra region, and, in particular, Legon.

MATERIALS AND GENERAL METHODS

(i) MATERIALS

A. Vegetables

Plant materials of the four vegetables used in this investigation were obtained from Crops Science Department of the University and Ghana Seed Company. They consisted of the Local and Clemson Spineless varieties of okra (Abelmoschus esculentus L.), the Red Creole and Texas Grano varieties of onion (Allium cepa L.), Long -shaped variety of pepper (Capsicum annuum L.),and the Heinz, Roma and Wosowoso varieties of tomatoes (Lycopersicon esculentum Mill.)

Each variety was raised on two beds on the Experimental Plot of the teaching garden of the Botany Department.The beds varied in size to suit the growth habits of the respective plants :

Okra bed :6.0X6.0m,

Onion bed :6.0X1.0m,

Pepper bed :6.0X3.0m,

Tomato bed :6.0X6.0m.

The beds were randomised and all plants received similar amounts of inorganic fertilizer.

Some of the varieties being raised at two other sites were included in some of the studies. One of the sites was the Research farm of the Faculty of Agriculture of the University, situated two kilometers north-west of the Botany Department. The other is a vegetable farm, also two kilometers, north-east of the Botany Department. All the plants therefore grew under the same climatic conditions.

B. Fungal Isolates

Some of the fungi isolated from the okra, onion, pepper and tomato test plants raised at the Botany Department were used in pathogenicity, spore germination and vegetative growth tests. The fungi used were Alternaria solani, Aspergillus clavatus, Aspergillus flavus, Aspergillus glaucus, Aspergillus niger, Aspergillus terreus, Cladosporium herbarum, Corynespora casiicola sp., Curvularia lunata, Fusarium oxysporum, Fusarium sp., Helminthosporium sp., Nigrospora oryzae, Penicillium citrinum, Penicillium funiculosum, Scopulariopsis brevicaulis, Syncephalastrum racemosus, Trichoderma viride and Trichothecium roseum.

The isolates were maintained on Potato Dextrose Agar slants in McCartney tubes at room temperature and sub-cultured fortnightly.

C. Inorganic Fertilizer

The inorganic fertilizer, 15:15:15 NPK + Ammonium Sulphate was used. An amount of 12g was applied to the soil at the base of each plant.

(ii) GENERAL METHODS

A. Raising of the Crops

The seeds were surface sterilized by immersing them in 5 per cent sodium hypochlorite solution for 10 minutes and rinsed in sterile distilled water. They were sowed in sterile soil in seed pots 25cm in diameter and 6cm deep. The seeds and later the seedlings were watered daily with sterile distilled water until the 35th day after germination.

Healthy young plants of the vegetables were then transplanted on to their respective plots. Okra, pepper and tomato were planted at a spacing of 25 X 25cm and onion at a spacing of 10X10cm. For each tomato variety, the plants on one bed were staked while those on the other bed were unstaked.

The plants were watered everyday using a water hose, and were fully exposed to sunlight. A portion of the experimental plot was left fallow and the soil mycoflora of that area was used as a control in tests which examined the effect of onion bulb and roots especially on the soil mycoflora.

B. Maintenance of constant Relative humidities

Glycerol solutions of different concentrations were used according to the data of Johnson (1940) (Table 2) to provide and maintain different atmospheric relative humidities from zero to 95% RH. A saturated atmosphere, 100% RH, was maintained with distilled water.

C. Humidity Chambers

(i) Polyethylene hoods

Thick transparent polyethylene bags drapped over wooden rectangular frames (35 X 30 X 26 cm) served as one of the humidity chambers in this study. Standard glycerol: water mixture which provided an Equilibrium Relative Humidity of 85% was put in an open large Petri dish (12.5cm diameter) placed inside the humidity chamber. The bags were made air- tight by stapling the opening.

(ii) Transparent Plastic Boxes

Transparent plastic boxes (21.5cm long, 10.5cm wide and 7.5cm

Table 2: Maintenance of Atmospheric Humidities with Glycerol-Water mixtures (Data of Johnson, C.G. 1940).

% RH	% Weight Glycerol	Specific Gravity	Water V.P (mm)
0.0	100.0	1.261	-
1.7	98.0	1.256	0.4
16.9	92.0	1.240	4.0
33.8	83.0	1.215	8.0
44.3	75.0	1.194	10.5
62.4	60.0	1.153	14.8
73.4	50.0	1.126	17.4
85.2	35.0	1.085	20.2
92.8	25.0	1.059	22.0
97.0	15.5	1.036	23.0
100.0	0.0	0.998	23.7

deep) with tightly fitting lids sealed air-tight with vaseline were also used as humidity chambers. These were used mainly in conidial germination tests. Glass slides with dry spores were supported by solid watch glasses above 4mm.deep humidity - maintaining fluid at the bottom of the boxes. The plastic chambers proved very convenient since very little condensation occurred when the relative humidity was maintained at 100% R.H.

(iii) Desiccators

Desiccators were also used as humidity chambers in tests determining moisture sorption isotherm of dry okra fruit chips and pepper fruits. The glycerol: water mixture was poured into the well of the desiccator to a depth of 3.0 cm.

D. Buffer solution

The pH of media was adjusted, when required, by adding Buffer solutions. Buffer solutions were prepared according to the data provided by Hale (1958) as shown in Tables 3 and 4. The pH of all adjusted media were checked with Glass electrode pH meter (HM-60s).

E. Solar Drier

A Solar Drier was used to dry okra fruit chips and whole pepper fruits. The solar drier protected the samples from dust, rain and minimised bacterial and fungal contamination. It consisted of a 15 cm deep wooden tray, 150 X 70 cm, with a polyethylene gable roof and supported by 58 cm high legs.

TABLE 3: Citric acid: Na_2HPO_4 (McIlvaine Buffer Standards) for providing pH 2.2 to 8.0.
Stock Solution A: 0.1 M Citric acid; ($C_6H_8O_7$).
Stock Solution B: 0.2 M Disodium hydrogen orthophosphate (Na_2HPO_4) (Hale, 1958).

pH	Solution A (ml)	Solution B (ml)
2.2	490.0	10.0
3.0	397.3	102.7
4.0	307.3	192.7
5.0	242.3	257.5
6.0	184.3	315.7
7.0	88.3	411.7
8.0	13.8	486.2

TABLE 4: Clark and Lub's Buffer standards for providing pH 8 to 10
Stock Solution A: 0.2 M Boric Acid + 0.2M Potassium chloride. Stock Solution B: 0.2 M Sodium Hydroxide (Hale, 1958)

pH	Solution A (ml)	Solution B (ml)	Deionised Water (ml)
8.0	50	4.0	146.0
9.0	50	21.4	128.6
10.0	50	43.9	106.1

F. Culture Media

All chemicals used in the preparation of the media were of either 'Analar' grade or of the B.D.H. (British Drug House).

(i) Water Agar

Agar	12.0g
Distilled Water	1000ml

(ii) Potato dextrose broth (PDB)

Irish potato	200g
Dextrose	20.0g
Distilled water	1000ml

To prepare the medium, 200g of peeled tuber cut into pieces was boiled in 500 ml distilled water. The extract was strained with muslin cloth, made up to 1000 ml and 20 g dextrose added.

(iii) Sweet potato dextrose broth

Sweet potato	200g
Dextrose	20.0g
Distilled water	1000 ml

(Prepared as in PDB)

(iv) Pawpaw extract broth

Unripened pawpaw fruit flesh	200g
Distilled water	1000ml

(Prepared as in PDB)

(v) Cassava dextrose broth

Cassava	200g
Dextrose	20.0g
Distilled water	1000ml

(Prepared as in PDB)

(vi) Glucose agar

Dextrose	200.0g
Distilled water	1000ml
Agar	12.0g

(vii) Yeast Extract Medium

Yeast extract	3.0g
Peptone	10.0g
Distilled water	1000ml

(viii) Basic Culture medium (Halm, 1971)

D L-Asparagine	2.0g
Glucose (Dextrose)	30.0g
Magnesium sulphate ($MgSO_4.7H_2O$	0.5g
*Mineral solution	1.0ml
Potassium dihydrogen Phosphate (KH_2PO_4)	1.0g
Distilled water	1000ml

*Mineral solution

Copper sulphate ($CuSO_4.5H_2O$)	0.4g
Sodium Borate ($NaB_4O_7.2H_2O$)	0.04g
Ferrous Phosphate ($FePO_4.2H_2O$)	0.8g

Magnesium Sulphate ($MgSO_4.5H_2O$) 0.8g

Sodium Molybdate ($Na_2MoO_4.2H_2O$) 0.08g

Zinc sulphate ($ZnSO_4.7H_2O$) 0.8g

Distilled water 1000ml

(ix) Plate Count Agar (PCA) Oxoid 325

PCA 17.5g

Distilled water 1000ml

(x) Oxytetracycline Glucose Yeast Extract (OGYE)

OGYE 37.0g

Distilled water 1000ml

Freeze dried oxytetracycline (oxoid SR 73) in 10 ml sterile distilled water.

Yeast Dextrose agar

Yeast extract 5.0g

Dextrose 20.0g

Biotin 0.0001g

Agar 12.0g

(xi) Modified Cooke's Medium (Cooke, 1954)

Dextrose 10.0g

Peptone 5.0g

KH_2PO_4 . . . . . 1.0g

$MgSO_4.7H_2O$ 0.5g

Rose Bengal 0.03g

Streptomycin 0.35µg

Agar 12.0g

Distilled water 1000ml

(xii) Malt Extract Agar

Malt extract 15.0g

Agar 12.0g

Distilled water 1000ml

(xiii) Nutrient Agar

Nutrient agar 28.0g

Distilled water 1000ml

(xiv) V-8 Broth

V-8 juice. 200.0ml

Distilled water 1000g

(Suspension was filtered using cotton wool and pH adjusted to pH 6.5)

G. Preparation of tomato and pepper fruit and onion bulb extracts

Different weights, 500g of tomato fruits ,50g of pepper fruits and 100g of onion bulbs were blended using a Manullete blender in 250ml, 250ml and 50ml of sterile distilled water, respectively. Each was then filtered through clean absorbent cotton wool and next with filter paper sing Compton Vacuum pump (351vm). The filtrate was then centrifuged at 400g for 20 minutes in a Hitachi Table -top centrifuge (SCT5BA). The supernatant liquid obtained was the stock solution. Various dilutions were prepared from the stock filtrate as desired.

H. Isolation of fungal pathogens.

The infected fruits were surface sterilized by immersing in 5 percent sodium hypochlorite solution for 5 minutes and rinsing in sterile distilled water. The mesocarp tissue at the edge of the rot was cut into 2 X 2 X 2mm cubes and five cubes were placed equidistantly on a Petri-plate containing a few drops of streptomycin solution to inhibit bacterial growth. Five Petri-plates were used for each exercise. They were incubated at 28^{0}C for 5days.

The fungal pathogens which grew out of the mesocarp pieces were isolated, subcultured and incubated at 28^{0}C in MaCartney tubes containing Potato Dextrose Agar slants. They were stored in a refrigerator and sub-cultured fortnightly.

I. Air -spora trapping

The plate exposure method was used to make a monthly estimate of the level of airspora. Petri plates of oxytetracycline glucose yeast extract-agar (OGYE) were exposed on 100cm-high laboratory stools at the centres of the experimental plot at the Botany Department, University farm and the Private farm for 15 minutes. The plates were then incubated at 28^{0}C.

The colonies which appeared on the plates were counted on the 4th day of incubation, and the species identified on the 7th day.

J. Isolation of plant- surface fungi

Fungi were isolated from the surfaces of the fruits and leaves of okra, pepper and tomato and from aerial leaves and scale leaves of the bulbs of onion.For each determination, 200-250g of fruits or 10g of

leaves were washed in 100ml of sterile distilled water. The washing was subsequently shaken for 30 minutes in Gallenkamp orbital- shaker at 140 revolutions per minute and dilutions of this stock were prepared. An aliquot of 1.0ml of the selected dilution was put in a sterile Petri dish and a 20ml of cool OGYE added. The plates were incubated at 28^0C and the fungal colonies counted and identified after 7days.

K. Isolation of soil fungi

A cork borer ($\frac{1}{2}$ cm in diameter) was used in sampling the soil at 5cm and 10 cm depths on the farm monthly. The soil samples were pooled together and 10g was stirred in 100 ml of sterile distilled water and the mixture shaken vigorously to obtain an evenly dispersed suspension. One milliliter aliquots of the diluents (up to $1:10^{-5}$) were plated in 15 ml of cool (40^0C) molten Cooke's medium. Three replicates were prepared for each sample. The plates were incubated at 28^0C. Fungal colony counts were made after 3 days. The total colony of fungi was estimated as CFU g^{-1} sample. The fungi were identified after 7 days incubation.

L. Spore germination tests

The glass slide method was used in the spore germination tests. The spore suspension of standard density of 10^6 to 10^7 spores per ml was prepared on each occasion with the respective medium. Two separate drops delivered with a micropipette onto a cooled flame sterilized slide, and the slide placed with the suspension drop slide facing upwards on a solid watch glass (3.7 X 3.7 X 1.6 cm) standing in the plastic humidity chamber with an internal atmosphere of 100% RH.

Three slides were withdrawn at 2-hour intervals and examined for germinating spores. Those which could not be examined immediately were

kept in the refrigerator at 4^0C after adding a drop of 5% formalin solution to each suspension drop to arrest germination and growth until observations could be made.

Percentage germination for each treatment was based on not less than 400 observed conidia from all the six suspension drops. The mean length of germ tubes of 40 germinated conidia was also determined. A conidium was regarded as having germinated if it showed a discernible germ tube.

M. Methods of sterilization

All media, distilled water and MaCartney tubes were sterilized by autoclaving for 20 minutes at 1.1 kg/cm^3 (121^0C) steam pressure. Cotton wool plugs were temporarily covered with cellophane to prevent the penetration of any condensed water during autoclaving. Pipettes were wrapped in aluminium foil or cellophane, put in a canister and sterilized by autoclaving.

Clean glass slides and cover slips were kept in 90% ethanol and flame-sterilized just before use. Petri dishes and soils were sterilized by heating at 100^0C for 12 hours in an electrically heated oven (Townson and Merler Ltd).

Dissecting blades, cork borers and inoculating needles were cleaned with 90 per cent ethanol and sterilized by heating in the flame of a spirit lamp.

Tomato, okra and pepper fruits were surface-sterilized by immersing the fruits for 5 minutes in a 5 per cent sodium hypochlorite solution and then rinsing in three changes of sterile distilled water. The inoculation room was sterilized by spraying with 5% dettol solution for 10 minutes before it was used.

N. Incubation

Incubation conditions varied with the experiments and are described in appropriate places in the text.

O. Measurement of light intensity

Light intensity was measured with a photometer (Cassela, England).

P. Measurement of pH

The pH of all culture media, and filtrates and germination media were measured with a Glass electrode pH meter (TOA, HM 605).

Q. Moisture content determination

Moisture content of pepper (whole and flour), okra (chips and flour) and soil was determined using the oven-dry method. Individual pre-weighed Petri-dishes each containing 10 g of the sample were kept at 75^{0}C in an electrically heated oven for 24 hours and then re-weighed after cooling in a desiccator. The loss in weight represented the moisture content of the sample.

R. Statistical analysis

Experimental results, where necessary, were analysed statistically and the results are quoted at 5 per cent level of significance.

S. Experimental Precautions

1. Glassware were kept scrupulously clean. Glassware which had already been cleaned with detergents were thoroughly

rinsed several times with tap water and in three changes of distilled water and allowed to drain dry before use.

2. Disks of filter paper carrying oven-dried mycelia were conveyed from the oven to the balance room in a closed desiccator to avoid absorption of moisture.
3. For each fungus, conidia of approximately the same age were used in all experiments.
4. The density of conidial suspension was standardized 10^6 to 10^7 spores per ml of suspension medium, for all tests.
5. In the spore germination tests using the slide method, all the suspension drops of each treatment were examined and used in the determination of percentage germination.
6. As far as could be determined, fruits of the same age were used in the various experiments for each crop.
7. Soil samples collected from the farm were immediately put in polyethylene bags to prevent contamination.
8. In the pathogenicity experiments, except in those investigating the effect of relative humidity, the lids of the plastic containers were removed for a few seconds each morning to let off any gases which might have accumulated in the chambers.
9. When aqueous glycerol solution was used to maintain relative humidities, these were thoroughly shaken on preparation to ensure homogenous mixtures. Stock preparations were kept in tightly sealed glass bottles.

EXPERIMENTAL DETAILS

A. ENVIRONMENTAL CONDITIONS DURING GROWTH OF THE VEGETABLES

Infection of plants by pathogens and the establishment of plant surface mycoflora are influenced by many factors. Many of the factors do not only affect the establishment of the fungi but also influence the dispersal of the propagules. Often the optimum of a particular factor for the different phases of colonization may be different. It could be different in respect of germination of propagules, growth of the germ tube and perhaps different in respect of colonization of the plant and sporulation. Thus the germination of uredospores of Puccinia graminis var tritici on wheat leaves requires darkness and surface wetness and occurs over a wide range of temperatures whereas penetration of the leaf requires light and a slightly higher temperature than is needed for germination. Infection of wheat leaves, therefore, was caused in the morning with incident light and rising temperature by uredospores which had germinated in the preceding night in dew droplets on the leaves (Burrage, 1970).

These environmental factors may also affect the resistance of the plant by influencing plant vigour. But the effect cannot be predicted because experiments on disease susceptibility in relation to plant vigour have given conflicting results. Tapke (1951), for example, reported a positive correlation between the two factors in barley attacked by the powdery mildew, Erysiphe graminis, whereas Trelease and Trelease (1928) found no such correlation with the same pathogen on wheat. Each fungus-host plant interaction must be related to the specific environmental conditions under which it occurs. The climatic conditions were, therefore, recorded throughout the two periods of

cultivation of the four vegetables at Legon.

Record of the rainfall was provided by the Meteorological Station at the University Farm, while atmospheric relative humidity, air temperature and soil temperature were measured in the Experimental Plot at the Botany Department.

B GROWTH AND YIELD OF THE FOUR VEGETABLES IN THE TWO GROWING PERIODS

The environmental conditions could be different in the two periods, November to February, and June to August, each year in which the crops were raised. The former occurred in the harmattan season and the latter in the rainy season. The growth and yield of the plants under these two extreme conditions were studied.

Plants of the three varieties of tomato were either staked or not staked. There were 40 plants for each treatment. The fruits were harvested 80 days after transplanting. The following details were recorded: (a) the number of leaves on a plant; (b) the total number of fruits on each plant and (c) the number of cracked fruits on each plant.

The two varieties of onions, Red Creole and Texas Grano, received either organic manure or a combination of inorganic fertilizer and organic manure. There were 250 plants for each treatment. The bulbs were harvested 95 days after transplanting and the number of bulbs per treatment was recorded.

The two varieties of okra and single pepper variety used were harvested 60 days after sowing the okra seeds and 45 days after transplanting the pepper seedlings. The number of leaves per plant,

the number of fruits per plant and the number of pepper fruits showing obvious bird damage, were recorded.

C AIRSPORA OF THE EXPERIMENTAL PLOT

The dispersal of the fungal spores by air is very well known and numerous investigations have been reported in the relevant literature. These studies have led to good understanding of fungal spore transport and deposition. Such information is particularly valuable in investigations of diseased crops.

Most of the fungi which grow on plants, whether as pathogens or as epiphytes, originate from air-borne spores. Deposition may occur by a number of methods, eg. impaction, sedimentation, turbulent deposition and electrostatic deposition (Gregory, 1950; 1951; Gregory and Stedman, 1953). Any study of the mycoflora of a standing crop must consider as well the airspora from which most derive.

Close correlation, it must be pointed out, does not always occur, because infection in the final analysis, may be influenced by both the infective capacity (energy for growth) of the inoculum arriving by air and the environmental conditions under which it is operating. The most interesting problem connected with the infectivity of fungal spores is raised by the observation that an inoculum of more than one spore is almost always required to secure infection at 50 per cent of the inoculation sites ie $ED_{50}>1$. Leach (1955) and later Waistie (1962) found that the minimum effective dosage of conidia of Botrytis fabae for infection of bean (Vicia faba L.) was three or four spores. Thus, there would be less infection spots than the number of spores in the atmosphere. Furthermore, some of the spores in the air may not be

6deposited at the natural infection site and would be wasted (Brooks, 1965).

The airspora was studied at monthly intervals by trapping the fungi on exposed Oxytetracycline glucose yeast extract agar (OGYE) plates. Fungal species which appeared on the agar plates after incubation were identified and the frequency of occurrence of each species calculated.

D. FUNGAL INFECTION OF THE LEAVES OF THE PEPPER AND TOMATO

In intensive agricultural systems, there is the need for regular crop inspection and systematic disease surveys. In this way, the progress of the disease could be followed and the magnitude of possible losses could be more or less accurately forecast.

Disease assessment keys have been constructed for many pathogens and their use for particular diseases has been standardized to ensure that assessments may be compared (Dickinson and Lucas, 1982). Such assessment keys do not exist for okra, onion, pepper and tomato for the West African sub-region. To provide pertinent information, the development of leaf diseases of the four vegetables with time was studied over the entire period of cultivation. Disease development was studied by counting infected leaves and determining the infection rate, that is, percentage of the total number of leaves, at 10 days intervals. A leaf with a discernible diseased spot was counted as diseased, without distinguishing between the size of the spots nor the causal fungi of the spot. The Infection rate was determined for each variety of each crop in the two growing periods.

E. FRUCTIPLANE FUNGI OF OKRA, PEPPER AND TOMATO

Fungal diseases also take a heavy toll on fruits of crops at different stages of development in the field. Fruit rot is a serious production problem under the warm moist conditions of the tropics. In tomato, most of the damage occurs when fruits lying on, or near the soil begin to ripe (Barksdale, 1968; Batson, 1973).

As in the study of the development of the leaf diseases described in the previous experiment, all the fruits were examined at monthly intervals, counted and the number showing infection was recorded. Infection rate was then determined with these values, for each variety of each crop, in the two growth periods.

F. PHYLLOPLANE FUNGI OF OKRA, PEPPER, TOMATO AND ONION

The surfaces of the leaves and fruits would naturally collect the airspora recorded in Experiment C. The successful establishment on the surfaces, whether as saprophytes, which is the case in the majority of them (Last, 1955a; Sinha, 1965) or even as hyperparasites (McKenzie and Hudson, 1976), depends on three main factors namely the nature of the exudate from the plant organs (Tukey, 1971), antibiosis among the colonizing species (Warren, 1972) and the prevailing climatic conditions (Gregory, 1950; Hirst and Stedman, 1963; Sinha, 1965). The mycoflora populations of the crops could portray some specificity according to the interaction of these three factors. Any possible specificity in fungal populations on the plants was investigated.

The populations of the filamentous fungi and of the yeasts were determined at monthly intervals during the growth periods. The species

of filamentous fungi were also identified and the frequency of occurrence of each species determined.

G. SOIL AND RHIZOSPHERE FUNGAL POPULATIONS

The fungal species present in the soil and in the rhizosphere of the crops were also investigated. Rhizosphere populations of different plant species and even different varieties of the same species in the same area often do not contain the same species nor identical levels of a population of a particular microbial species (Buxton, 1957a; Parkinson et al., 1963; Peterson, 1958). It was expected that this study would, therefore, provide evidence of any possible unique relationship between the fungi and the different crops and the different varieties of a particular crop. The quality and quantity of the rhizosphere flora could have affected the growth of the plants recorded in section B.

At sampling time, non-rhizosphere soil was collected by removing 5 cm long core of soil with a sterile No. 6 cork borer (1 cm diameter) from the root free region in the plot of each crop. Two batches of cores were removed, one to a depth of 5 cm and the other from 5-10 cm deep. Plugs of soil samples from the plots of each treatment were pooled, pulverised and thoroughly mixed and the fungal population estimated by the soil dilution plate method.

Rhizosphere soil for estimation of the fungal population, by the soil dilution plate method, was collected, without uprooting the plants. First the soil was carefully dug close to the plant to expose some of the large branch roots. The large roots were excised and carefully lifted to preserve as much of the branchlets as possible. Excess soil was removed from the rootlets by gently shaking

them. The closely adhering soil remaining on the roots which constituted the rhizosphere soil was collected by vigorous shaking of the rootlets in a sterile empty 100 ml Erlenmeyer flask. The rhizosphere soil from five plants were pooled, pulverised and thoroughly mixed.

In the case of the onion plants the study was only on the fungi inhabiting the surface of the bulbs. There were three replicate Petri plates for each treatment.

H. FUNGAL CONTAMINANTS OF OKRA FRUIT CHIPS AND BOILED PEPPER FRUITS DURING DRYING

Harvested fruits of okra and pepper are normally sun-dried before storage. They consequently, become further exposed to the airspora. Maybe the pepper fruits which are dried whole face less danger of contamination than the okra fruits which are cut into pieces while fresh before being laid out to dry. The cut surfaces with the thick coating of mucilage could support considerable fungal growth. The mucilage could be particularly suitable to the 'sugar' fungi. The fungal flora of the drying okra and pepper fruits was studied.

Freshly harvested okra fruits were divided into two lots. One was surface sterilized while the other was not. The fruits of the two batches were then cut into 2 mm thick slices.

Following the normal local practice, ripe pepper fruits were put into boiling water for exactly three minutes and then drained dry. The chips of okra and whole pepper fruits were thinly spread out in separate wooden trays lined with absorbent white paper for drying. Half of each of the treatments, viz.. discs of surface sterilized okra

fruits, discs of non-sterile okra fruits and boiled pepper fruits, were exposed uncovered in the open, while the other half was put in the solar drier until they attained a constant weight. Samples of the products were plated at the end of the drying period and the fungal contaminants identified.

I. MOISTURE SORPTION ISOTHERMS OF DRY PEPPER FRUITS AND OKRA FRUIT CHIPS AND THEIR RESPECTIVE FLOURS

Ambient equilibrium relative humidity (ERH) is an important parameter when considering storage potential as it determines the amount of water available to micro-organisms and hence an indication of the biological activity of a product (Ayerst, 1965). Generally, stored products absorb moisture at humidities above 75 % RH and fungi develop on them during storage. Each produce has its own characteristic balance equilibrium curve between the moisture it contains and the ambient water vapour (Darvey and Elcoate, 1965). This experiment examined the characteristic equilibrium curve at varying ERH's at constant temperature for dried pepper fruits and okra fruit chips of the preceding experiment and flour prepared from them. Their initial percentage moisture content was first determined. Aliquots of 10 g of each product were then put into several oven-dried and pre-weighed Petri dishes and placed in a series of desiccators containing appropriate glycerine solutions which maintained internal humidities of 20 and 85 % RH.

Three Petri dishes were withdrawn after 2, 4, 6, 8, 14, 21, 28 and 35 days to determine percentage moisture content of the products.

J. FUNGAL FLORA OF DRY PEPPER FRUITS AND OKRA FRUIT CHIPS AND THEIR RESPECTIVE FLOURS DURING STORAGE

Having determined the moisture isotherms of the products, it would be easier to interpret fungal contamination on the basis of their moisture content under natural atmospheric humidity conditions. Petri plates containing separately, the four products were kept exposed on the laboratory bench for 35 days. The relative humidity and temperature of the atmosphere of the laboratory were recorded with a thermohydrograph. The fungal flora of each product was estimated at desired intervals by the plating method. There were three replicate plates for each treatment.

K. IRRADIATION TREATMENT OF ONION BULBS

Apart from storage rot, sprouting of onion bulbs during storage is often a problem as has already been mentioned. The possibility of combating both problems with irradiation treatment in the varieties being used was examined.

Bags of 10 bulbs each of both onion varieties were treated with gamma irradiation from ^{60}Co source (Gamma cell 220) at 0.05 and 0.10 Gy dose levels. There were two replicate bags for each treatment. The fungal flora of samples of the bulbs were determined immediately after irradiation. The irradiated bulbs were stored in humidity chambers of 85 % RH, at 30±2 ^{0}C for 6 months after which the fungal load was estimated by the plating method, and the extent of sprouting recorded.

Since irradiation led to a loss of Ascorbic acid (Vitamin C) of plant organs in certain instances (Pamalaks et al., 1958; Romani et al., 1963), the ascorbic acid content of the bulbs before and after

irradiation was also determined.

Ten grammes of bulb tissue was blended in Waring blender in 0.4% oxalic acid solution. The mixture was filtered using Whatman's No. 4 filter paper and the filtrate titrated against 0.04% 2,6-dichlorophenol-indophenol blue dye (Anonymous, 1963) until a faint pink colour that persisted for more than 15 seconds was attained. The total ascorbic acid content of the onion was calculated as mg per 100g (Pearson, 1976).

L. PATHOGENICITY OF FUNGI ISOLATED FROM TOMATO FRUITS

Since the 'skin' of the tomato fruits does not possess any natural opening, the method of penetration by the fungi could be either by a direct penetration or through wounds.

Tests were made to establish the mode of penetration of tomato fruits by the following fungi which were predominant on the fruits: Alternaria tenuis, Aspergillus clavatus, Aspergillus glaucus, Aspergillus terreus, Cladosporium herbarum, Corynespora casiicola, Curvularia lunata, Fusarium oxysporum, Helminthosporium sp., Nigrospora oryzae, Penicillium citrinum, Penicillium funiculosum, Scopulariopsis brevicaulis, Syncephalastrum racemosum and Trichothecium roseum.

Surface sterilized fruits were inoculated by placing inocula of 3 mm of mycelium disc either on the surface or into shallow wounds. Five fruits were inoculated in each case and they were examined for rotting after incubation in polythene hoods for 10 days.

M. GERMINATION OF SPORES IN EXTRACTS OF ONION BULB AND FRUITS OF PEPPER AND TOMATO

The airspora contains predominantly spores. The fate of spores landing in wounds of plants would be, therefore, crucial in the colonization of the plant. The suitability of the extracts of onion bulbs, pepper and tomato fruits as germinating medium for conidia of the predominant fungi was investigated. The conidia of Alternaria tenuis, Aspergillus flavus, Aspergillus niger, Corynespora casiicola, Curvularia lunata, and Fusarium oxysporum and sporangiospores of Syncephalastrum racemosum were incubated in different concentrations of the extracts for varying periods at 30±2 ^{0}C and the percentage germination determined.

The conidia of A. flavus and A. niger were collected from the culture plates by touching the culture surface with a sterile inoculating loop and stirring the conidia in the respective extracts. The suspensions were shaken vigorously for five minutes to disperse the spores.

One centimeter discs of cultures of the remaining fungi were cut with a flamed No. 6 cork borer from sporulating plates. A disc was picked with a flamed pair of fine forceps and dipped into the test medium in a MaCartney tube and gently shaken to dislodge the spores. In this way, the spore suspensions were practically free of hyphal fragments.

The density of the spores were standardized to 500,000 spores per millilitre of suspending medium. Percentage germination was based in each case on a total of 200-300 spores.

N. GROWTH OF CORYNESPORA CASIICOLA (BERK. & CURTIS) C.T.WEI IN NATURAL AND SEMI-SYNTHETIC MEDIA

Because Corynespora casiicola has been reported on many crop plants such as Ananas comosus, Carica papaya, Hevea brasiliensis, Abelmoschus esculentus, Manihot esculenta and Xanthosoma sagittifolium and other plant hosts in Ghana (Hughes, 1952), it was decided to carry out some studies on the growth of this fungus.

The growth habits of this isolate could be compared to that of other isolates studied in other West African countries.

C. casiicola is a pathogen of a large number of plant species including the crops, cotton (Gossypium hirsutum) (Jones, 1961), cowpea (Vigna unguiculata) (Olive et al., 1945; Wei, 1950), cucumber (Cucumis sativus) (Blazquez, 1972), papaya (Carica papaya) (Bird et al., 1966; Melendez and Pinero, 1971), sesame (Sesamum indicum) (Stone and Jones, 1960), Soyabean (Glycine max) (Boosalis and Hamilton, 1957; Olive et al., 1945; Seaman et al., 1965), tobacco (Nicotiana tobacum), (Fajola and Alasoadura, 1973) and tomato (Arny, 1968; Blazquez, 1972; Deighton, 1936; Mohanty and Mohanty, 1955; Simmonds, 1958) and the weeds Aspilia africana, Calapogonium mucunoides, Lepistemon sp. and Synedrella nodiflora (Onesirosan et al., 1974).

C. casiicola was first reported on tomato in the West African sub-region in Sierra Leone by Deighton (1936). Target leaf spot of tomato caused by C. casiicola is a serious disease in Southern Nigeria, particularly during the dry season (Arny, 1968). There is rapid defoliation accompanied by development of lesions on the stems and the fruits.

The first of the several experiments carried out investigated its growth in natural and semi-synthetic media.

The liquid media used were Cassava dextrose broth, Malt extract broth , Pawpaw extract broth, Potato dextrose broth, Sweet Potato dextrose extract broth, Yeast extract medium and V-8 broth. The media were dispensed in aliquot of 30 ml into 250 ml Erlenmeyer flasks and inoculated appropriately. There were 25 flasks of each medium. Five of these were withdrawn at 2-day intervals, the mycelia harvested separately and dried at 80^{0}C for 24 hrs. The mean of the dry weights of each treatment was then calculated. After using the above listed media, another series was set up using extracts of the host plants. Corynespora casiicola was grown in extracts of bulbs of onion and fruits of pepper and tomato, following the same procedure.

O. EFFECTS OF THIAMINE ON GROWTH OF C. CASIICOLA

Many fungi require an external supply of Thiamine or one of its two moieties, pyrimidine and thiazole (Cochrane, 1958; Hawker, 1950; Lilly and Barnett, 1951). Natural plant products used in mycological laboratories usually contain thiamine. This experiment was carried out to verify whether C. casiicola could synthesize its own Thiamine needs or depended on external supply from the natural products of the various media.

A stock of basal medium was prepared and divided into seven equal lots. Thiamine was excluded from one of them which served as control. Thiamine at concentrations of 50, 100, 200, 300, 400 and 500 µg/l respectively was added to the remaining six. Since Thiamine has been found to be unstable when heated in an alkaline medium (Lilly and Barnett, 1951) an aqueous solution of the vitamin was prepared separately, the pH was then adjusted to pH 5 and autoclaved. This was

then added to the sterile basal medium aseptically immediately before inoculation. Each medium was dispensed in 30 ml aliquots into five 250ml Erlenmeyer flasks and inoculated. The inoculated flasks were incubated at 30±2 ^{0}C and the mycelia were harvested after 8 days. They were dried at 80 ^{0}C for 24 hours and their dry weights and mean dry weight for each treatment determined.

P. EFFECT OF TEMPERATURE ON GROWTH OF C. CASIICOLA

Before any further investigations on the growth of C. casiicola were carried out, it was considered necessary to find the effects of two basic factors on its growth, namely, temperature and pH. The considerable growths recorded in the different natural and synthetic media at room temperature (30 ± 2^{0}C) clearly showed that C. casiicola is a mesophile. This experiment was designed to find out whether the temperature of incubation (30 ± 2^{0}C) of that experiment was the optimum or close to the optimum for this fungus.

The range of temperature over which the majority of mesophilic will grow varies to some extent with the various species. The optimum temperature for growth is usually between 20^{0}C and 30^{0}C (Hawker, 1950). Inoculated plates of Pawpaw extract agar, Potato dextrose agar and Sweet potato dextrose agar and their corresponding broths, Pawpaw extract broth and Potato dextrose broth, were incubated at 6, 25, 27, 30 and 35 ^{0}C. Diameters of the cultures on agar plates were measured and dry weights of the cultures of the broths were determined after 4, 6, 8 and 10 days incubation. There were five replicate Petri plates for each agar medium treatment. Similarly, five flasks of each treatment were withdrawn on the days specified for the mycelial dry weight determinations.

Q. EFFECT OF pH ON GROWTH OF C. CASIICOLA

The effect of the pH of the medium was next investigated. Most fungi grow best in slightly acid or neutral media, but the pH range supporting growth altogether is in the majority wide (Hawker, 1950). This range can often be altered by many factors such as type of culture media, type of buffer used and temperature of incubation. The various experiments on growth of C. casiicola which would follow, would involve media, naturally of varying initial pH's. But the addition of buffer or other chemicals to adjust the pH might add substances which could alter the response of the fungus especially in studies investigating the effects of inorganic ions. A knowledge of the optimum pH for growth would enable a critical assessment of the effect of treatment. The basal medium containing 1.0 ml thiamine was prepared at double strength and different pH's were obtained by mixing equal volumes of this and either McIlvaine's or Clark and Lub's buffer solutions (Hale, 1958). The medium was thus simultaneously brought to its normal concentration and the pH adjusted to the desired level. Samples of flasks were withdrawn after autoclaving for the measurement of the initial pH. There were 25, 250ml Erlenmeyer flasks for each pH level. The inoculated flasks were incubated at $30 \pm 2\ ^{0}C$, which was found to be optimal for growth in the preceding experiment.

The mycelia of five flasks of each pH level were harvested after 4,6, 8 and 10 days and their dry weights determined.

R. EFFECT OF LIGHT ON GROWTH OF C.CASIICOLA

Most reports on the effect of light on fungi have been concerned with sporulation and spore discharge rather than vegetative growth.

Reports on the effect of light on fungal vegetative growth in the relevant literature are limited. Light retarded the growth in Sclerotinia fructigena and Karlingle rosea (Cochrane, 1958), Ceratocytis paradoxa (Olutiola and Cole, 1977) and in Aspergillus giganteus (Fienia, 1974). On the other hand, light stimulated growth of Blastocladiella emersonii (Cochrane, 1958). Many fungi are indifferent to light.

The effect of light on vegetative growth of C. casiicola was investigated so that the findings could be applied in the subsequent experiments. There were three light conditions. Continuous light (250 lux) provided by white fluorescent tube, Continuous darkness by keeping the cultures in a dark cupboard, and, normal day/night light conditions. Sweet potato dextrose broth were used in three separate tests. The inoculated flasks were incubated at 30 ± 2^{0}C and five in each set were withdrawn at 2-day intervals for the determination of the mycelia dry weights.

S. EFFECT OF DIFFERENT CARBON SOURCES ON GROWTH OF C. CASIICOLA

The preceding experiment established that the best growth occurred under normal night/day conditions. The optimum temperature of 30^{0}C were adopted for all the subsequent experiments.

The type of carbon source present in a medium or in a host organ determines directly the success in the establishment of the fungus because of its immense structural and functional importance. The carbohydrate preference of C. cassicola was investigated using fructose, galactose, glucose, lactose, maltose, mannose and sucrose in separate media each of a concentration of 1.0 per cent in a basal

liquid medium. Dry weights of mycelia of cultures in five flasks of each treatment withdrawn after 4,6,8 and 10 days incubation were determined.

T. EFFECT OF DIFFERENT CONCENTRATIONS OF GLUCOSE ON GROWTH OF C.CASIICOLA

The previous experiment showed that maltose and galactose were superior to glucose as a carbon source for growth of the fungus. This experiment was set up to find out whether glucose, which is the best carbon source for most fungi (Hawker, 1950), was used at a non-optimal concentration. Growth in C. casiicola was studied again using concentrations of 1.5, 2.0 and 3.0 per cent.

U. INFLUENCE OF NITROGEN SOURCES ON GROWTH OF C. CASIICOLA

Since different nitrogen sources do not support the growth of individual fungal species to the same extent the best nitrogen-source for C. casiicola was next investigated. The compounds tested were Ammonium chloride, Ammonium nitrate, Ammonium sulphate, L-asparagine, L-aspartic acid, Potassium nitrate and Sodium nitrate. Each nitrogen-source was added to a basal medium at a concentration of 0.1 per cent of nitrogen. Five Erlenmeyer flasks of the growing cultures incubated at 30 ± 2^{0}C were withdrawn at 2-day intervals over a period of 10 days for mycelial dry weight determinations.

V. INFLUENCE OF INORGANIC IONS ON GROWTH OF C.CASIICOLA

It is well known that inorganic ions are also important for the growth of fungi. The optimum concentration of each inorganic ion for different fungus species is not the same. This experiment was carried out to define the best concentration of the major inorganic ions for the growth of C. casiicola. The elements studied were calcium, magnesium, phosphorous, potassium and sulphur. The following changes were made in the composition of the basic culture medium to eliminate a particular element as indicated below, in the control medium:

i Calcium: $CaCl_2.2H_2O$ was omitted

ii Magnesium: $NaSO_4$ replaced $MgSO_4.7H_2O$

iii Phosphorous: K_2SO_4 replaced KH_2PO_4 and $FeSO_4.7H_2O$ replaced $FePO_4.2H_2O$

iv Potassium: NaH_2PO_4 replaced KH_2PO_4

v Sulphur: $MgCl_2$, $CuCl_2.2H_2O$ and CH_3COOZn replaced $MgSO_4.7H_2O$, $CuSO_4.5H_2O$ and $ZnSO_4.7H_2O$, respectively.

The various elements were used at three different concentrations. The liquid media were inoculated and incubated at 30 ± 2^0C for 10 days. Five flasks of each treatment were withdrawn at 2-day intervals, the mycelia were harvested and their dry weights determined.

RESULTS

A. CLIMATIC CONDITIONS AT LEGON DURING CULTIVATION OF THE CROPS

There were two growing periods with contrasting climatic conditions in some aspects as shown in Figs. 5,6 and 7. There was only slight rain in the dry season, in the first crop growing period of November, 1988 to February, 1989 while it rained every month in the second crop growing period of May to August, 1989, during the rainy season (Fig. 5). The rains began in March, 1989 and reached a peak in June, 1989.

The mean monthly maximum and minimum atmospheric temperatures are also recorded in Fig. 5. Generally, the drier months, November 1988 to March 1989, had higher temperatures than the wetter months of May to September, 1989.

There was also a night and day temperature fluctuation. There were lower temperatures at dusk and early morning as the records obtained in 1989 or January 26 and 27, February 26 and 27, June 21 and 22 and July 28 and 29, and higher temperatures at day time (Figs 6 and 7). It was detected that the pattern of soil temperatures followed quite closely that of the atmospheric temperature, with the time of peak of soil temperature lagging slightly behind that of the atmospheric temperature. At daytime, between 8.00 a.m and 5.00 p.m, the temperature of the soil was lower than that of the air above the soil, but higher at dusk, 5.00-9.00 p.m. and early morning from 6.00 to 8.00 a.m.

The atmospheric relative humidity on these days showed an inverse relationship with temperature. The humidities were high, between 80 and 100%R.H. in the night and were below 50%R.H. around mid-day in January and February, 1989 (Fig.6) and about 70% RH in June and July, 1989 (Fig.7).

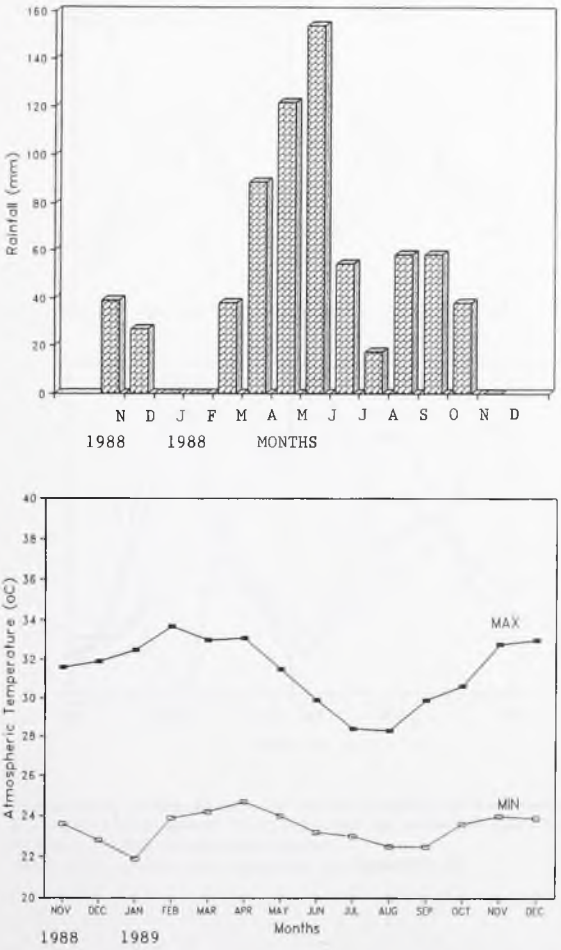


Fig.5 Monthly temperatures and rainfall for the months of November and December, 1988, and January to December, 1989 for Legon.

(Data for histograms and graphs are presented in Appendix A).

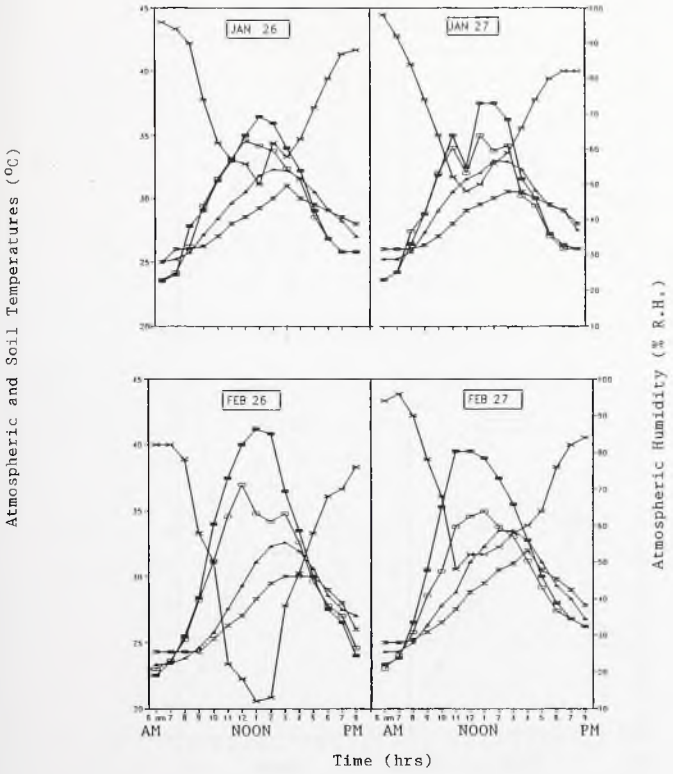


Fig. 6 Atmospheric temperatures, relative humidities and soil temperatures of Legon Experimental Plot recorded on selected days in January and February, 1989 in the dry season.
(Data for graphs are presented in Appendix B)

5 cm Depth — 10 cm Depth — 5 cm Above Soil
10 cm Above Soil — Atmospheric RH

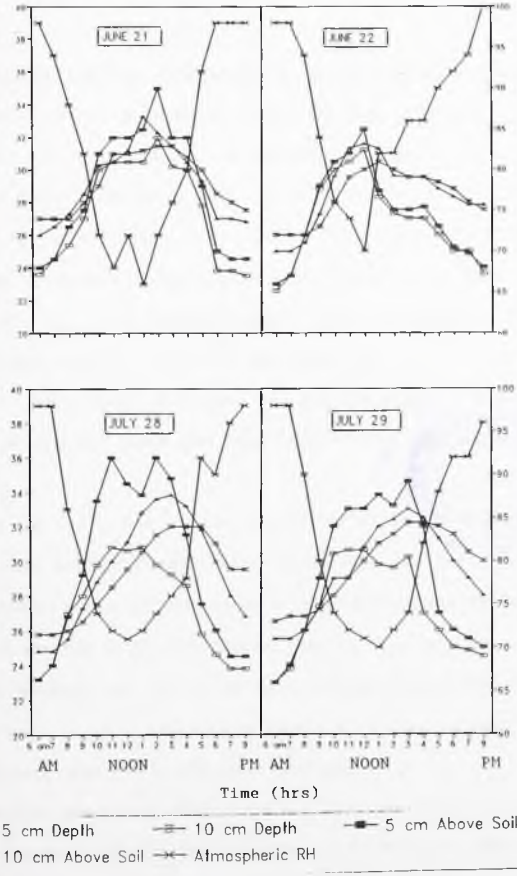


Fig.7 Atmospheric temperatures, relative humidities and soil temperatures of Legon Experimental Plot recorded on selected days in June and July, 1989 in the rainy season.
(Data for graphs are presented in Appendix C).

B. GROWTH AND YIELD OF THE FOUR VEGETABLES IN THE TWO GROWING PERIODS

The yield and loss of the produce through rotting, bird damage or rotting in the dry and rainy seasons are presented in Tables 5 and 6.

The results clearly indicated that the total yields of the three tomato varieties in the dry season (Nov. 1988 - Feb. 1989) were about three times those of plants grown in the rainy season from June to August, 1989 (Table 5). The Wosowoso variety had the highest yield followed by Roma and Heinz in that order for both seasons.

There is no significant difference between the yield of tomato plants that were staked and those that were left prostrate during both seasons.

Cracking of the fruits was associated with varieties and seasons. Wosowoso fruits were most prone and Heinz fruits were least prone to cracking. In Wosowoso where the percentage of fruits which cracked was high, it was much severer in the dry season than in the rainy season. On the other hand Wosowoso was less affected by rotting than any of the other two varieties. In fact, during the season there were no rotted fruits therefore more than 600 fruits were harvested.

Observations on the three other crops are shown in Table 6. The two onion varieties were given either cow dung or Sulphate of ammonia treatments as recommended by Sinnadurai (1970).

The results showed that onion varieties, Red Creole and Texas Grano, cultivated in the dry season generally produced more bulbs than those grown in the rainy season. There was no significant difference between total yield of onions of the two varieties cultivated in the rainy season in soil amended with organic manure only and those in the soil amended with

TABLE 5: Yield of tomato plants grown in the dry and rainy seasons

Time of Planting	Tomato variety	Treatment	Total No of fruits produced by 40 plants	%(Loss) Cracked	%(Loss) Rotted
Nov. 1988–Feb. 1989	Heinz	Staked	235	11.9	3.4
		Unstaked	239	11.3	9.2
	Roma	Staked	352	1.1	7.7
		Unstaked	287	1.4	11.1
	Wosowoso	Staked	680	29.6	0.0
		Unstaked	634	36.3	0.0
June–August 1989	Heinz	Staked	42	0.0	4.8
		Unstaked	34	70.6	20.6
	Roma	Staked	112	1.8	5.4
		Unstaked	100	0.0	13.0
	Wosowoso	Staked	251	15.5	6.0
		Unstaked	207	11.6	3.4

TABLE: 6 Yield of okra, onion and pepper plants grown in the dry and rainy seasons

Time of Planting	Plant and Variety	Fertilizer Treatment	Total No. of bulbs produced by 200 plants	Total No. of fruits produced by 40 plants	%(Loss) Bird Damage	%(Loss) Rotted
Nov. 1988-Feb. 1989	Okra					
	Clemson spineless	-	-	131	-	0
	Local	-	-	103	-	0
	Onion					
	Red Creole	Cowdung	138	-	-	0
		Cowdung + Sulphate of Ammonia	108	-	-	0
	Texas Grano	Cowdung	119	-	-	0
		Cowdung + Sulphate of Ammonia	196	-	-	0
	Pepper	-	-	1442	69.4	2.1
June - August 1989	Okra					
	Clemson spineless	-	-	736	-	0
	Local	-	-	257	-	0
	Onion					
	Red Creole	Cowdung	117	-	-	2.6
		Cowdung+Sulphate of Ammonia	121	-	-	2.5
	Texas Grano	Cowdung	96	-	-	10.4
		Cowdung+Sulphate of Ammonia	110	-	-	3.6
	Pepper	-	-	3394	2.8	3.5

organic manure and inorganic fertilizer. In the dry season, the mixture of cowdung and Sulphate of ammonia fertilizer, however, greatly improved the yield of the Texas Grano variety.

Rotted bulbs were not found in the dry season. Rotting at a low level, was however, observed in all treatments in the rainy season.

Taking all the treatments together, in the rainy season, Texas Grano produced more bulbs while in the dry season it produced few bulbs.

For both varieties of okra, yield was significantly higher in the rainy season than in the dry season (Table 6). Clemson spineless was also more productive than the Local variety. There was no incidence of rot in fruits of both varieties.

Pepper plants yielded more fruits in the rainy season than in the dry season (Table 6). There was, however, significantly higher percentage rot in the rainy season than in the dry season. The fruits greatly attracted birds in the dry season and 69.4 per cent of the fruits was fed on by birds, compared to only 2.8 per cent in the rainy season.

The plants showed greater vegetative growth in the rainy season than in the dry season. Table 7 show the general observations made. The number of leaves on the local variety of okra, pepper and Wosowoso variety of tomato was counted at 20-day intervals after they had been transplanted. The mean number of leaves present by the 120^{th} day on the okra, pepper and tomato plants in the dry season was approximately 33, 40 and 80 per cent respectively, of the number produced in the rainy season.

TABLE: 7 Growth assessed as number of leaves, of okra, onion and tomato plants grown in the dry and rainy seasons

Time of planting	Days after transplanting	Mean No. of leaves per plant (to the nearest whole number)		
		Okra (Local)	Pepper	Tomato (Wosowoso)
Nov. 1988 - Feb. 1989	20	5	12	11
	40	7	25	28
	60	13	216	39
	80	17	484	57
	100	19	843	76
	120	22	721	79
June-Aug. 1989	20	6	15	13
	40	12	35	33
	60	17	241	51
	80	24	842	73
	100	29	1,226	90
	120	36	1,741	103

C. AIRSPORA OF THE EXPERIMENTAL AREAS

Record of airspora for the Experimental Plot, University farm and the Private farm for each month from January, 1989 to December, 1990 are presented in Fig. 8. It was natural to expect variation in levels of the airspora populations. It was surprising however, that the patterns were quite different. There was a single prominent peak at the Experimental plot in January and February 1989, three peaks in January 1989 and February and April in 1990 in the University Farm and at the Private farm in June, 1990. The highest populations recorded at all the sampling times were very different. These were 396, 287 and 151 CFU ml^{-1} respectively, at the Experimental plot, University farm and the Private farm.

Similarly, the total number of species at each sampling time recorded at the three stations did not synchronise. While the species were most abundant in June-August and October-December in 1989 and November-December in 1990 at the University farm, there was on the other hand just a single peak at the Private farm in August, 1989. Peaks were in February to April and in December in 1989 and in January to March, and in June and July, 1990 at the Experimental Plot.

The airspora of the University farm and the Private farm contained between three and twelve fungal species at any sampling time compared to between six and seventeen species at the Experimental Plot. The number of species at the different sampling times did not show any recognisable relationship with the total number of colonies which developed on the plates.

The predominant fungal species at the Experimental plot were Cladosporium herbarum and Fusarium oxysporum. They were followed in

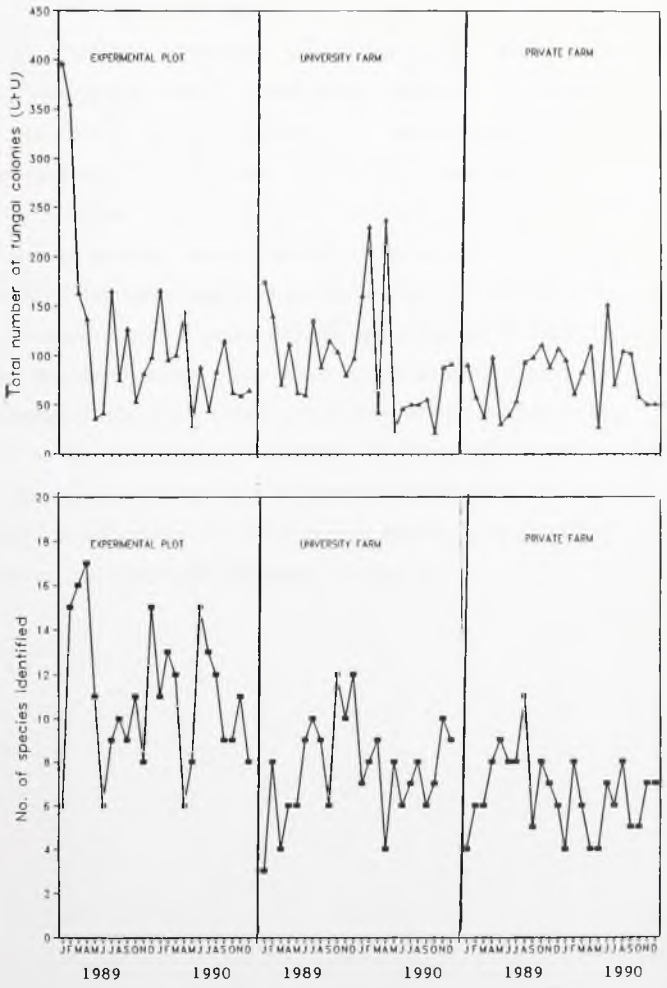


Fig.8 Total Fungal Populations and Total Number of Fungal Species of the atmospheres of the Experimental Plot, University Farm and Private Farm trapped monthly from January 1989 and December 1990 on PDA plates.

abundance by Alternaria alternata, Aspergillus flavus, Aspergillus ochraceus, Aspergillus niger, Aspergillus terreus, Corynespora casiicola, Curvularia lunata, Fusarium sp., Helminthosporium sp., Neurospora sitophila, Nigrospora sp., Penicillium cyclopium, Rhizopus sp., Sterile mycelium, Trichoderma viride and Yeast spp. These were also more or less the most abundant species of the airspora at the two other stations. The percentage frequencies of these species and some of lesser frequencies at the three stations are presented in Table 8. The rest of the fungal species occurred tardily showing no relation at all to seasons of the year. Their occurrence would, therefore, be considered totally random and unpredictable. The percentage frequency of any of these species at any sampling time encountered was less than 2.0 per cent. These species with the number of months out of the total of 24 in which they were found are shown in Table 9.

Months/S	Penicillium cyclopium			Aspergillus species			Mycelia Sterilia			Trichoderma viride			Yeast spp.		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
January	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
March	0	0	0	0	1	0	1	0	10	0	0	0	1	0	0
April	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
May	0	0	0	1	0	1	0	0	0	0	0	0	2	0	1
June	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
August	1	7	0	0	0	2	0	0	0	0	11	6	0	0	0
September	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0
October	0	8	0	1	1	1	0	0	0	0	1	0	0	0	0
November	0	0	0	1	1	0	0	0	0	4	5	0	0	6	0
December	0	0	0	0	1	0	3	0	0	0	1	0	0	0	0
January	2	0	0	1	8	0	3	0	0	0	0	0	37	0	1
February	3	0	3	0	0	0	2	0	0	0	0	0	10	0	0
March	1	2	0	0	0	1	1	0	0	0	0	0	20	16	0
April	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
May	2	1	0	6	0	0	0	0	0	0	9	0	17	0	0
June	1	0	4	0	0	0	0	0	0	0	0	0	19	0	3
July	1	0	0	0	0	0	1	0	0	0	5	0	0	0	0
August	2	0	19	1	0	1	2	0	0	0	0	2	0	0	0
September	0	3	0	1	1	0	0	0	0	0	0	0	0	0	0
October	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
November	0	2	0	2	1	1	0	0	0	4	0	0	0	0	0
December	0	1	1	0	1	1	0	0	0	0	0	0	0	5	0

TABLE 9: Fungal species occurring only occasionally and at frequency of less than 2.0 per cent on PDA trapping plants from atmospheres of the Experimental Plot, University Farm and Private Farm from January 1989 to December 1990.

Species	Species isolated in indicated months in 1989-1990 at		
	Experimental Plot	University farm	Private farm
Aspergillus effusus	4	1	3
Aspergillus fumigatus	6	1	0
Aspergillus sulphureus	1	0	0
Cephalosporium acremonium	1	1	0
Cuninghamella elegans	1	0	0
Drechslera sp.	1	2	0
Fusarium heterosporium	2	0	1
Gilmaniella sp.	1	0	0
Paecilomyces varioti	0	2	3
Penicillium camemberti series	0	1	0
Penicillium sp.	4	0	0
Pithomyces sp.	0	1	0
Pullularia pullulans	4	0	1
Scopulariopsis sp.	1	0	1
Stachybotrys sp.	0	1	0
Stemphylium sp.	0	1	0
Syncephalastrum racemosum	2	1	3
Synnematum sp.	3	0	0
Trichothecium roseum	1	0	0

D. FUNGAL INFECTION OF THE LEAVES OF PEPPER AND TOMATO PLANTS

The percentages of leaves of pepper and tomato plants showing fungal infections determined at 10 day intervals during the dry and rainy seasons were used to draw the Disease Incidence Curves presented in Figs. 9 and 10. Leaf infections of both vegetables occurred in both seasons. The graphs depicted typical disease sigmoid curves.

In the dry season, 100 per cent infection was recorded eventually on all the tomato varieties and on both unstaked and upright plants. However, rate of development of leaf infections was more rapid in unstaked plants of all the three tomato varieties (Fig. 9) than the staked plants. In all tomato varieties, disease development was slow from November 30 to December 20, 1988. This phase was then followed by a logarithmic phase from December 20, 1988 to January 29, 1989.

In the rainy season, the initial stage of slow disease development was not obvious. Infection in this season also proceeded more slowly in the staked plants than in the unstaked ones. It was slowest in the Wosowoso staked plants which showed 95.7 per cent infection on September 13, 1989, compared to 100 per cent infection in the rest. The tomato plants suffered principally from Cercospora leaf spot.

The pepper plants were heavily infected by the powdery mildew, Leveillula taurica. Fig. 10 showed that powdery mildew development at the logarithmic phase was more rapid in dry season than in the rainy season. Furthermore, a higher percentage infection (97.6 per cent) occurred in the dry season than in the rainy season (71.7 per cent).

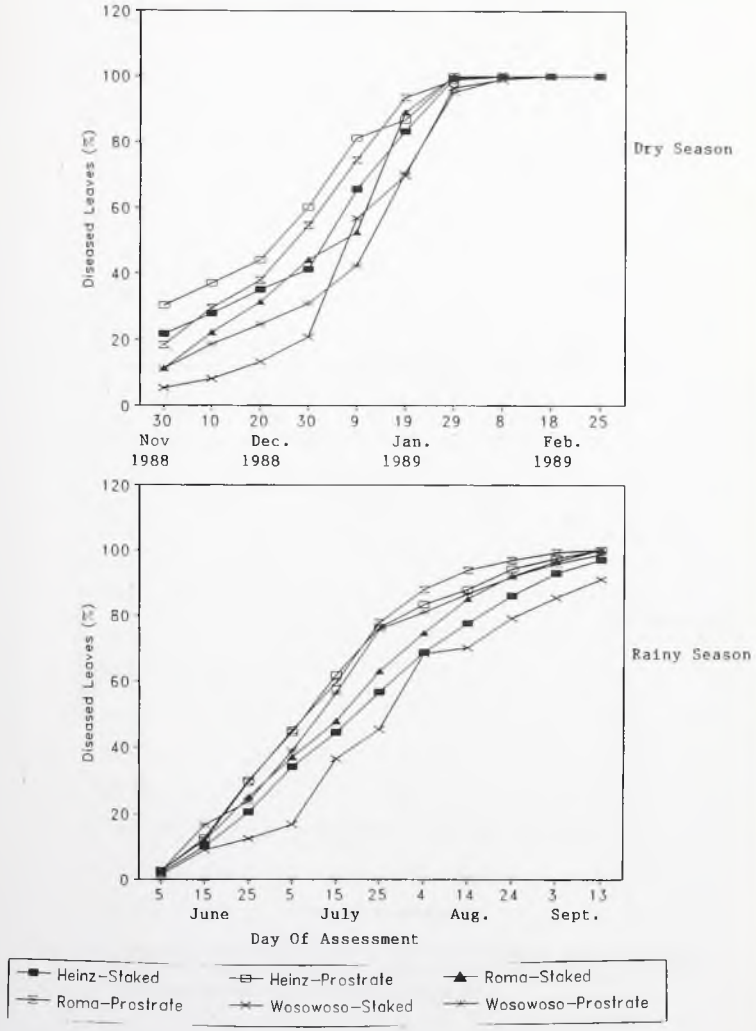


Fig.9 Disease incidence curve of leaves of Tomato varieties growing during the dry season and rainy season at the Experimental Plot. (Graphs based on data in Appendices F and G.)

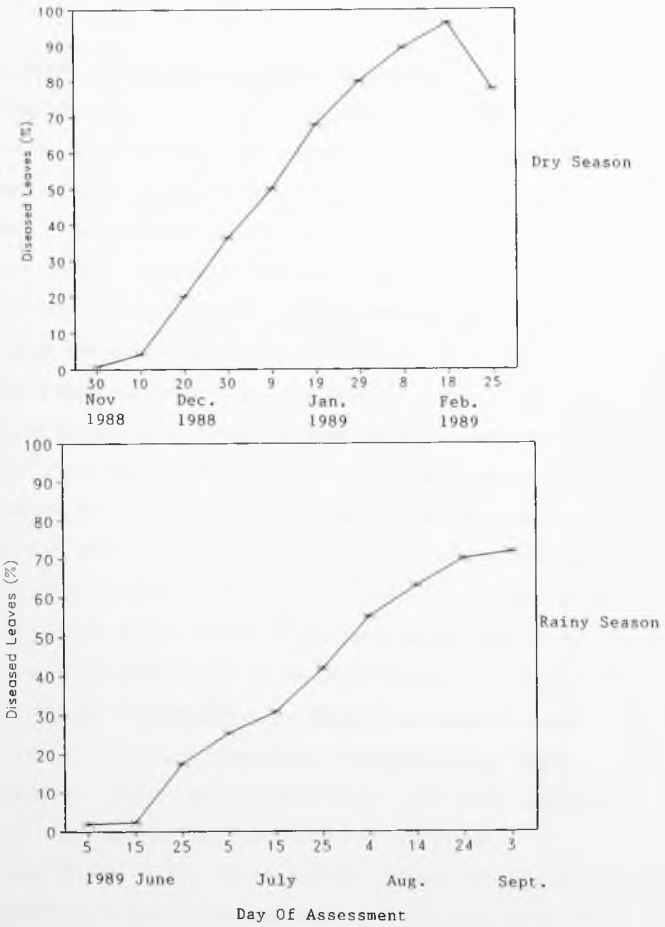


Fig. 10 Disease Incidence Curve of leaves of Pepper growing during the dry season and rainy season at the Experimental Plot. (Graphs based on data in Appendix H)

E. FRUCTIPLANE FUNGI OF OKRA ,PEPPER AND TOMATO

Comprehensive lists of fungi isolated from the surfaces of the fruits of okra, pepper and tomato plants grown at the three locations, Experimental Plot, University Farm, Private Farm and in the dry season (November, 1988 to February, 1989) and in the rainy season (June to September, 1989) are presented in Tables 10,11,12a,12b,13,14,15a,15b, 16,17,18a,18b,19, and 20. In the case of pepper and tomato fruits, the mycoflora of the epicarp was distinguished from that of the calyx.

Many fungal species were isolated from the surface of each fruit. However, a considerable number of them could be described as of occasional occurrence. These were of very low frequency on the occasions they were found, usually less than 2.0 per cent, and could be considered as a minor component of the flora. Generally, the largest number in this category occurred on the fruits at the Experimental Plot, and were in greater number in the rainy season than in the dry season, and on the epicarp than on the calyx (Tables 11,13,14,16,17,19 and 20). Species of Aspergillus and Penicillium occurred on all the three fruits. Species of Chaetomium, Helminthosporium, Mucor, and Paecilomyces were common to okra and tomato fruits while species of Fusarium and Syncephalastrum occurred on okra and pepper.

Tables 10,12a,12b,15a,15b,18a and 18b indicate the major species which occurred at higher frequencies and more often on the okra, pepper and tomato fruits and could be considered as important contaminants. The type of fruit had an effect on the contaminant population, and frequencies of the species were related to the weather conditions.

The dominant species on the okra fruits were Aspergillus niger,

TABLE 10: Fungal species on surface of fruits of the Local variety of okra plants growing in the dry season (November 1988 - February 1989) and in the rainy season (June -September 1989) at three different localities at Legon and Madina

Plot/Farm	Date of Assessment (1989)	Percentage Frequency								
		Alternaria alternata	Aspergillus ochraceus	Aspergillus niger	Cladosporium herbarum	Corynespora cassicola	Fusarium oxysporum	Mycelia sterilia	Neurospora crassa	Rhizopus species
Experimental Plot	Jan 3	23	0	0	0	0	0	70	0	0
	Jan 18	0	0	68	0	0	15	10	4	0
	Feb 6	24	0	0	0	0	48	22	5	0
University Farm	Jan 3	19	0	0	0	0	4	41	0	0
	Jan 18	0	0	0	0	0	65	36	0	0
	Feb 6	7	0	0	0	0	65	28	0	0
Private Farm	Jan 3	0	0	0	47	0	53	0	0	0
	Jan 18	7	0	0	30	10	20	14	0	6
	Feb 6	0	0	0	0	0	31	33	18	18
Experimental Plot	Jul 5	0	10	0	0	0	57	24	0	0
	Jul 14	0	10	0	52	0	31	0	0	0
	Jul 27	0	0	10	0	11	40	0	0	10
	Aug 14	0	0	12	19	0	29	14	0	6
	Sept 3	0	0	13	0	14	67	0	0	6
University Farm	Jul 5	0	0	0	51	0	48	0	0	0
	Jul 14	0	0	0	36	0	23	39	0	0
	Jul 27	0	11	18	17	0	38	18	0	14
	Aug 14	0	0	13	20	0	31	19	0	9
	Sept 3	0	0	21	14	0	27	26	0	8
Private Farm	Jul 5	0	15	0	54	0	30	0	0	0
	Jul 14	0	0	24	34	0	18	24	0	0
	Jul 27	0	0	0	22	12	33	0	0	15
	Aug 14	0	0	13	20	0	29	0	23	5
	Sept 3	0	0	14	14	10	23	17	0	5

TABLE 11: Fungal species which occurred only occasionally and at very low frequencies of less than 2.0 per cent on the surface of fruits of the Local variety of okra during both the dry season, January and February, 1989, and the rainy season, June to September, 1989.

Fungal species	Number of occasions the species was isolated at the Experimental Plot	University Farm	Private Farm
Aspergillus flavus	1r*	1r	1r
Aspergillus nidulans	1r	0	0
Aspergillus terreus	1r	0	1d
Chaetomium globosum	1r	0	1r
Drechslera sp.	0	0	2dr
Fusarium sp.	0	0	1r
Geotrichum sp.	1r	1r	0
Helminthosporium sp.	2d	0	1r
Mucor sp.	1r	0	1r
Mycosphaerella sp.	2r	0	0
Nigrospora oryzae	1r	0	2r
Paeciliomyces sp.	2r	1r	0
Penicillium cyclopium	2r	0	0
Syncephalastrum racemosum	1d	0	0

* d: dry season; r: rainy season

TABLE:13 Fungal species which occurred only occasionally and at very low frequencies of less than 2.0 per cent on the surface of the epicarp of fruits of pepper during both the dry season, January and February, 1989, and the rainy season, June to September, 1989.

Fungal species	Number of occasions the species was isolated at the Experimental Plot	University Farm	Private Farm
Alternaria alternata	0	0	1r
Aspergillus effusus	0	2r	0
Aspergillus fumigatus	0	2r	0
Aspergillus ochraceus	2r	0	0
Fusarium sp.	2dr	1r	1d
Penicillium cyclopium	2r	0	0
Syncephalastrum racemosum	2r	0	0
Trichoderma viride	1r	0	0

* d: dry season; r: rainy season

TABLE 14: Fungal species which occurred only occasionally and at very low frequencies of less than 2.0 per cent on the surface of the calyx of fruits of pepper during both the dry season, January and February, 1989 and the rainy season, June to September 1989.

Fungal species	Number of occasions the species was isolated at the		
	Private Plot	Experimental Farm	University Farm
Aspergillus ochraceus	2dr	0	0
Byssochlamys sp.	1r	0	0
Fusarium sp.	2d	1d	0
Penicillium citrinum	1r	0	0
Syncephalastrum racemosum	1r	0	0
Trichoderma viride	1r	0	0

* d: dry season; r: rainy season

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Geotrichum species	Mucor species	Rhizopus species	Yeast
4	0	0	45
4	0	5	0
14	0	0	0
0	0	0	0
0	0	54	0
0	0	0	0
1	0	29	11
3	0	14	7
0	0	60	0
0	0	0	0
0	1	6	0
0	0	2	0
4	0	9	0
2	0	14	0
1	0	18	0
1	0	9	0
1	0	6	0
1	0	13	0

TABLE: 15b F

Piot/Farm	*Mucor* spp.	*Rhizopus* sp.	Yeast spp.
Experimental Piot	0	0	19
	0	0	16
	0	3	19
	0	2	0
	0	0	11
	2	0	64
	0	38	14
	0	4	25
	1	7	0
	7	0	0
Univerisity Farm	0	16	36
	0	4	38
	1	6	[illegible]
	[illegible]	[illegible]	16
	2	5	0
	0	7	26
	0	9	12
	8	4	17
	0	0	35
	5	10	30
Private Farm	0	0	9
	0	5	0
	0	10	0
	0	8	0
	0	8	0
	0	0	62
	0	0	32
	0	12	[illegible]
	0	[illegible]	34
	0	7	21

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TABLE 16: Fungal species which occurred only occasionally and at very low frequencies of less than 2.0 per cent on the surface of the epicarp of fruits of Wosowoso variety of Tomato during both the dry season, January and February, 1989 and the rainy season, June to September, 1989.

Fungal species	Number of occasions the species was isolated at the Experimental Plot	University Farm	Private Farm
Aspergillus clavatus	1r	2r	0
Aspergillus fumigatus	0	2r	0
Aspergillus ochraceus	1	2	0
Aspergillus terreus	2r	0	0
Nigrospora oryzae	0	1r	0
Oidiodendron sp.	1r	2dr	0
Paecilomyces sp.	0	1d	0
Penicillium citrinum	2r	0	0
Penicillium cyclopium	2r	0	0
Penicillium funiculosum	0	1r	0
Pullularia pullulans	3d	0	0
Sclerotium rolfsii	0	1r	0
Scopulariopsis brevicaulis	0	1r	0

*d: dry season; r: rainy season

TABLE 17: Fungal species which occurred only occasionally and at very low frequencies of less than 2.0 per cent on the surface of the calyx of fruits of Wosowoso variety of Tomato during both the dry season, January and February, 1989 and the rainy season, June to September, 1989.

Fungal species	Number of occasions the species was isolated at the Experimental Plot	University Farm	Private Farm
Aspergillus ochraceus	1r*	0	0
Aspergillus terreus	1r	0	0
Corynespora casiicola	1r	0	0
Helminthosporium sp.	1r	0	0
Nigrospora oryzae	2r	1r	0

* r: rainy season

TABLE 18a: Fung… 1989…

Tomato variety	Part of fruit	Date Asses… (1989…	…cilli… …pi…	Pullularia pullulans	Rhizopus species	Scopulariopsis brevicaulis	Yeast spp.
[illegible]	Epicarp Surface	Jan.		[illegible]	[illegible]	[illegible]	[illegible]
		Jan.1…		[illegible]	[illegible]	[illegible]	[illegible]
		Feb.		[illegible]	[illegible]	[illegible]	[illegible]
	Calyx	Jan.		[illegible]	[illegible]	[illegible]	[illegible]
		Jan.1…		[illegible]	[illegible]	[illegible]	[illegible]
		Feb.		[illegible]	[illegible]	[illegible]	[illegible]
Roma	Epicarp Surface	Jan.		[illegible]	[illegible]	12	[illegible]
		Jan.1…		20	10	10	[illegible]
		Feb.		21	[illegible]	[illegible]	[illegible]
	Calyx	Jan.		[illegible]	[illegible]	[illegible]	[illegible]
		Jan.1…		[illegible]	[illegible]	[illegible]	[illegible]
		Feb.		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Epicarp Surface	Jan.		[illegible]	[illegible]	[illegible]	[illegible]
		Jan.1…		[illegible]	[illegible]	[illegible]	[illegible]
		Feb.		[illegible]	[illegible]	[illegible]	[illegible]
	Calyx	Jan.		[illegible]	[illegible]	[illegible]	[illegible]
		Jan.1…		[illegible]	[illegible]	[illegible]	[illegible]
		Feb.		[illegible]	14	[illegible]	[illegible]

TABLE 18b:

Plot/Farm	Penicillium cyclopium	Pullularia pullulans	Rhizopus species	Scopulariopsis brevicaulis	Yeast spp.
Seiri	0	4	4	0	19
	3	0	1	0	9
	0	0	7	0	0
	1	0	19	0	5
	2	0	0	0	0
	0	0	6	0	0
	0	0	9	0	0
	0	0	7	0	0
	0	0	2	0	0
	0	0	9	0	0
Kuma		0	7	0	31
		0	12	0	27
		0	10	0	0
		0	12	0	0
		0	0	0	0
		0	13	0	0
		0	10	0	0
		0	2	0	0
		0	40	0	0
		0	13	0	0
Yobowato		0	0	0	20
		0	0	0	16
		0	1	0	19
		0	2	0	0
		0	0	0	11
		0	0	0	64
		0	28	0	14
		0	4	0	25
		0	7	0	0
		0	0	0	0

TABLE 19: Fungal species which occurred only occasionally and at very low frequencies of less than 2.0 per cent on the surface of the epicarp of fruits of different tomato varieties during both the dry season, January and February, 1989, and the rainy season, June to September, 1989.

Fungal species	Number of occasions the species was isolated from the Heinz variety	Roma variety	Wosowoso variety
Acrospeira sp.	1	0	0
Alternaria alternata	2d*	0	2dr
Aspergillus clavatus	0	0	1r
Cephalosporium sp.	1r	0	0
Chaetomium globosum	1r	2r	0
Oidiodendron sp.	0	0	1r
Paeciliomyces sp.	1d	0	0
Penicillium citrinum	1r	0	2r
Penicillium funiculosum	0	1r	0
Mucor sp.	2r	0	0
Sporobolomyces sp.	2r	2r	0

* d: dry season; r: rainy season

TABLE 20: Fungal species which occurred only occasionally and at very low frequencies of less than 2.0 per cent on the surface of the calyx of fruits of different tomato varieties during both the dry season, January and February, 1989, and the rainy season, June to September, 1989.

Fungal species	Number of occasions the species was isolated from the		
	Heinz variety	Roma variety	Wosowoso variety
Aspergillus ochraceus	1r*	0	1r
Corynespora casiicola	0	0	1r
Helminthosporium sp.	0	0	1r

* r: rainy season

Cladosporium herbarum and Fusarium oxysporum. There were also unusually large numbers of Sterile mycelia. The three dominant species were all more abundant in the rainy season than in the dry season (Table 10). While F. oxysporum was present at practically the same level at all the three locations, a greater number of isolates of A. niger and C. herbarum was obtained on fruits at the University Farm and Private Farm.

During the rainy season, Aspergillus flavus , Cladosporium herbarum and Rhizopus species occurred in large numbers on both the epicarp and calyx of pepper fruits. Yeasts occurred at high frequencies on the calyx of the fruits at the Experimental Plot and University Farm (Table 12b). Apart from C. herbarum which occurred at high frequencies at all the three localities in the dry season, and on both the epicarp and calyx, the percentage frequencies of the remaining species were low and their presence was inconsistent (Table 12a).

When the surface fungal flora of the fruits of the Wosowoso variety of tomato was studied, far more isolates were obtained in the rainy season than in the dry season (Table 15a and 15b). The dominant species were Aspergillus niger, Cladosporium herbarum, Fusarium oxysporum, Geotrichum sp., Rhizopus species and Yeasts. From the evidence provided by A. flavus, A. niger, Geotrichum sp. and Rhizopus species, the epicarp surface was a better microhabitat for the fungi than the calyx surface. The Yeasts, however, established equally well on the epicarp and the calyx. Many species occurred at uniform frequencies at the three localities, but A. niger was more abundant at the University Farm and the Private Farm than at the Experimental Plot, both in the dry and rainy seasons.

When the fungal flora of the three tomato varieties were

compared, it was found that C. herbarum and F. oxysporum occurred in large numbers on fruits of all three, both in the dry and rainy seasons (Table 18a and 18b). Geotrichum sp. and Yeasts occurred in greatest numbers on fruits of the Wosowoso variety, while A. flavus, A. niger, A. terreus, and Rhizopus species occurred at greater frequencies in the rainy season on fruits of the Heinz and Roma varieties than on fruits of the Wosowoso variety.

F. PHYLLOPLANE FUNGI OF OKRA, PEPPER, TOMATO AND ONION

The results in Tables 21 and 22 showed that practically the same dominant fungal species occurred on leaves of okra plants in the dry and rainy seasons. Significantly high numbers of colonies of Cladosporium herbarum. Fusarium oxysporum and Mycelia sterilia were recorded in both the dry and rainy seasons at all the three localities.

Some species were completely absent at some of the localities during either dry or rainy season. This occurred mostly in the dry season (Table 21). During this season, Alternaria alternata. Aspergillus flavus, Aspergillus terreus. Fusarium sp. Helminthosporium sp., Penicillium cyclopium and Rhizopus sp. were not encountered on the leaves at the Experimental Farm, while only Helminthosporium sp., P. cyclopium and Rhizopus sp. were absent on plants at the University Farms, and A. alternata. Aspergillus niger and A. terreus at the Private Farm. In contrast only Fusarium sp. was absent on plants at the Experimental Plot during the rainy season (Table 22). Evidently, on the whole, more colonies were recorded in the rainy season than in the dry season.

Eight filamentous species and Yeasts occurred sparsely during the investigation (Table 23). They occurred practically evenly in the dry and rainy seasons as shown in the table of results. They also occurred randomly in either season at the three localities.

Practically the same major species characterised the phylloplane mycoflora of onion, pepper and tomato as recorded in Tables 24, 26, 27, 29 and 30, but they, naturally, did not occur at the same frequencies. Two notable examples were the high frequencies of colonies of Cladosporium herbarum and Fusarium oxysporum on leaves of pepper (Tables 26, and 27)

Table 23: Fungal species which occurred only occasionally and at very low frequencies of less than 2.0 per cent on the surface of leaves of the Local variety of okra during both the dry season, January and February, 1989, and the rainy season, June to September, 1989.

Fungal Species	No. of occasions species was isolated at the		
	Experimental Plot	University Farm	Private Farm
Aspergillus glaucus	3dr*	1r	1d
Botrytis cinerea	1r	1r	0
Byssochlamys fulva	1r	1r	0
Drechslera sp.	0	2r	1d
Geotrichum candidum	0	2r	0
Paecilomyces sp.	2r	1d	0
Penicillium sp.	1d	1d	1r
Stemphylium sp.	2d	1d	0
Yeast spp.	2r	1d	0

*d: dry season r: rainy season

TABLE 24: Phylloplane fungal species of the Red Creole onion plants growing in the dry season (Nov., 1988 - Feb., 1989) (June-September, 1989) at the Experimental Plot and University Farm, Legon

Plot/Farm	Date of Assessment (1989)	Percentage Frequency								
		Alternaria alternata	Aspergillus niger	Cladosporium herbarum	Curvularia lunata	Fusarium oxysporum	Fusarium sp.	Mycelia sterilia	Penicillium cyclopium	Rhizopus sp.
Experimental Plot	Jan., 10	0	54	7	0	12	0	27	0	0
	" 24	0	52	14	0	10	0	25	0	0
	Feb., 7	4	70	11	0	15	0	0	0	0
	" 21	0	82	14	0	0	0	0	0	0
	" 28	0	80	20	0	0	0	0	0	0
University Farm	Jan., 10	0	64	9	0	23	0	14	0	0
	" 24	0	71	9	0	11	0	9	0	0
	Feb.,	0	50	4	2	10	0	10	1	2
	" 21	1	58	9	1	14	0	13	4	0
	" 28	0	63	8	0	6	0	16	4	0
Experimental Plot	June 10	0	6	10	0	19	10	0	0	19
	July 14	0	40	18	0	12	0	11	4	9
	" 28	0	37	19	0	10	2	14	0	17
	Aug., 11	7	65	8	1	0	9	0	0	5
	" 25	4	76	12	1	0	0	0	0	0
University Farm	June 10	0	74	2	0	12	0	13	0	0
	July 14	0	82	6	0	13	0	0	0	0
	" 28	5	70	5	2	10	0	3	0	5
	Aug., 11	0	78	6	0	8	1	0	0	3
	" 25	0	65	10	0	15	0	5	0	4

Table 25: Fungal species which occurred only occasionally and at very low frequencies of less than 2.0 per cent on the surface of leaves of Red Creole onion during both the dry season, January and February, 1989, and the rainy season, June to September, 1989.

Fungal Species	No. of occasions species was isolated at the	
	Experimental Plot	University Farm
Aspergillus flavus	1r	1r
Corynespora casiicola	2r	0
Nigrospora oryzae	1r	1d
Syncephalastrum racemosum	2r	1r
Trichoderma viride	2r	1r

*d: dry season r: rainy season

Table 28: Fungal species which occurred only occasionally and at very low frequencies of less than 2.0 per cent on the surface of leaves of pepper during the rainy season June to September, 1989.

Fungal Species	No. of occasions species was isolated at the		
	Experimental Plot	University Farm	Private Farm
Chaetomium globosum	2	0	0
Helminthosporium sp.	1	1	1
Paecilomyces sp.	1	1	1
Stemphylium sp.	1	1	1
Trichoderma viride	1	0	0

and tomato (Tables 29 and 30) compared with their low frequencies on onion leaves (Table 24) from which exceptionally high Aspergillus niger colonies were isolated.

Onion was grown on the Experimental Plot and University Farm only as shown in Table 24. A. niger colonies were far greater than those of the other dominant species, C. herbarum and F. oxysporum in both seasons. Out of the eight dominant species, a number of species occurred at low frequencies at both localities. These were Alternaria alternata, Curvularia lunata, other Fusarium species, Penicillium cyclopium and Rhizopus sp. in the dry season, and A. alternata, C. lunata, other Fusarium species and P. cyclopium in the rainy season. Fungal species which occurred only occasionally and presented in Table 25 were only five in number, and they were isolated mostly in the rainy season.

The data recorded for studies on the leaves of pepper are shown in Tables 26, 27 and 28. Besides Mycelia sterilia, 12 fungal species were isolated. The dominant species in the dry season, taking all the three localities together, were C. herbarum, C. lunata and F. oxysporum. In the rainy season A. niger, C. herbarum and F. oxysporum constituted the dominant species. Many species including A. niger, Aspergillus ochraceus, Aspergillus terreus, P. cyclopium, Rhizopus sp. and Syncephalastrum racemosum were not obtained from the leaf surfaces at the Experimental Plot during the dry season (Table 26). In the rainy season only A. alternata and C. lunata were absent. On the whole, therefore, leaves of plants of the University Farm and the Private Farm, carried more fungal propagules than those of plants of the Experimental Plot. As in the case of onion, the occasional species were only five in number but in this case, all the species were

recorded in the rainy season.

Fourteen fungal species listed in Tables 29 and 30 as major species, were obtained from the surfaces of the leaves of the Wosowoso variety of tomato plants. There were many members of Sterilia mycelia. The dominant species of the dry season were C. herbarum and F. oxysporum (Table 29) and those of the rainy season were A. niger, C. herbarum, C. lunata, F. oxysporum and P. cyclopium (Table 30). Furthermore, A. flavus, A. niger, Corynespora casiicola, C. lunata and Nigrospora oryzae colonies in the dry season were far less than the corresponding values recorded in the rainy season. On the other hand, many more members of Mycelia sterilia were encountered in the dry season than in the rainy season.

There were occasional species (Table 31). These were Yeast species and nine filamentous species with a greater proportion found in the rainy season.

Table 31 : Fungal species which occurred only occasionally and at very low frequencies of less than 2.0 per cent on the surface of leaves of the Wosowoso variety of tomato plants during both the dry season, January and February, 1989, and the rainy season, June to September, 1989.

Fungal Species	No. of occasions species was isolated at the		
	Experimental Plot	University Farm	Private Farm
Aspergillus glaucus	1r	0	0
Chaetomium globosum	1r	0	1r
Drechslera	2d	0	1r
Mycosphaerella sp.	2r	1r	1d
Paecilomyces sp.	3dr	1r	1r
Penicilium citrinum	1r	1r	1d
Stemphylium sp.	1r	0r	1r
Syncephalastrum racemosum	1r	2r	0
Trichoderma viride	1r	0	0
Yeast spp.	0	0	1r

*d: dry season r: rainy season

G. SOIL AND RHIZOSPHERE FUNGAL POPULATIONS

Comprehensive lists of fungi isolated from the rhizospheres of plants of okra, pepper and tomato and from the non-rhizosphere soils are presented in Tables 32, 33, 34, 35, 36 and 37. In the rhizosphere of all the three plants and the non-rhizosphere soils, species of Aspergillus were more abundant than those of any other genus. The rhizosphere effect differed from one plant species to another.

There were 10 species in the non-rhizosphere soil which occurred very sparingly. They are listed in Table 32, and they could be considered to be very minor. These species were variously distributed among the three locations. Cephalosporium sp., Neurospora crassa and Nigrospora oryzae were isolated from soil of the Experimental Plot, Byssochlamys sp. only was isolated from soil of the University Farm, whereas Penicillium digitatum, Chaetomium globosum, Corynespora casiicola, Helminthosporium sp. and Mucor sp. were isolated from the soil of the Private Farm.

Comparing the number of minor species of the rhizosphere and non-rhizosphere soil, the number was greater in the rhizosphere of okra and tomato (Wosowoso variety) at all the three locations, but in the rhizosphere of pepper plants at only the Experimental Plot and University Farm. The results in Table 33 showed that the number of minor species in the rhizosphere of the Heinz variety was far smaller than in rhizosphere of Roma and Wosowoso varieties cultivated at the Experimental Plot.

The important features of the populations of the major fungal species of the rhizospheres of the plants presented in Tables 34, 35, 36 and 37 could be summarised as follows:

Table 32: Fungal species occurring at very low frequencies and only occasionally in Rhizospheres of Okra, Pepper and Tomato (Nosowoso variety) plants and in Non-rhizosphere soils during growth of the plants at three different locations over 10 months (November, 1988 - August, 1989).

Fungal Species	Occurrence in indicated number of months at											
	Experimental Plot				University Farm				Private Farm			
	Non-Rhizo-sphere Soil	Rhizosphere of Okra	Pepper	Tomato	Non-Rhizo-sphere Soil	Rhizosphere of Okra	Pepper	Tomato	Non-Rhizo-sphere soil	Rhizosphere of Okra	Pepper	Tomato
Aspergillus clavatus	0	0	1	2	0	3	4	3	0	1	0	0
Aspergillus fumigatus	0	0	0	0	0	0	0	1	0	1	0	3
Aspergillus glaucus	0	0	1	0	0	0	0	0	0	0	0	0
Aspergillus nidulans	0	0	0	1	0	0	0	0	0	3	0	1
Byssochlamys sp.	0	0	0	0	1	0	1	1	0	0	0	0
Cephalosporium sp.	1	0	0	0	0	0	0	0	0	0	0	0
Chaetomium globosum	0	0	1	0	0	2	1	0	3	2	1	0
Cladosporium herbarum	0	2	0	1	0	0	1	1	0	2	1	1
Corynespora casiicola	0	0	0	0	0	0	0	0	1	0	0	0
Cunninghamella elegans	0	0	0	0	0	0	0	0	0	0	1	0
Curvularia lunata	0	0	0	0	0	0	0	0	0	0	0	0
Gliocladium sp.	0	1	0	0	0	0	0	0	0	1	0	0
Helminthosporium sp.	0	0	0	0	0	0	0	0	1	0	0	0
Mucor sp.	0	0	0	0	0	0	0	1	1	0	0	0
Neurospora crassa	1	0	1	0	0	2	0	2	0	1	0	1
Nigrospora oryzae	1	0	1	0	0	2	1	2	0	0	0	1
Penicillium digitatum	0	0	1	0	0	0	1	2	1	0	2	1
Penicillium sp.	0	1	0	0	0	1	0	0	0	1	0	0
Pullularia pullulans	0	1	0	0	0	2	0	0	0	0	0	0
Scopulariopsis brevicaulis	0	0	0	1	0	0	0	0	0	0	0	0
Trichocladium sp.	0	0	0	0	0	0	0	0	0	1	1	0

Table 33: Fungal species occurring at very low frequencies and only occasionally in Rhizospheres of Heinz, Roma and Wosowoso Tomato varieties and in the non-rhizosphere soil during growth of the plants at the Experimental Plot at Legon over 10 months (November, 1988 - August, 1989).

Fungal Species	Occurrence in indicated number of months in			
	Non-rhizosphere soil	Rhizosphere of		
		Heinz variety	Roma variety	Wosowoso variety
Aspergillus clavatus	0	0	2	2
Aspergillus fumigatus	0	0	2	0
Aspergillus glaucus	0	1	0	0
Aspergillus nidulans	0	0	0	1
Byssochlamys sp.	0	0	0	0
Cephalosporium sp.	1	0	0	0
Chaetomium globosum	0	0	0	0
Cladosporium herbarum	0	2	1	1
Corynespora casiicola	0	0	0	0
Helminthosporium sp.	0	0	0	0
Mucor sp.	0	0	0	0
Neurospora crassa	1	0	1	0
Nigrospora oryzae	1	0	0	0
Penicillium digitatum	0	0	0	0
Scopulariopsis brevicaulis	0	0	0	1

Okra plants

The rhizosphere mycoflora of okra plants showed 10 dominant species (Table 34). The most abundant were Aspergillus niger, Aspergillus terreus and Penicillium cyclopium. The 10 dominant species could be separated into three groups, based on the influence of the roots. One group, comprising of Aspergillus flavus and Fusarium oxysporum, was not affected by the roots and they occurred at approximately the same frequencies in the rhizosphere and non-rhizosphere soils. The other two groups were influenced by the root exudates and by the microbial population established in the rhizosphere. A. niger, Paecilomyces sp. and Syncephalastrum racemosum populations increased in the rhizosphere, whereas the third group, made up of Aspergillus ochraceus, A. terreus and Trichoderma viride populations declined in the rhizosphere.

P. cyclopium occurrence was a peculiar one. It was stimulated in the rhizosphere in the dry season and suppressed during the rainy season.

At the same time, these dominant species thrived at different times during the period of sampling. This response to the moisture conditions also separated the species into three identifiable groups. A. ochraceus, F. oxysporum and Paecilomyces sp. occurred in greater numbers in the dry season than in the rainy season. On the other hand, Rhizopus sp. and S. racemosum were favoured by the rainy season, while A. flavus, A. niger, A. terreus and T. viride respective populations were approximately the sam% $uring the dry and rainy seas'ns.

Pepper plants

There were 11 dominant fungal species in the rhizosphere of the pepper plants (Table 35). The

most abundant species were also A. niger, A. terreus and P. cyclopium. Species which occurred mostly in the dry season were F. oxysporum, Paecilomyces sp. and P. cyclopium and those with greater populations in the rainy season than in the dry season were A. flavus, A. niger, Rhizopus sp. and T. viride. The rest, including A. fumigatus and A. ochraceus were not particularly affected by time of sampling.

Conditions of the rhizosphere did not affect A. fumigatus, Paecilomyces sp. and S. racemosum. The populations of A. flavus, A. niger, A. terreus and F. oxysporum, on the other hand, increased in the rhizosphere, while those of A. ochraceus, Rhizopus sp. and T. viride decreased, in comparison to the populations in the non-rhizosphere soil.

Tomato plants

Twelve dominant fungal species were isolated from the rhizosphere of the tomato plants grown at the three localities (Table 36). The most abundant species were A. niger and P. cyclopium. Using the same criteria based on rhizosphere influence and effect of seasons the species could be classified as follows:

(a) Species which were not affected by root: Chaetomium globosum, F. oxysporum, Paecilomyces sp. and T. viride.

(b) Species stimulated on the rhizosphere: A. flavus, A. niger, C. lunata, P. cyclopium and S. racemosum.

(c) Species suppressed in the rhizosphere: A. ochraceus, A. terreus and Rhizopus sp.

(d) Species with higher populations in the rainy season: A. flavus, A. terreus, Rhizopus sp., S. racemosum and T. viride.

(e) Species with higher populations in the dry season: A. ochraceus, F. oxysporum, Paecilomyces sp. and P. cyclopium.

(f) Species occurring to approximately the same degree in the dry and rainy seasons: A. niger.

Considering the species in the non-rhizosphere soils which reflected the baseline populations of the three locations, no single plot could be identified to contain the highest population or the smallest populations, because of the great variation in occurrence shown by the individual species, when all the experiments were put together.

Plants of Tomato Varieties

Each fungal species apparently responded almost to the same extent to the influence of the three tomato varieties as shown in Table 37. A. flavus, A. niger, Chaetomium sp., C. lunata, F. oxysporum, Paecilomyces sp., P. cyclopium, Rhizopus and S. racemosum were stimulated in the rhizosphere of all the three tomato varieties. A. ochraceus and A. terreus, on the other hand, were suppressed in all the three rhizospheres.

H. FUNGAL CONTAMINANTS OF OKRA CHIPS AND BOILED PEPPER FRUITS AFTER DRYING

Fungi isolated from okra (Local variety) fruit chips and pepper fruits air-dried and solar-dried during the dry and rainy seasons are listed in Table 38. A. niger was the dominant species of okra chips dried both in the dry season (Nov. 26 - Dec. 6, 1989) and the rainy season (June 15 - June 25, 1990), with surprisingly higher populations on chips under the solar drier. Generally more colonies of the other species of both air-dried and solar-dried, occurred on unwashed chips than the washed chips.

During the rainy season, approximately similar fungal populations occurred on the washed and unwashed okra chips under each type of drying. Secondly, air-dried chips carried higher number of colonies than the solar-dried chips.

A. niger, A. flavus, P. cyclopium, C. herbarum and Rhizopus sp. constituted the dominant fungi on the different batches of pepper fruits. C. herbarum was, however, restricted to the air-dried fruits during both seasons.

The atmospheric relative humidity during the dry season, from Nov. 26 to Dec. 6, 1989, was 48 to 74% RH and during the rainy season, from June 15 to June 25, 1990 was 66 to 82% RH.

Table 38 : F

Time of Drying	...lium ...um	Rhizopus sp.	Syncephalastrum racemosum	Mycelia sterilia
June 15-June 24, 1990		5	0	5
		4	0	0
		14	3	1
		20	4	1
		0	0	0
		0	0	0
		0	0	0
		0	0	0
Nov. 26-Dec 6, 1989		1	0	0
		2	4	1
		9	2	0
		20	3	1
		0	0	0
		0	0	0
		11	0	0
		9	0	0

I. MOISTURE SORPTION ISOTHERMS OF DRY PEPPER FRUIT AND OKRA FRUIT CHIPS AND THEIR RESPECTIVE FLOURS

The graphs in Figs. 11, 12, 13 and 14 are results of studies on tests on gain or loss of moisture of dried fruits under the following conditions:

1. Dried whole pepper fruits under room conditions
2. Dried pepper fruit powder under room conditions
3. Dried whole pepper fruits at 20 and 85% RH
4. Dried pepper fruit powder at 20 and 85% RH
5. Dried okra fruit chips under room condition
6. Dried okra fruit powder under room conditions
7. Dried okra fruit chips at 20 and 85% RH
8. Dried okra fruit powder at 20 and 85% RH.

The graphs show that the materials in all treatments gained moisture from the ambient atmosphere. The level of gain in moisture was higher under room conditions with humidities ranging from 68 to 81% RH and in desiccators with controlled humidity of 85% RH, and very little moisture was absorbed in atmosphere of 20% RH.

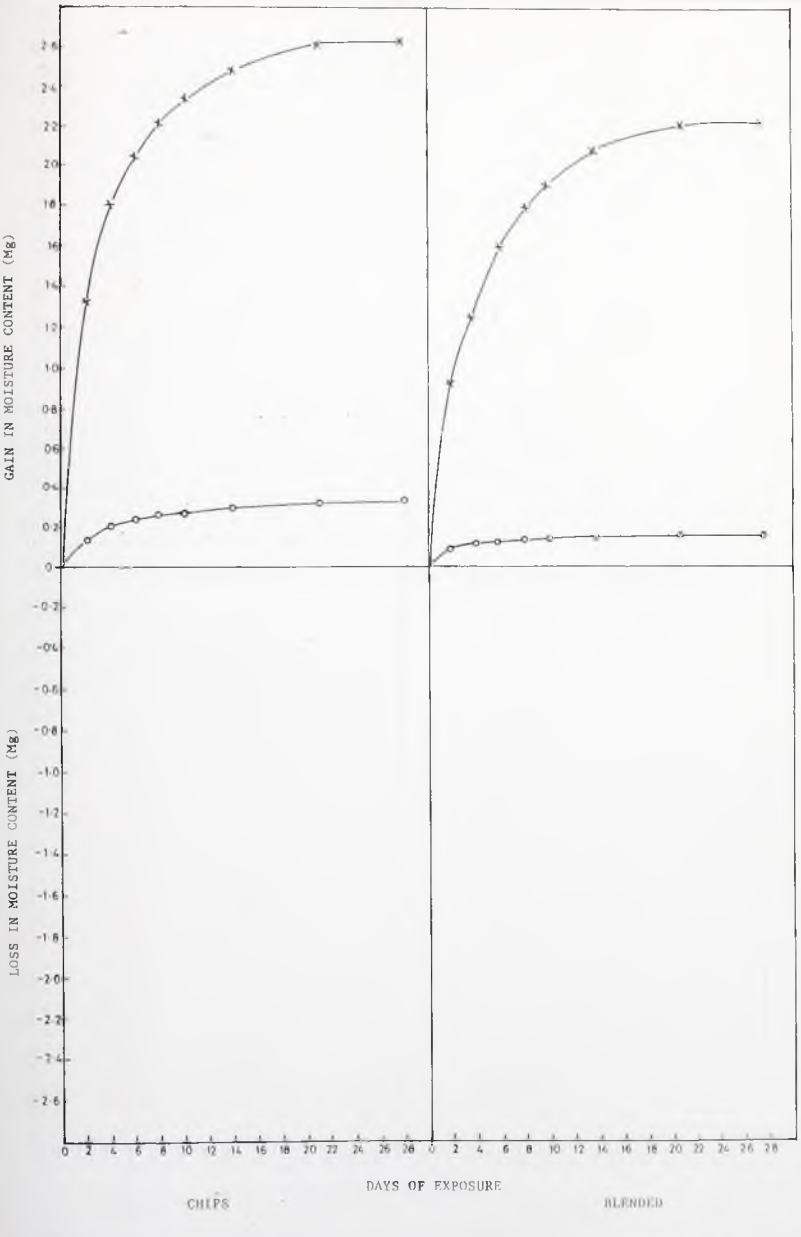


Fig. 11: Moisture gained by Dried Chips and Blended Chips of Okra in atmospheres of 20 and 85% R.H.:
initial weight of materials - 1.0g. 20% R.H ——o—— 85% R.H. ——X——

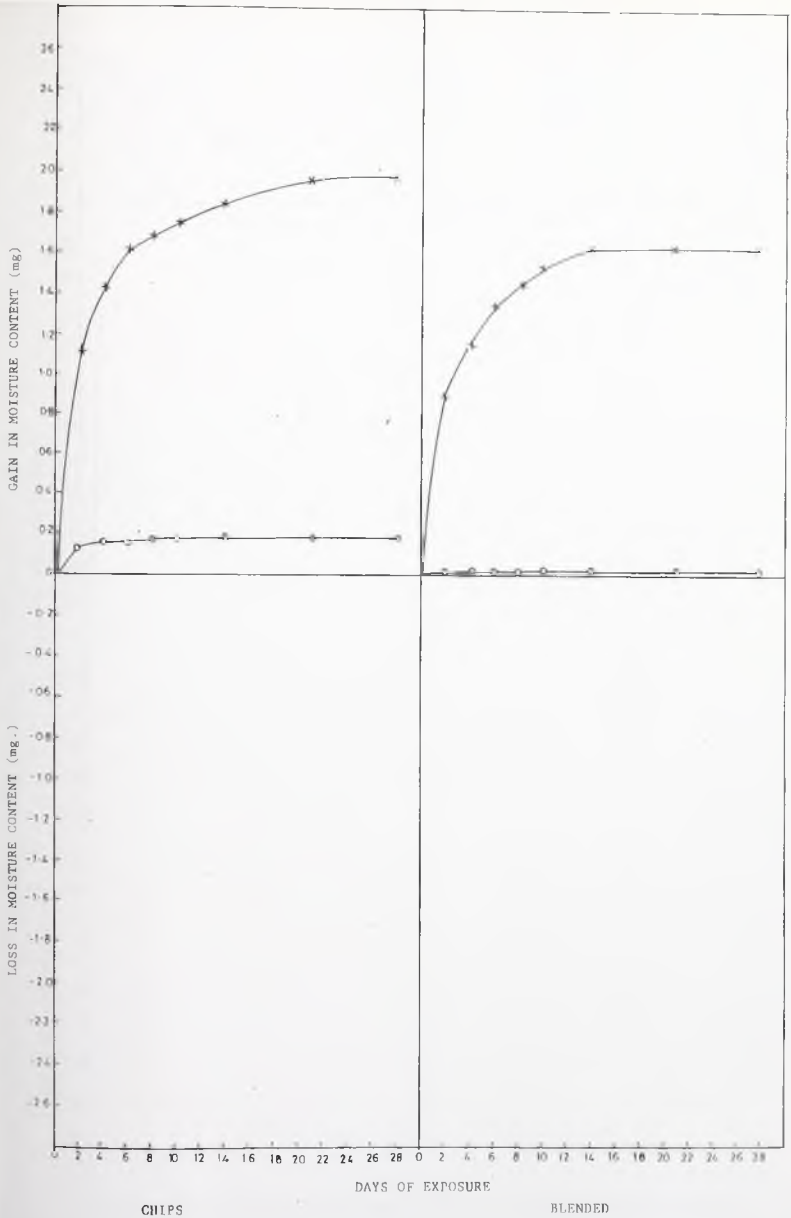


Fig. 12: Moisture gained by dried Pepper Fruit and Blended Pepper Fruit in atmospheres of 20 and 85% R.H.: initial weight of materials - 1.0g.

20% R.H —— o —— 85% R.H —— X ——

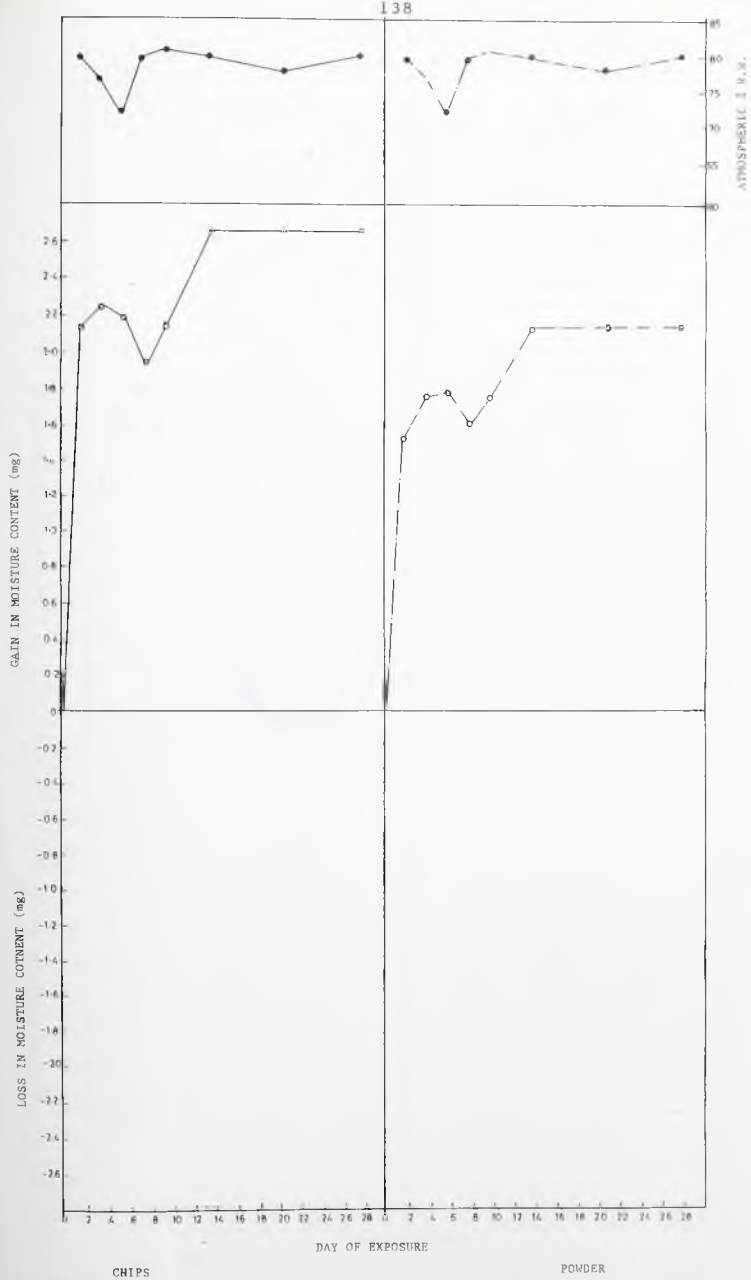


Fig. 13: Moisture gained by Dried Chips and Powdered Chips of Okra exposed under normal atmospheric conditions: initial weight of materials - 1.0g.

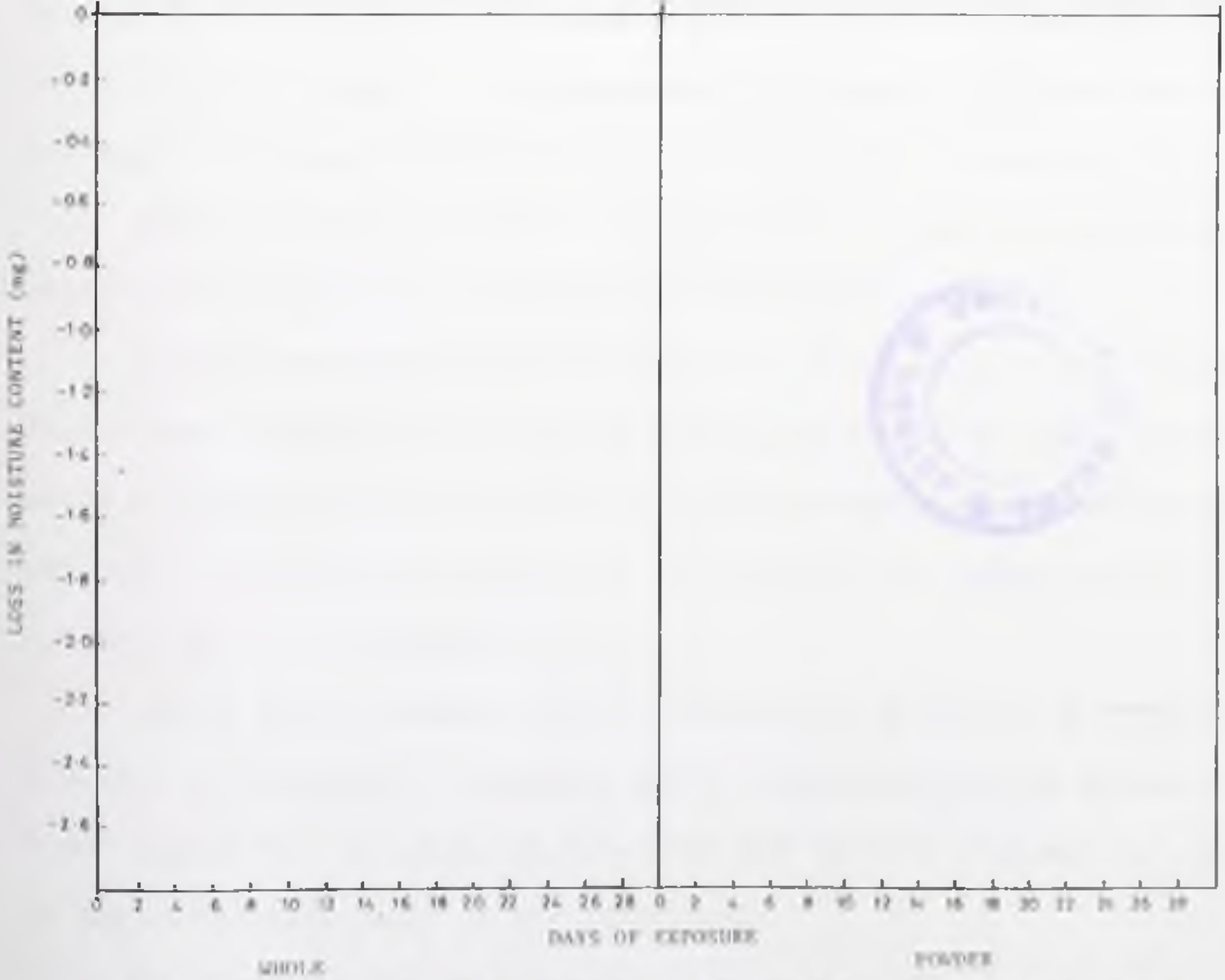
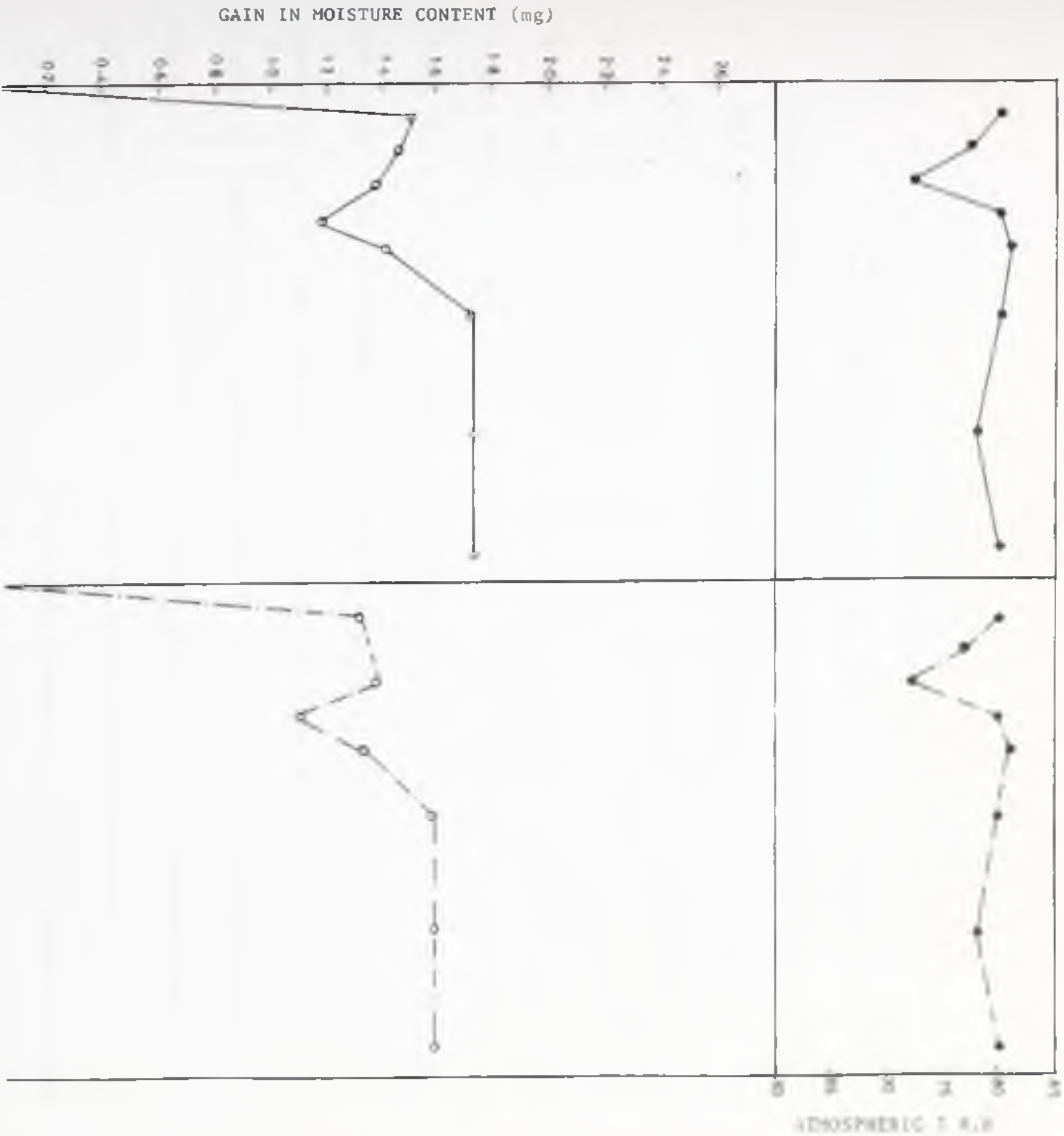


Fig. 4: Moisture gained by Dried Pepper Fruits and Powdered Pepper exposed under normal atmospheric conditions; initial weight of materials - 1.0g.


GAIN IN MOISTURE CONTENT (mg)

J. FUNGAL FLORA OF DRY PEPPER FRUITS AND OKRA FRUIT CHIPS AND THEIR RESPECTIVE FLOURS DURING STORAGE

Lists of fungal species isolated from okra chips and blended okra stored under laboratory condition, 85% RH and 20% RH are presented in Tables 39, 40, 41 and 42. The species occurred at widely varying frequencies; they did not follow any particular pattern of distribution. On the chips and blended okra fruits for all the seasons and under the different conditions, Aspergillus niger was the most abundant of all the species. The dominant species were A. flavus, A. niger, C. herbarum, F. oxysporum and P. cyclopium. The populations of some of the dominant species showed some seasonal appearance. P. cyclopium in particular, was favoured by the rainy season.

In all the set ups, fungal development in the stored chips exposed to the laboratory atmosphere and 85% R.H., the same species, for example, A. niger, P. cyclopium and C. herbarum increased during storage or decreased without any relationship with the season.

Tables 43 and 44 indicate the major species which occurred at different frequencies on stored whole and blended pepper.

The dominant fungal species recorded on whole pepper fruit stored in different atmospheres was Aspergillus flavus during the rainy season while A. niger which was abundant initially almost disappeared during storage. Many species, as shown by Table 44 did not appear at all or appeared at very low frequencies.

During the dry season (Dec.11, 1989 to Jan.8, 1990), A. flavus, A. niger, C. herbarum, F. oxysporum and P. cyclopium occurred at fairly high frequencies. F.oxysporum rose from 20 % to 58 % frequency at 85% RH and in the atmosphere of the laboratory.

The same species were the dominant species on the blended pepper.

Table 39 : Fungi isolated from okra fruit chips after storage at different relative humidities at 30 ± 2°C for 28 days (Dec. 11, 1989 - Jan. 8, 1990)

Species		Initial Percentage Frequency of species	Percentage Frequency of species after incubation for 40 days at		
			The Laboratory	85% RH	20% RH
Aspergillus	flavus	6	10	10	67
Aspergillus	niger	64	23	25	25
Aspergillus	ochraceus	0	0	0	0
Aspergillus	terreus	0	0	2	0
Cladosporium	herbarum	18	28	33	0
Curvularia	lunata	0	0	0	0
Fusarium	oxysporum	0	7	1	0
Penicillium	chrysogenum	0	7	2	0
Penicillium	cyclopium	12	23	27	8
Syncephalastrum	racemosum	0	0	0	0
Synnemarum sp.		0	0	0	0
Yeast spp.		0	0	0	0
Mycelia	sterilia	0	2	0	0

Table 40: Fungi isolated from blended okra fruit after storage at different relative humidities at 30 ± 2°C for 28 days (July 4 - Aug. 1, 1990)

Species		Initial Percentage Frequency of species	Percentage Frequency of species after incubation for 40 days at The Laboratory	85% RH	20% RH
Aspergillus	flavus	20	5	28	26
Aspergillus	niger	20	30	40	3
Aspergillus	ochraceus	0	0	0	0
Aspergillus	terreus	0	0	0	0
Cladosporium	herbarum	20	10	0	0
Curvularia	lunata	0	10	0	0
Fusarium	oxysporum	0	0	0	0
Penicillium	chrysogenum	0	0	0	0
Penicillium	cyclopium	40	30	30	71
Syncephalastrum	racemosum	0	0	0	0
Stemenatum sp.		0	0	0	0
Yeast	spp.	0	15	12	0
Mycelia	sterilia	0	0	0	0

Table 41: Fungi isolated from okra fruit chips after storage at different relative humidities at 30 + 2°C for 28 days (July 4 - Aug. 1, 1990)

Species		Initial Percentage Frequency of species	Percentage Frequency of species after incubation for 40 days at		
			The Laboratory	85% RH	20% RH
Aspergillus	flavus	8	31	9	23
Aspergillus	niger	31	13	37	36
Aspergillus	ochraceus	0	0	0	0
Aspergillus	terreus	0	0	0	0
Cladosporium	herbarum	36	6	6	0
Curvularia	lunata	0	0	0	0
Fusarium	oxysporum	11	8	17	0
Penicillium	chrysogenum	2	8	0	0
Penicillium	cyclopium	12	23	23	29
Syncephalastrum	racemosum	0	1	0	0
Synnematum	sp.	0	8	0	0
Yeast	spp.	0	0	8	0
Mycelia	sterilia	0	0	0	0

Table 42: Fungi isolated from blended okra fruit after storage at different relative humidities at 30 ± 2°C for 28 days (Dec. 11, 1989 - Jan. 8, 1990)

Species		Initial Percentage Frequency of species	Percentage Frequency of species after incubation for 40 days at		
			The Laboratory	85% RH	20% RH
Aspergillus	flavus	22	5	7	0
Aspergillus	niger	32	10	17	57
Aspergillus	ochraceus	0	21	0	0
Aspergillus	terreus	0	5	0	0
Cladosporium	herbarum	19	16	0	0
Curvularia	lunata	0	0	0	0
Fusarium	oxysporum	10	43	35	29
Penicillium	chrysogenum	0	0	0	0
Penicillium	cyclopium	17	0	34	0
Syncephalastrum	racemosum	0	0	7	14
Synnegatum sp.		0	0	0	0
Yeast spp.		0	0	0	0
Mycelia	sterilia	0	0	0	0

Table 43: Fungi isolated from blended pepper fruits after storage at different relative humidities at 30 ± 2°C for 28 days (July 4- Aug.1,1989 or Dec. 11, 1989-Jan. 8, 1990)

Period	Species		Initial Percentage Frequency of species	Percentage Frequency of species after incubation for 40 days at		
				Laboratory	85% RH	20% RH
July-	Aspergillus	flavus	15	32	50	24
August	Aspergillus	niger	24	19	10	6
1989	Aspergillus	terreus	0	0	20	6
	Cladosporium	herbarum	16	11	0	6
	Curvularia	lunata	0	0	0	0
	Fusarium	oxysporum	10	30	0	6
	Penicillium	cyclopium	35	8	20	35
	Rhizopus sp		0	0	0	17
	Syncephalastrum	racemosum	0	0	0	0
	Mycelia	sterilia	0	0	0	0
Dec. 1988-	Aspergillus	flavus	10	8	8	6
Jan. 1989	Aspergillus	niger	23	10	10	10
	Aspergillus	terreus	0	3	0	0
	Cladosporium	herbarum	16	10	22	17
	Curvularia	lunata	0	3	0	6
	Fusarium	oxysporum	18	51	40	31
	Penicillium	cyclopium	33	9	20	24
	Rhizopus sp		0	0	0	0
	Syncephalastrum	racemosum	0	0	0	0
	Mycelia	sterilia	0	6	0	6

Table 44: Fungi isolated from pepper fruits after storage at different relative humidities at 30 ± 2°C for 28 days (July 4- Aug. 1, 1990 and Dec. 11, 1989 - Jan. 8, 1990)

Period	Species		Initial Percentage Frequency of species	Percentage Frequency of species after incubation for 28 days at		
				Laboratory	85% RH	20% RH
July-Aug. 1990	Aspergillus	flavus	22	87	94	95
	Aspergillus	niger	75	4	6	5
	Aspergillus	terreus	0	0	0	0
	Cladosporium	herbarum	0	0	0	0
	Curvularia	lunata	0	0	0	0
	Fusarium	oxysporum	0	2	0	0
	Penicillium	cyclopium	0	0	0	0
	Rhizopus sp.		3	4	0	0
	Syncephalastrum	racemosum	0	0	0	0
	Mycelia	sterilia	0	3	0	0
Dec.1989-Jan.1990	Aspergillus	flavus	16	10	6	8
	Aspergillus	niger	26	15	6	5
	Aspergillus	terreus	0	4	10	0
	Cladosporium	herbarum	11	15	0	16
	Curvularia	lunata	0	0	0	3
	Fusarium	oxysporum	2	48	58	48
	Penicillium	cyclopium	23	8	15	20
	Rhizopus sp.		4	0	5	0
	Syncephalastrum	racemosum	0	0	0	0
	Mycelia	sterilia	0	0	0	0

K. IRRADIATION TREATMENT OF ONION BULBS

Fungal flora of onion bulbs of Red Creole and Texas Grano which had received irradiation treatments are shown in Tables 45 - 55. Plants were raised in the dry season and the rainy season in soils containing either Manure alone or Manure and Sulphate of Ammonia. The tables show fungal flora of:

i. freshly harvested bulbs (Tables 45 and 46)

ii. bulbs cured for 30 days and those cured for 30 days and irradiated at dosages of 0.05 Gy and 0.10 Gy (Tables 47 - 50).

iii. bulbs cured for 30 days, irradiated at dosages of 0.05 and 0.10 Gy and then stored at 90% RH at room temperature for 90 days (Tables 51 - 54).

Very few fungal species were present in substantial numbers on freshly harvested bulbs. Analysis of variance of varieties on fungal flora at harvesting of onion bulbs of Red Creole and Texas Grano varieties in Tables 45 and 46 have shown that the differences in relationship of the two onion varieties with A. niger , F. oxysporum and Yeast spp. were significant ($p \leq 0.05$). Also the seasons the onions were raised had significant effect on growth of A. niger, F.oxysporum and Fusarium sp. There was a very high population of Fusarium oxysporum and Fusarium sp. on bulbs of both varieties grown in the dry season (Table 45). Penicillium cyclopium and Yeast spp. constituted an intermediate group while Aspergillus flavus, Aspergillus niger, Cladosporium herbarum, Penicillium chrysogenum and Rhizopus sp. which occurred at extremely low frequencies constituted a third group.

The picture changed dramatically in bulbs formed during the rainy

Table

Onion Variet	Rhizopus species	Syncephalastrum racemosum	Trichoderma viride	Yeast spp.
Red Cr	0	0	0	5
	0	0	0	15
	0	0	0	10
	0	0	0	0
	0	0	0	26
	0	0	0	46
	0	0	0	21
	0	0	0	0
Texas	0	0	0	1
	0	0	0	1
	0	0	0	0
	0	0	0	0
	1	0	0	21
	0	0	0	13
	0	0	0	11
	0	0	0	0

*1. (

Rhizopus species	*Syncephalastrum racemosum*	*Trichoderma viride*	Yeast spp.
0	0	0	41
0	0	0	0
0	0	0	0
9	0	0	0
0	0	0	10
0	0	0	0
0	0	0	0
0	0	0	9
1	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
1	0	0	0
0	0	0	0
0	0	0	0
3	0	0	0

Table 55: Ascorbic acid (Vitamin C) content of irradiated onion bulbs after 90 days' storage at 80% RH at room temperature.

Period Plants Raised	Onion Variety	Dosage (Gy)	Ascorbic acid content (mg/100g)
Dry Season			
Nov.,1988-	Red Creole	0.0	9.4
Feb.,1989		0.05	8.5
		0.10	8.5
	Texas Grano	0.0	9.4
		0.05	10.8
		0.10	10.2
Rainy Season			
April-June,	Red Creole	0.0	8.0
1989		0.05	10.0
		0.10	10.0
	Texas Grano	0.0	11.5
		0.05	9.8
		0.10	8.3

Season. A. niger constituted the dominant flora, and C. herbarum and F. oxysporum and P. cyclopium formed an intermediate group. The rest formed the third group of very low percentage frequency of occurrence (Table 46).

Manure, and Manure and Sulphate of Ammonia treatments significantly ($p < 0.05$) increased growth of F. oxysporum. However, there was no significant difference between Manure, and Manure and Sulphate of ammonia treatments, as shown by the calculations in Appendices M-Q.

Curing for 30 days produced notable changes in the fungal flora of the bulbs as shown in Tables 47 - 50.

(a) Alternaria alternata and Trichoderma viride which were not isolated from the freshly harvested bulbs occurred on the cured bulbs, although at very low frequencies. Significantly, greater numbers of C.herbarum, F.oxysporum, Fusarium sp., P. cyclopium, and T.viride were associated with Texas Grano variety while Red Creole was a significantly better substrate for Rhizopus sp. A.niger and Alternaria alternata on the other hand occurred to the same extent on the two varieties as shown in Appendices R-Y.

(b) Bulbs of plants grown in the dry season showed more dominant species. Four species, A. niger, C. herbarum, F. oxysporum and P. cyclopium occurred in far greater quantities than any of the rest (Tables 47 and 48).

(c) The intermediate category consisted of only Fusarium sp. while very few colonies of the rest were encountered.

There is no consistent effect of irradiation on the fungal species. Gamma irradiation did not suppress fungal growth. Contamination of irradiated bulbs by F.oxysporum, Rhizopus sp. and

T.viride increased significantly ($p \leq 0.05$) (Appendices U, X and Y). It increased C. herbarum and F. oxysporum frequency in Red Creole bulbs (Table 47), decreased A. niger frequency and had inconsistent effect on P. cyclopium. The rest did not seem to have been affected by irradiation.

In Texas Grano bulbs, irradiation increased the incidence of F. oxysporum and decreased the incidence of A. niger. There was no effect at all on the other species or had inconsistent effect as with C. herbarum and P. cyclopium.

Two very outstanding results were provided by bulbs of Red Creole and Texas Grano plants grown in the rainy season. While irradiation at both 0.05 and 0.10 Gy highly stimulated A. niger, it completely eliminated Rhizopus sp. and Trichoderma viride (Tables 49 and 50).

Curing followed by irradiation and then storage for 90 days did not eliminate the fungi. As shown in Tables 51-54, significantly higher levels of incidence ($p \leq 0.05$) of A.niger, Rhizopus sp., S.racemosum , T.viride and Yeast spp. occurred on both varieties. The calculations are given in Appendices A_1, C_1,D_1,E_1 and F_1.

Three species appeared on the irradiated bulbs during the long storage of 90 days at 80% RH at room temperature. These were Aspergillus clavatus, Curvularia lunata, and Syncephalastrum racemosum. Apart from the highly dominant A. niger, the rest occurred at very low frequencies on all the bulbs (Tables 51-54) of the two varieties and of the various treatments.

The levels of Ascorbic acid (Vitamin C) of bulbs of the plants grown in soils with Manure and Sulphate of Ammonia and irradiated are shown in Table 55. Curiously, irradiation at both 0.05 and 0.10 Gy raised the levels of Ascorbic acid in one batch of bulbs of Red Creole

and Texas Grano and reduced them in the other batch of each variety, irrespective of the initial concentration.

The effect of gamma irradiation on rotting and sprouting and on the loss of weight of the bulbs of onion are tabulated in Table 56. It is clear that sprouting is reduced or completely prevented by some of the treatments. Suppression of sprouting increased as gamma dosage increased. The pattern of rotting, on the other hand showed three different trends. For example, rotting was reduced by irradiation of Red Creole bulbs from soils treated with manure only. Irradiation, on the other hand, increased rot in some bulbs such as Red Creole bulbs of the rainy season in soils treated with a combination of Manure and Sulphate of Ammonia, while it had no effect in certain instances. Examples are dry season bulbs of Red Creole variety of soils treated with Manure and Sulphate of Ammonia and bulbs of Texas Grano of soils treated with manure only.

Table 56: Rotting and sprouting of onion bulbs stored at 30 °C for 3 months after gamma irradiation

Onion Variety and Seasons of Planting	Soil Treatment	Effect on Bulb	Bulbs irradiated with Gamma dosages (Gy)		
			0.0	0.5	0.10
RED CREOLE					
Dry Season Crop	Manure and Sulphate of Ammonia	No. of rotted bulbs out of 10	1	1	1
		No. of sprouted bulbs out 10	6	0	0
		% Weight loss	15.9	8.33	10.07
	Manure	No. of rotted bulbs out of 10	1	0	0
		No. of sprouted bulbs out 10	3	1	1
		% Weight loss	11.02	7.65	8.62
Rainy Season Crop	Manure and Sulphate of Ammonia	No. of rotted bulbs out of 10	1	4	2
		No. of sprouted bulbs out 10	0	0	0
	Manure	No. of rotted bulbs out of 10	2	1	1
		No. of sprouted bulbs out 10	0	0	0
		% Weight loss	11.83	18.93	11.88

Table 56: Contd.

Onion Variety and Seasons of Planting	Soil Treatment	Effect on Bulb	Bulbs irradiated with Gamma dosages (Gy) 0.0	0.5	0.10
TEXAS GRANO					
Dry Season Crop	Manure and Sulphate of Ammonia	No. of rotted bulbs out of 10	1	0	0
		No. of sprouted bulbs out 10	6	0	0
		% Weight loss	16.96	4.67	12.02
	Manure	No. of rotted bulbs out of 10	1	1	1
		No. of sprouted bulbs out 10	4	0	0
		% Weight loss	15.19	9.98	5.14
Rainy Season Crop	Manure and Sulphate of Ammonia	No. of rotted bulbs out of 10	9	9	6
		No. of sprouted bulbs out 10	0	0	0
		% Weight loss	*	-	-
	Manure	No. of rotted bulbs out of 10	9	7	7
		No. of sprouted bulbs out 10	0	0	0
		% Weight loss	-	-	-

* Rotting too extensive

L. PATHOGENICITY OF FUNGI ISOLATED FROM TOMATO FRUITS

Infection of tomato fruits inoculated with 15 fungal species varied with the fungal species, and with the mode of inoculation. It was observed that, with all the three tomato varieties, Heinz, Roma and Wosowoso:

(a) some of the fungal species - Aspergillus terreus, Alternaria alternata, Corynespora casiicola, Curvularia lunata, Fusarium oxysporum, Nigrospora oryzae and Scopulariopsis brevicaulis - caused considerable rot while the rest had negligible effect, even when inoculated into wounds, and

(b) in case of the virulent fungal species, rot was greater when the fruits were wound-inoculated than when the inocula were placed on the intact fruit skin.

Eight species, namely, Aspergillus clavatus, Aspergillus glaucus, Cladosporium herbarum, Helminthosporium sp., Penicillium citrinum, Penicillium funiculosum, Syncephalastrum racemosum and Trichothecium roseum, were found to be non-virulent caused very slowly growing rot as shown in Table 57.

The development of the rot in fruits inoculated with the virulent fungal species compared with that of fruits inoculated with C. herbarum, an example of a non-virulent species, is shown in Figs. 15 and 16. The graphs show that there was generally a rapid development of the rot between the 4th and 6th days of incubation.

Table : 57 Rotting of tomato fruits inoculated with different fungal species and incubated at 27 C for 10 days

Inoculum	Tomato Variety	Type of Inoculation	Mean Rot Diameter (mm) after 6 Days	10 Days
Alternaria alternata	Heinz	Surface	18.5±0.5	24.5±0.5
		Wound	29.5±1.0	60.0±0.5
	Roma	Surface	12.5±0.5	15.0
		Wound	18.5±0.5	36.0±0.5
	Wosowoso	Surface	21.5±0.5	27.0
		Wound	36.5±1.0	70.0±0.5
Aspergillus clavatus	Heinz	Surface	5.5	5.5
		Wound	5.5	5.5
	Roma	Surface	6.0	6.0
		Wound	6.5	6.5
	Wosowoso	Surface	5.0	5.0
		Wound	6.0	6.0
Aspergillus glaucus	Heinz	Surface	4.5	6.5
		Wound	5.0	8.0
	Roma	Surface	6.0	6.0
		Wound	6.5	6.5
	Wosowoso	Surface	4.7	7.0
		Wound	5.0	9.0

Table 57: Contd.

Aspergillus terreus	Heinz	Surface	9.0 ± 0.1	15.0
		Wound	46.5 ± 0.5	75.5 ± 1.5
	Roma	Surface	8.5 ± 0.1	13.0
		Wound	41.5 ± 0.5	59.5 ± 0.5
	Woso-woso	Surface	12.0	28.5 ± 0.1
		Wound	59.5 ± 0.5	82.0 ± 0.5
Cladosporium herbarum	Heinz	Surface	5.0	6.0
		Wound	6.0	7.5 ± 0.1
	Roma	Surface	5.0	6.0
		Wound	5.0	6.5 ± 0.1
	Woso-woso	Surface	5.0	6.0
		Wound	9.0	9.0
Corynespora casiicola	Heinz	Surface	16.0	21.0
		Wound	28.5 ± 0.1	64.0 ± 1.0
	Roma	Surface	15.3 ± 0.3	19.0
		Wound	36.0 ± 0.1	65.5 ± 0.5
	Woso-woso	Surface	17.0	22.0
		Wound	21.0	69.0 ± 1.0
Curvularia lunata	Heinz	Surface	8.5 ± 0.1	16.5 ± 0.1
		Wound	10.5 ± 0.1	29.5 ± 0.5
	Roma	Surface	7.0	12.0
		Wound	8.0	21.5 ± 0.5
	Woso-woso	Surface	11.5 ± 0.5	18.5 ± 0.5
		Wound	38.5 ± 0.5	62.0 ± 1.0

Table 57: Contd.

Penicillium funiculosum	Heinz	Surface	3.0	3.0
		Wound	3.0	3.0
	Roma	Surface	3.0	3.0
		Wound	3.0	3.0
	Woso-woso	Surface	3.0	3.0
		Wound	3.0	3.0
Scopulariopsis brevicaulis	Heinz	Surface	15.0	36.5 ± 0.5
		Wound	42.0 ± 1.0	67.0 ± 1.0
	Roma	Surface	13.0	13.0
		Wound	40.5 ± 0.5	52.5 ± 0.5
	Woso-woso	Surface	17.5 ± 0.5	37.5 ± 0.5
		Wound	37.0 ± 1.0	65.5 ± 1.0
Sncephalastrum racemosum	Heinz	Surface	5.3 ± 0.4	5.3 ± 0.4
		Wound	6.7 ± 0.2	6.7 ± 0.2
	Roma	Surface	5.3 ± 0.4	5.3 ± 0.2
		Wound	6.7 ± 0.2	6.7 ± 0.2
	Woso-woso	Surface	5.3 ± 0.4	5.3 ± 0.4
		Wound	5.6 ± 0.3	5.6 ± 0.4
Trichothecium roseum	Heinz	Surface	7.5 ± 0.1	12.5 ± 0.1
		Wound	18.5 ± 0.5	39.5 ± 0.5
	Roma	Surface	7.0	10.5 ± 0.1
		Wound	18.5 ± 0.5	32.5 ± 0.5
	Woso-woso	Surface	8.3 ± 0.4	15.0
		Wound	18.6 ± 0.3	45.0 ± 0.5

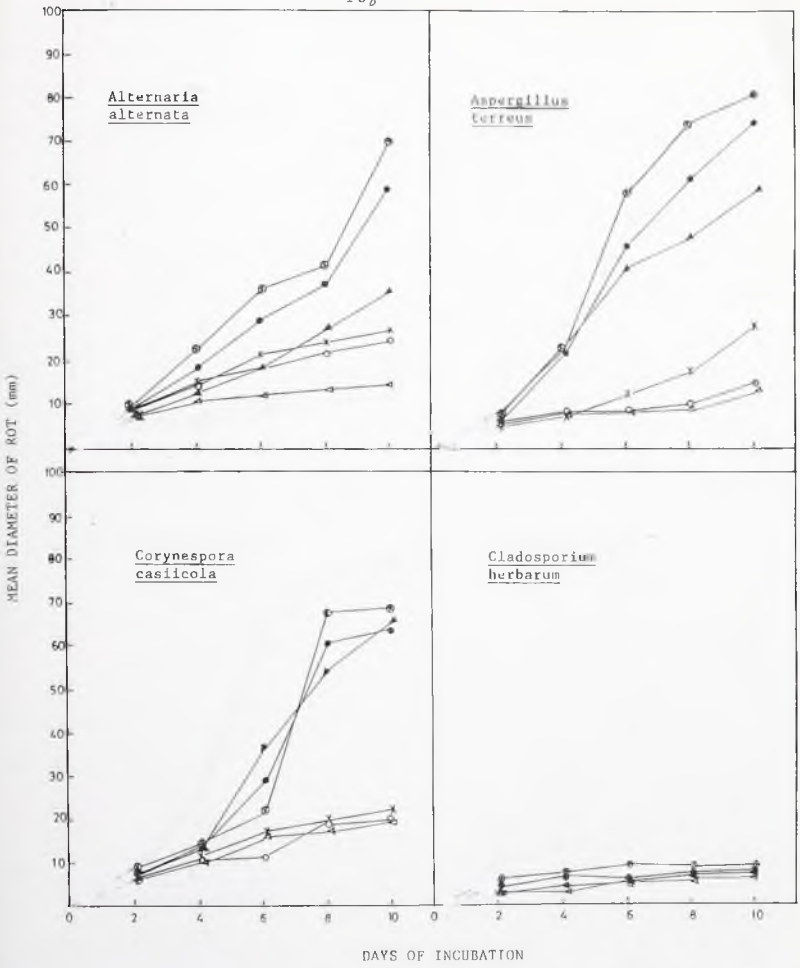


Fig. 15 Growth of lesions in Tomato Fruits inoculated with A. alternata, A. terreus, C. casiicola and C. herbarum and incubated at 27°C for 10 days.

Heinz : Surface-inoculated —o— wound-inoculated —•—

Roma : Surface-inoculated —◄— wound-inoculated —◄—

Wosowoso : Surface-inoculated —×— wound-inoculated —⊕—

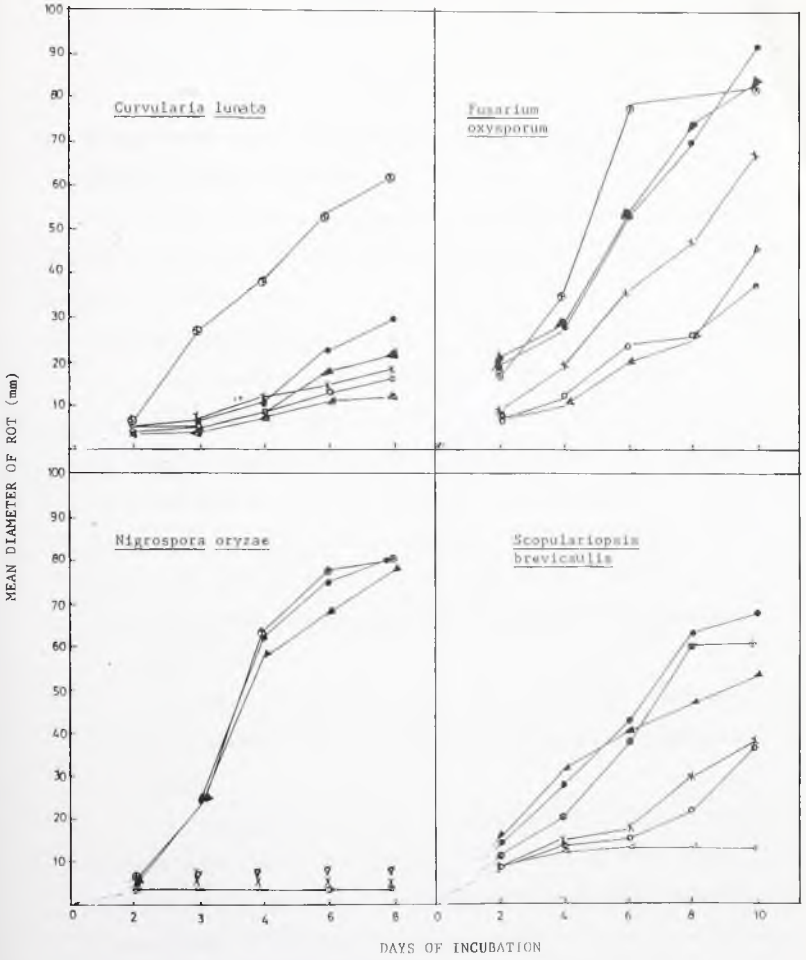


Fig. 16 : Growth of lesions in Tomato Fruits inoculated with C. lunata, F. oxysporum, N. oryzae and S. brevicaulis and incubated at 27°C for 10 days.

Heinz : Surface-inoculated — Wound-inoculated

Roma : Surface-inoculated — Wound-inoculated

Wosowoso : Surface-inoculated — Wound-inoculated

M. GERMINATION OF SPORES IN EXTRACTS OF ONION BULBS AND FRUITS OF PEPPER AND TOMATO

The results in Tables 58-61 were obtained from germination tests using different extracts, with pHs lying between pH 3.9 and 5.7, and spores of different fungi.

(a) Germination of Conidia in extracts of onion bulbs

The conidia showed different levels of germination in distilled water as shown in Table 58. Conidia of A. flavus and A. niger did not germinate in distilled water; those of T. viride attained only 8.7 per cent germination in 24 hours while C. casiicola, C. lunata and F. oxysporum conidia germinated very well, 100, 95.3 and 89.7 per cent, respectively. Conidia of C. casiicola, and F. oxysporum achieved those levels of germination in only 8 hours.

Extracts of bulbs of both onion varieties completely inhibited germination of conidia of C. casiicola, C. lunata and T. viride.

F. oxysporum conidia did not germinate in extract of Red Creole bulb and did so sparingly in extract of Texas Grano. Conidia of A. niger showed the highest percentage germination in the extracts, followed by A. flavus conidia.

(b) Germination of spores in tomato fruit extracts

The results of the tests are shown in Table 59. The extracts highly stimulated germination of conidia of Helminthosporium sp. and C. lunata and sporangiospores of S. racemosum, but reduced percentage germination, particularly extract of Heinz fruits, of conidia of A. alternata.

Table 58: Germination of condia of various fungal species in undiluted extract of Onion bulb varieties at 30 ± 2 ^{0}C

Fungus	Onion Variety	pH	% Germination after following hours			
			8	10	12	24
Aspergillus flavus	Red creole	5.7	0.0	0.0	0.0	16.2
	Texas Grano	5.3	0.0	0.0	0.0	18.2
	Distilled Water	4.9	0.0	0.0	0.0	0.0
Aspergillus niger	Red creole	5.7	0.0	0.0	0.0	36.4
	Texas Grano	5.3	0.0	0.0	0.0	100
	Distilled Water	4.9	0.0	0.0	0.0	0.0
Corynespora casiicola	Red creole	5.7	0.0	0.0	0.0	0.0
	Texas Grano	5.3	0.0	0.0	0.0	0.0
	Distilled Water	4.9	98.0	100	100	100
Curvularia lunata	Red creole	5.7	0.0	0.0	0.0	0.0
	Texas Grano	5.3	0.0	0.0	0.0	0.0
	Distilled Water	4.9	62.4	92.0	93.0	95.3
Fusarium oxysporum	Red Creole	5.7	0.0	0.0	0.0	0.0
	Texas Grano	5.3	0.0	0.0	0.4	2.7
	Distilled Water	4.9	89.7	89.7	89.7	89.7
Trichoderma viride	Red creole	5.7	0.0	0.0	0.0	0.0
	Texas Grano	5.3	0.0	0.0	0.0	0.0
	Distilled Water	4.9	0.0	5.2	5.9	8.7

Table 59: Germination of various fungal spores in undiluted extracts of Tomato fruit varieties at 30 ± 2 °C

Spore	Tomato Variety	pH	% Germination after following hours 4	6	8
Alternaria alternata conidia	Heinz	4.2	24.4	69.6	75.5
	Roma	3.9	44.9	76.2	82.5
	Wosowoso	4.1	42.3	88.0	98.3
	Distilled Water	4.9	80.5	100	100
Curvularia lunata conidia	Heinz	4.2	88.3	97.0	100
	Roma	3.9	92.9	96.3	99.2
	Wosowoso	4.1	91.3	95.0	100
	Distilled Water	4.9	92.0	93.0	95.3
Helminthosporium sp conidia	Heinz	4.2	93.0	97.6	100
	Roma	3.9	98.5	99.8	100
	Wosowoso	4.1	100	100	100
	Distilled Water	4.9	9.2	12.8	15.6
Syncephalastrum racemosum sporangiospores	Heinz	4.2	0.0	0.0	57.4
	Roma	3.9	0.0	0.0	95.5
	Wosowoso	4.1	0.0	0.0	60.7
	Distilled Water	4.9	0.0	0.0	0.0

Table 60: Germination of macroconidia of Fusarium oxysporum in extract of Tomato fruits at 30 ± 2 °C

Tomato Variety	Extract Dilution	pH	% Germination after following 4	6	8
Heinz	Undiluted	4 . 2	17 . 8	100	100
	1 : 1	4 . 1	25 . 9	100	100
	1 : 2	4 . 1	49 . 9	100	100
	1 : 5	4 . 1	65 . 2	100	100
	1 : 10	4 . 1	100	100	100
Roma	Undiluted	3 . 9	16 . 6	86. 8	100
	1 : 1	3 . 9	24 . 7	100	100
	1 : 2	3 . 8	48 . 5	100	100
	1 : 5	3 . 9	55 . 2	100	100
	1 : 10	3 . 9	100	100	100
Wosowoso	Undiluted	4 . 1	14 . 0	16. 4	100
	1 : 1	4 . 2	16 . 0	59. 9	100
	1 : 2	4 . 2	28 . 9	99. 4	100
	1 : 5	4 . 1	37 . 6	100	100
	1 : 10	4 . 1	100	100	100
	Distilled Water	4 . 9	95 . 7	100	100

Table 61: Germination of Conidia of C. casiicola in extract of Onion and fruit of Pepper and Tomato at 30 ± 2 °C

Plant	Variety	Extract dilution	pH	% Germination after following hours 4	6	8
Pepper	Long Fruited	Undiluted	5.6	75.0	83.0	100
		1 : 1	5.7	79.0	88.0	100
		1 : 2	5.8	95.0	97.0	100
		1 : 5	5.9	94.0	97.0	100
		1 :10	5.9	100	100	100
Tomato	Heinz	Undiluted	4.2	69.0	90	100
		1 : 1	4.1	65.2	81.3	100
		1 : 2	4.1	74.2	90.8	100
		1 : 5	4.1	76.1	91.4	100
		1 :10	4.1	58.3	83.6	100
	Roma	Undiluted	3.9	65.1	76.2	100
		1 : 1	3.9	74.9	86.8	100
		1 : 2	3.8	78.6	89.3	100
		1 : 5	3.9	86.2	95.1	100
		1 :10	3.9	92.4	96.2	100
	Wosowoso	Undiluted	4.1	38.9	72.4	100
		1 : 1	4.2	89.2	90.6	100
		1 : 2	4.2	76.3	90.8	100
		1 : 5	4.1	70.2	93.5	100
		1 :10	4.1	66.0	89.0	100
Onion	Red Creole	Undiluted	5.7	0.0	0.0	0.0
		1 : 1	5.7	0.0	0.0	0.0
		1 : 2	5.7	0.0	0.0	0.0
		1 : 5	5.7	0.0	1.0	2.0
		1 :10	5.7	5.0	6.0	8.5
	Texas Grano	Undiluted	5.3	0.0	0.0	0.0
		1 : 1	5.3	0.0	0.0	0.0
		1 : 2	5.3	0.0	0.0	0.0
		1 : 5	5.3	0.0	0.0	0.0
		1 :10	5.3	0.0	0.0	0.0
	Distilled Water		4.9	84.2	95.6	97.5

All the spores germinated in distilled water except those of S. racemosum.

(c) Germination of macroconidia of Fusarium oxysporum in tomato fruit extracts

The conidia were germinated in the various dilutions of tomato fruit extracts indicated in Table 60. All the conidia germinated in 8 hours in distilled water and in the various media. Rate of germination was, however, faster in distilled water than in the tomato fruit extracts.

(d) Germination of conidia of C. casiicola in various extracts

The results of germination tests using different dilutions of onion bulb extract, and extracts of fruits of pepper and tomato are shown in Table 61. The different dilutions of extracts of pepper and tomato fruits supported 100 per cent germination in 8 hours compared to 97.5 per cent in distilled water whereas no germination occurred in the extracts of Texas Grano bulbs and in the higher concentrations of extract of Red Creole bulbs.

N. GROWTH OF C. CASTICOLA (BERK AND CURTIS) C.T. WEI IN NATURAL AND SEMI-SYNTHETIC MEDIA.

The data in Table 63 also showed that C. castlcola grew at different rates in the six natural and semi-synthetic media. Taking the maximum mycelium dry weight achieved in each case, the media can be arranged in order of suitability for growth as follows:
Sweet potato dextrose > Potato dextrose > Cassava dextrose >Yeast extract > Pawpaw extract > V-8 juice. Details of the statistical analysis are shown in Appendices K $_1$ (i) and (ii).

The patterns of growth were quite varied:

(a) The fungus was still growing by the 10th day in the Sweet potato and Yeast extract media.

(b) Mycelial dry weight reached a maximum by the 8th day of incubation in the Pawpaw extract and remained unchanged till the end of incubation.

(c) The mycelial dry weight reached a maximum by the 6th day of incubation in the Cassava dextrose, Potato dextrose and V-8 juice and then declined.

As shown in Fig. 17, in all cases the pH drifted from initial pH's ranging from pH 4.2 to pH 5.9 to the alkaline side ranging from pH 7.5 to pH 8.6, on the 10th day of incubation. In contrast, changes in the conductivity of the media did not show a uniform trend. It increased in Sweet potato dextrose, V-8 juice and Yeast extract media while it decreased in the Cassava dextrose, Pawpaw extract and Potato dextrose media during growth of the fungus.

Extent of growth differed in the extracts of the host plants as

TABLE 62: Growth of C. casiicola in broth of different natural media at 30±2°C under normal day night conditions

Broth	Mean Dry wt (mg)±S.E. of mycelium after following days incubation				
	2	4	6	8	10
Cassava Dextrose	43.0±0.6b	140.0±0.8c	180.0±0.5c	180.0±2.6c	108±1.5b
Pawpaw Extract	20.0±0.0a	47.0±0.6b	63.0±0.8b	90.0±1.0b	50.0±1.2a
Potato Dextrose	53.0±1.8b	250.0±2.0d	270.0±2.5d	230.0±0.6d	246.0±0.9c
Sweet Potato Dextrose	63.0±0.8c	230.0±2.6a	276.0±2.8d	296.0±2.3b	313.0±0.6d
V-8	12.5±0.8a	52.5±0.5b	102.5±0.5c	67.5±2.8a	66.0±0.3a
Yeast Extract	10.0±1.0a	37.0±0.8a	37.0±0.8a	86.0±2.0b	136.0±1.8b

By the calculated Scheffe's Confidence Limit values in vertical rows bearing the same letters are not significantly different at 5% level of probability.

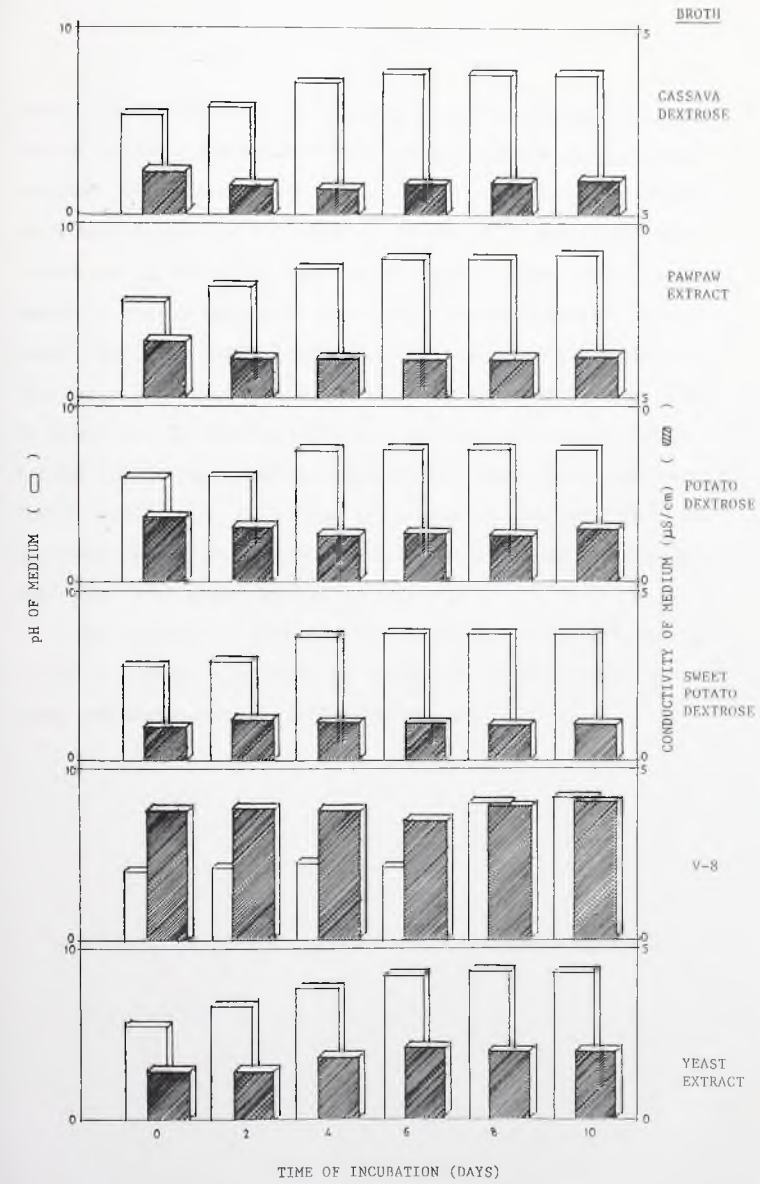


Fig 17: Hydrogen ion concentration and conductivity of different natural media during growth of C. casiicola at 30±2°C.

shown by the data in Table 63. Analysis of variance and multiple range test of the data (Appendices N_1 (i) and (ii) confirm the conclusions obtained. Growth was poorest in the pepper fruit extract. By the 8th day a maximum mycelium dry weight of 106.0mg was attained compared to a value of 322.0mg of the mycelium in the onion bulb extract on the same day. The dry weights of the mycelia declined thereafter, in both media. The fungus was still growing in the tomato fruit extract by the 10th day of incubation giving a mycelium dry weight of 296.0mg. Fig. 18 showed that the pH of all the media was initially acidic - pH 5.5, 5.2 and 4.6 for the extracts of onion bulbs, pepper fruits and tomato fruits, respectively. It shifted to the alkaline side (pH 7.9) in the onion bulb extract by the 10th day, while the pH's of the remaining two media were still acidic (pH 5.6 and 5.7).

The conductivity decreased in the onion bulb extract from an initial 2.4 uS/cm to a final 1.4 uS/cm, but hardly changed in the pepper and tomato extracts as shown by Fig. 18.

TABLE 63: Growth of C. casiicola in extracts of onion bulb and fruits of pepper and tomato at 30±2°C under normal day-night condition .

Time of Incubation (Days)	Mean dry weight (mg)±S.E. of mycelium in extracts of		
	Onion bulb	Pepper fruit	Tomato fruit
2	22.0±2.0a	44.0±2.5b	28.0±2.0a
4	90.0±2.5b	52.0±2.0a	116.0±2.5b
6	284.0±2.5c	58.0±2.0a	200.0±3.2b
8	322.0±2.0b	106.0±4.0a	276.0±2.5b
10	278.0±2.7b	87.5±2.5a	296.0±4.0b

By the calculated Scheffe's Confidence Limit values in horizontal rows bearing the same letters are not significantly different at 5% level of significant.

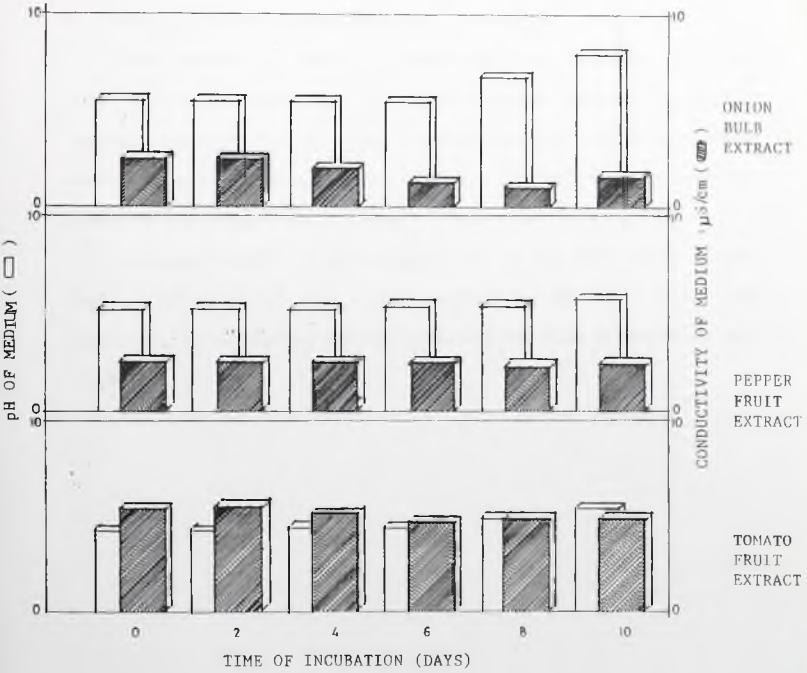


Fig. 18 : Hydrogen ion concentration and conductivity of culture media of extracts of onion bulb and fruits of pepper and tomato during growth of C. casiicola at 30°2°C.

O. EFFECT OF THIAMINE ON GROWTH OF *C. CASIICOLA*

The results in Table 64 showed that external supply of Thiamine at concentrations of 50-400ug/l greatly improved growth of C. casiicola, and the dry weight of the mycelium almost doubled at these concentrations. A concentration of 100ug/l proved to be optimal for growth of the fungus, while 500ug/l Thiamine depressed growth.

Changes in both pH and conductivity of the media were slight. The initial pH's, pH 4.4 - 4.5, shifted to pH 4.9 - 5.1. The conductivities of the media either remained the same or decreased very slightly.

Table 64: Effect of different concentrations of Thiamine on growth of C. casiicola incubated at room temperature (30 ± 2 ^{0}C) for 8 days

Thiamine Concentration (ug/l)	pH of Medium		Conductivity of Medium (uS/cm)		Mean dry weight of mycelium (mg) ± S.E.
	Initial	Final	Inital	Final	
0	4.5	5.0	1.0	0.9	70.0 ± 4.5
50	4.5	5.1	1.0	0.9	130.0 ± 4.5
100	4.4	5.1	1.0	0.9	144.0 ± 2.5
200	4.5	4.9	1.0	0.9	138.0 ± 3.8
300	4.5	5.1	1.0	1.0	136.0 ± 2.5
400	4.5	5.0	0.9	0.9	134.0 ± 2.5
500	4.5	5.1	1.0	0.9	104.0 ± 2.5

P. EFFECT OF TEMPERATURE ON GROWTH OF *C. CASIICOLA*

Mean dry weights of mycelia of C. casiicola growing at 10°, 23°, 27°, 30° and 35°C recorded at 2-day intervals over 10 days of incubation are presented in Table 65. Details of statistical analysis are shown in Appendices 9 (i) and (ii). Growth was very tardy at 10°C. There was better growth at 35°C than 10°C but inferior to growth at 23°, 27° and 30°C. Growth rates at these three temperatures were fairly close and the mean mycelial dry weights by the 10th day were 210, 230 and 250 mg, respectively. The best temperature was obviously 30°C (Plate 1).

The pH, as indicated in Fig. 19 drifted from an initial pH of 5.9 to the alkaline side (pH 7.0) in media at 23°, 27° and 30°C, while it rose to pH 6.8 and 6.9, respectively in media at 10° and 35°C by the 6th day and then fell to pH 6.1 and 6.0 respectively, by the 10th day.

The conductivity of the media (Fig. 19) at 10-30°C decreased during the period of incubation, but increased in the medium at 35°C.

TABLE : 65 Growth of Corynespora casiicola in Sweet Potato Dextrose Broth at different temperatures under normal day-night regime

Temperatures °C	Mean Dry wt (mg)±S.E. of mycelium formed after following days incubation				
	2	4	6	8	10
10	70±0.50a	70±0.80a	70±1.10a	80±1.60a	80±1.10a
23	113±2.50b	240±2.80c	245±4.30d	245±2.80d	210±1.80c
27	137±4.80c	226±3.70c	228±4.10c	240±3.20c	230±3.70c
30	150±4.50d	230±2.50c	236±3.70d	245±2.50c	250±2.89d
35	110±2.50b	163±3.20b	173±4.80b	150±3.70b	150±2.50b

By the calculated Scheffe's Confidence Limit values in vertical rows bearing the same letters are not significantly different at 5% level of probability

Plate 1. Effect of temperature on growth of C. casiicola. (From left to right: 35°C, 30°C, 27°C, 23°C and 10°C). (x1/6).

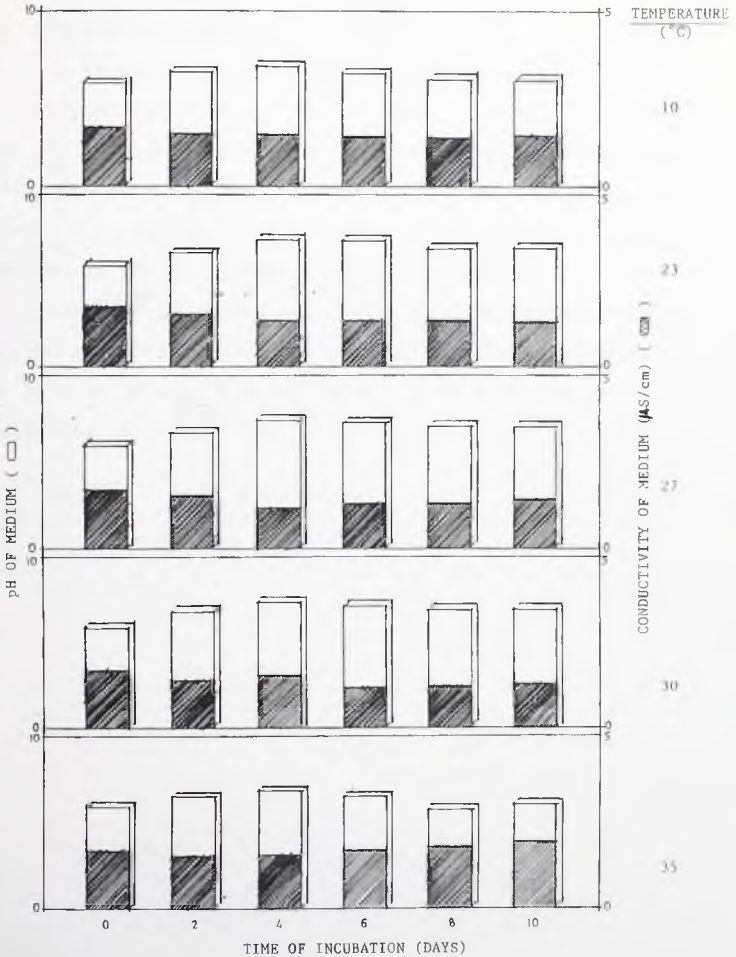


Fig 19: Hydrogen ion concentration and conductivity of Sweet Potato Dextrose Broth at different temperatures during growth of C. casiicola

Q. EFFECT OF PH ON GROWTH OF *C. CASIICOLA*

C. casiicola grew well over a wide pH range of 3.09 to 8.80, with a broad optimum at pH 3.8 - 7.9 as shown in Table 66. The mean mycelial dry weights by the 10th day at this broad optimum pH ranged from 342.0 to 387.5mg and the small differences in weight were not statistically significant ($p \leq 0.05$). Details of the statistical analysis are shown in Appendices R_1 (i) and (ii).

The initial conductivity of the media varied very widely (Table 67) being as low as 2.65 uS /cm at pH 2.6) and as high as 10.41 uS /cm at pH 7.9. Changes in the conductivity were rather slight in the majority of pH's.

TABLE 66: Growth of C. casiicola in buffered basal media of different initial pH's at 30±2°C under normal day night regime

Initial pH	Mean Dry wt (mg)±S.E. after following day incubation			
	4	6	8	10
2.61	74.0±6.8a	137.5±8.5a	157.5±4.8a	160.0±4.5a
3.09	152.0±5.8b	212.0±5.8b	222.5±4.9b	245.0±5.8b
3.77	157.5±6.3d	238.0±8.6d	262.0±5.8d	366.0±6.0d
4.57	177.5±6.3e	262.0±9.2e	328.0±9.7e	374.0±7.5e
5.67	182.5±8.5f	310.0±12.3f	314.0±6.8f	389.5±7.5f
6.49	188.0±6.6e	278.0±6.6e	384.0±6.8e	342.0±5.8e
7.87	72.5±3.0c	220.0±12.3c	280.0±12.3c	340.0±4.1c
8.80	116.0±8.1b	184.0±6.8b	224.0±6.8b	278.0±8.6b

By the calculated Scheffe's Confidence Limit values in vertical rows bearing the same letters are not significantly different at 5% level of probability.

TABLE : 67 Initial and Final pH and Conductivity of buffered media during growth of *Corynespora casiicola* at 30±2°C under normal day/night regime over 10 days

pH		Conductivity (uS/cm)	
Initial	Final	Initial	Final
2.61	2.86	2.65	2.69
3.09	3.21	2.63	3.61
3.77	4.25	4.93	4.43
4.57	4.58	6.00	5.81
5.67	5.81	7.20	6.69
6.49	6.86	9.01	8.63
7.87	6.99	10.14	10.41
8.80	7.43	3.30	4.03

R. EFFECT OF LIGHT ON GROWTH OF *C. CASIICOLA*

The data in Table 68 showed that continuous light significantly ($p \leq 0.05$) depressed growth of C. casiicola. (Appendices U_1 (i) and (ii)). The final mean dry weights of mycelia growing in continuous light, continuous dark and 12h-dark/12h-light regime were 390.0, 462.0 and 532.5mg, respectively. The pH drifted from an initial pH 5.3 to final pH's of 7.2, 7.3 and 7.1, respectively (Fig. 20).

Changes in conductivity of the media also showed similar trends under the three light conditions. It decreased from an initial 1.56 uS /cm to respective final conductivities of 1.13, 1.14 and 1.10 uS/cm.

TABLE 68: Growth of C. casiicola in Sweet Potato Dextrose Broth under different light conditions at 30±2°C

Time of Incubation (Days)	Mean Dry wt (mg)±S.E. of mycelium grown in Continuous Light	Continuous Dark	12hrs light/ 12hrs dark
2	74.0±2.5a	66.0±3.7a	74.0±5.4a
4	166.0±3.2a	210.0±2.8b	198.0±3.4b
6	360.0±3.2a	404.0±3.5b	426.0±3.4b
8	382.0±3.0a	450.0±4.0b	440.0±2.9b
10	390.0±3.6a	462.0±3.9b	532.0±3.4c

By the calculated Scheffe's Confidence Limit values in horizontal rows bearing the same letters are not significantly different at 5 % level of probability

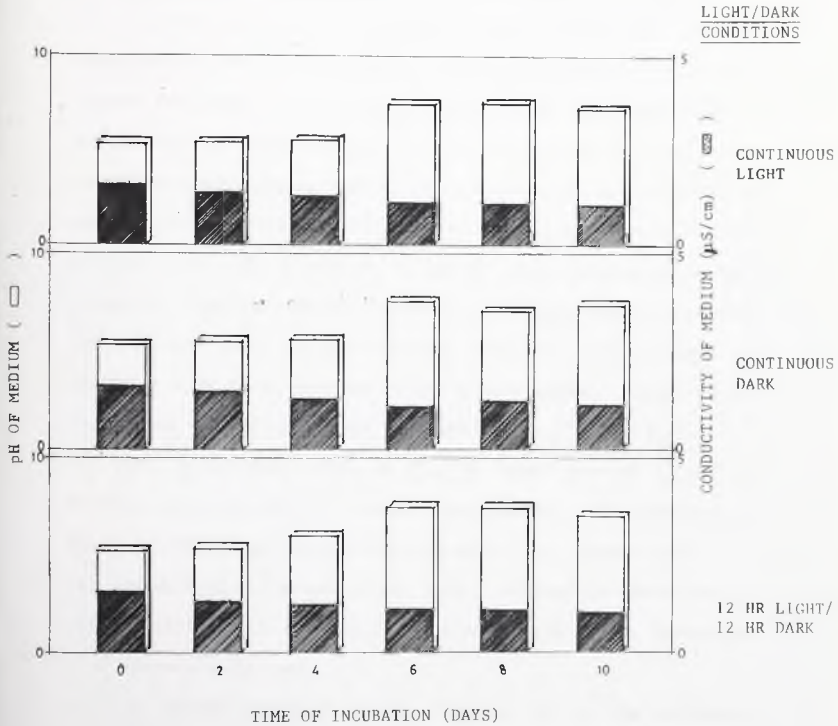


Fig. 20 : Hydrogen ion concentration and conductivity of culture media during growth of C. casiicola under different light conditions of 30 ± 2°C.

S. EFFECT OF DIFFERENT CARBON SOURCES ON GROWTH OF *C. CASIICOLA*

Growth in a basic culture medium containing different carbohydrates was not as great as that of the natural media. The highest mean mycelial dry weight attained was 102.5mg in the Galactose medium, and the lowest was 27.5mg in the Lactose medium. The various sets of mean dry weights recorded are indicated in Table 69. Lactose and sucrose supported the poorest growth (27.5 and 28.0mg dry weight, respectively) inferior even to the control medium (40.0mg dry weight) (Plate 2). Fructose, Glucose and Mannose provided final mean mycelial dry weights of 62.0, 60.0 and 50.0 mg, respectively, while a mean dry weight of 85.0 mg was obtained in the Maltose medium. Details of the statistical analysis are shown in Appendices X_1 (i) and (ii).

The initial pH's shown in Fig. 21 ranged from pH 4.8 in the Fructose medium to pH 5.6 in the Glucose medium. The changes in pH during growth of the fungus divide the media into three groups:

(a) pH drifted to the acidic side in the Fructose and Mannose media;

(b) pH shifted only slightly to the alkaline side in the Maltose and Sucrose media; and

(c) pH shifted markedly to the alkaline side in the Galactose, Glucose, Lactose and Control media.

The conductivity almost doubled in the Lactose and Control media, rose in the Glucose and Mannose media and barely changed in the Fructose, Galactose, Maltose and Sucrose media.

TABLE 69 Growth of C. casiicola in basal medium containing different carbon compounds at a concentration of 1% (w/v) at 30±2°C under normal day - night condition.

Carbon Compound	Mean dry weight (mm)±S.E. of mycelium formed in the following days of incubation			
	4	6	8	10
Fructose	16.0±2.5d	28.0±2.0e	55.0±2.9e	62.0±2.0d
Galactose	24.0±2.5f	46.0±2.5h	84.0±4.0h	102.5±2.5f
Glucose	28.0±2.0e	38.0±2.0f	66.0±2.5f	60.0±3.2d
Lactose	10.0±2.0a	22.0±2.0a	22.0±2.0a	27.5±2.5a
Maltose	14.0±2.5a	38.0±2.0g	70.0±7.2g	85.0±2.9e
Mannose	14.0±2.5a	36.0±2.5d	46.6±2.5d	50.0±5.8c
Sucrose	22.0±2.0b	42.0±2.0c	32.5±2.5c	28.0±2.0a
None	10.0±2.0a	16.0±2.5b	28.0±2.0b	40.0±4.1b

By the calculated Schefte's Confidence Limit values in vertical rows bearing the same letters are not significantly different at 5% level of probability.

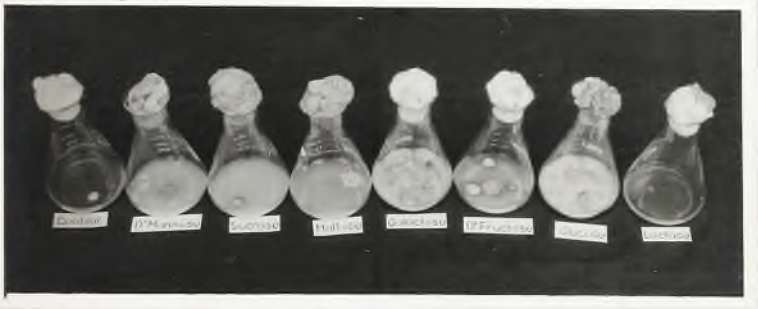


Plate 2. Growth of C. casiicola in basal medium containing different carbohydrates at 30°C.
(From left to right: Control, Mannose, Sucrose, Maltose, Galactose, Fructose, Glucose and Lactose). (x1/7).

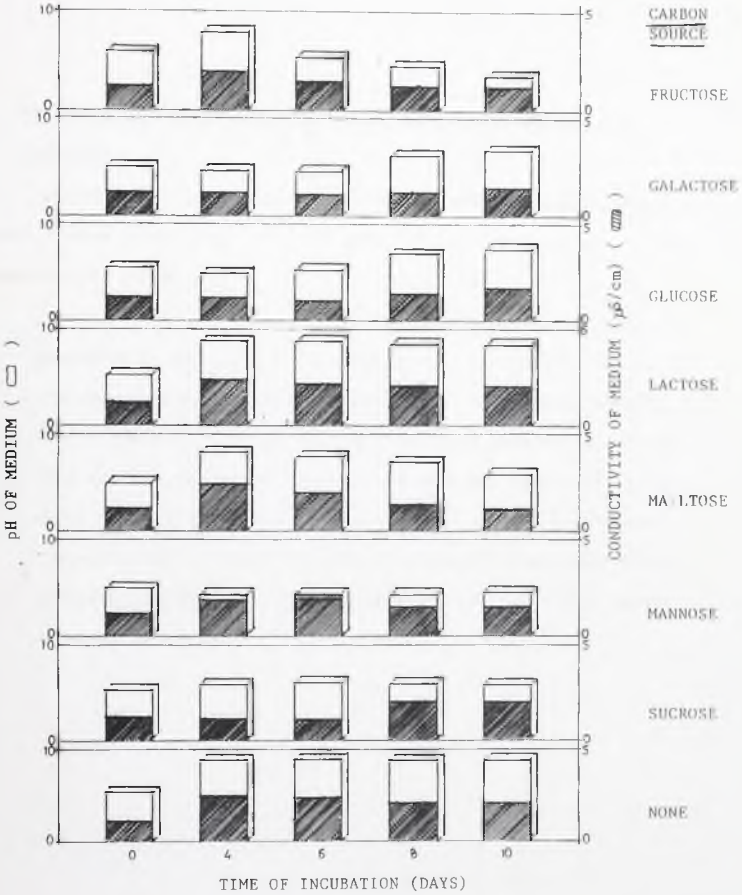


Fig. 21 : Hydrogen ion concentration and conductivity of different media during growth of C. casiicola at 30± 2°C.

T. EFFECT OF DIFFERENT CONCENTRATIONS OF GLUCOSE ON GROWTH OF *C. CASIICOLA*

The data in Table 70 show the extent of growth of C. casiicola in basal medium containing 1.5, 2.0 and 3.0 per cent Glucose. To summarise the effects:

Glucose concentrations of 1.5, 2.0 and 3.0 per cent supported growth of C. casiicola to the same extent, i.e. 152.0, 150.0 and 154.0mg mean dry weight, respectively. Growth was, however, faster in the 3.0 per cent medium, reaching a peak by the 8th day (Table 70). Analysis of variance and multiple range test of the data on Glucose concentrations confirm these observations (Appendices A_7 (i) and (ii)). Both the pH and conductivity of the different Glucose media did not change to any significant degree as shown in Fig. 22.

TABLE 70: Growth of C. casiicola in basal medium containing different amounts of Glucose at 30±2°C under normal day-night regime.

Incubation Time (Days)	Mean dry weight (mm) ±S.E. of mycelium in media with following glucose concentration (%)			
	0.0	1.5	2.0	3.0
2	7.5±2.5a	17.5±2.5b	22.5±2.5c	30.0±2.5d
4	22.0±2.0a	30.0±3.2b	62.0±2.0c	50.0±3.2c
6	36.0±2.5a	74.0±2.5b	96.0±4.0c	114.0±2.5d
8	37.0±2.0a	86.0±2.5b	98.0±3.7c	154.0±2.5d
10	50.0±3.2a	152.0±3.7c	150.0±4.1c	118.0±2.8b

By the calculated Scheffe's Confidence Limit values in horizontal rows bearing the same letters are not significantly different at 5% level of probability.

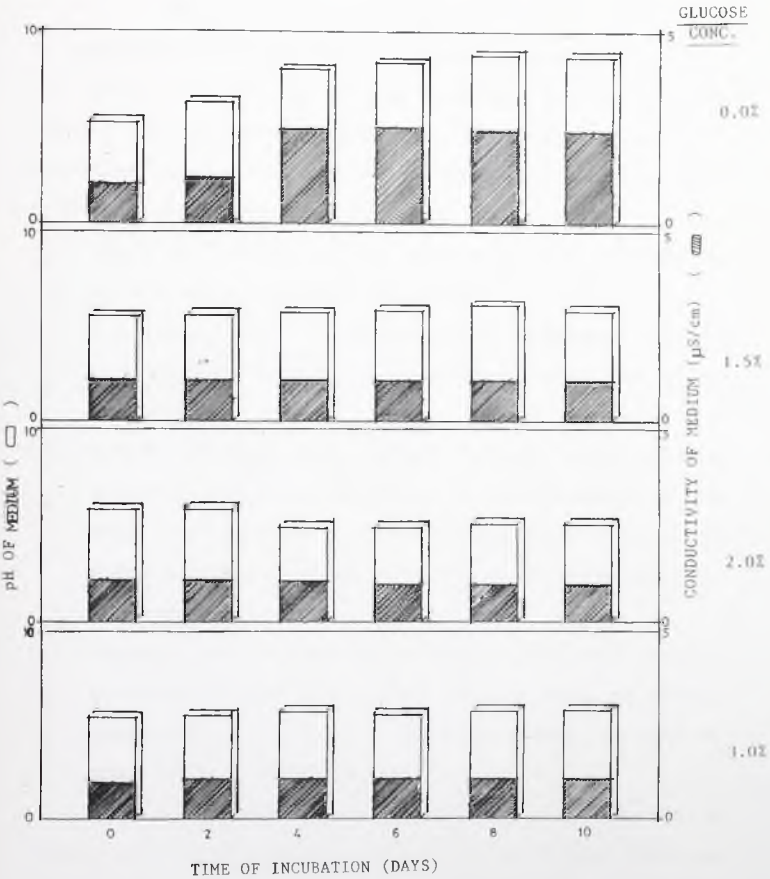


Fig. 22 : Hydrogen ion concentration and conductivity of culture medium with different amounts of Glucose during growth of *C. casiicola* at 30±2°C.

II. INFLUENCE OF NITROGEN COMPOUNDS ON GROWTH OF *C. CASTICOLA*

The effects of seven nitrogen compounds, Ammonium chloride, Ammonium nitrate, Ammonium sulphate, Asparagine, Aspartic acid, Potassium nitrate and sodium nitrate on growth of the fungus presented in Table 71. can be summarised as follows:

(a) Growth was inferior in the Ammonium chloride and Ammonium sulphate media to growth in the control.

(b) Growth was greater in the Ammonium nitrate, Asparagine, Aspartic acid, Potassium nitrate and Sodium nitrate media than in the control medium.

(c) In media producing greater growth than the control, maximum growth was attained by the 8th day in the Ammonium nitrate and Aspartic acid media while the highest mean mycelial dry weight was recorded on the 10th day in the Asparagine, Potassium nitrate and Sodium nitrate media.

(d) Asparagine, Potassium nitrate and Sodium nitrate media produced the highest mean mycelia dry weights of 247.5, 245.0 and 245.0mg, respectively. Details of the statistical analysis are shown in Appendices D $_1$ (i) and (ii).

Figure 23 shows that the pH of the Aspartic acid medium did not change, recording pH of either 3.0 or 3.1 over the 10 days, while the following media: Ammonium chloride (from pH 5.4 to 2.4), Ammonium nitrate (from pH 5.0 to 2.8) and Ammonium sulphate (from pH 4.4 to 2.6) became very acid, and the pH shifted to the alkaline side in the Asparagine medium (pH 5.7 to 7.6) and the neutral range in the Sodium nitrate medium pH 5.4 to 6.3).

TABLE 71: Growth of C. castlicola in basal medium containing different Nitrogen compounds at 30±2°C under normal day night light condition.

Incubation Time (Days)	Mean Dry wt (mg) ± S.E. of mycelium in media with following Nitrogen compounds							
	None	Ammonium Chloride	Ammonium Nitrate	Ammonium sulphate	D-L Asparagine	L-Aspartic acid	Potassium nitrate	Sodium nitrate
2	34.0±2.2b	32.0±1.8b	30.0±2.0b	20.0±0.0a	28.0±1.8b	32.0±3.6b	34.0±2.2c	24.5±1.8a
4	102.0±5.8b	118.0±3.7c	174.0±5.1e	80.0±3.2a	142.0±3.7d	106.0±4.0b	116.0±2.5c	112.0±3.7c
6	200.0±4.5d	188.0±5.8c	190.0±3.7c	88.0±3.7a	182.0±8.0c	202.0±5.8d	152.0±4.9b	186.0±5.1c
8	196.0±2.5b	138.0±2.0a	208.0±4.5c	142.0±3.7a	220.0±7.1d	220.0±3.2d	242.0±3.7e	196.0±4.0b
10	170.0±4.1c	137.5±6.3a	208.0±3.7e	147.5±4.8b	247.0±6.3e	195.0±2.9d	245.0±6.5f	245.0±2.9f

By the calculated Scheffe's Confidence Limit values in horizontal rows bearing the same letters are not signficantly different at 5% level of probability.

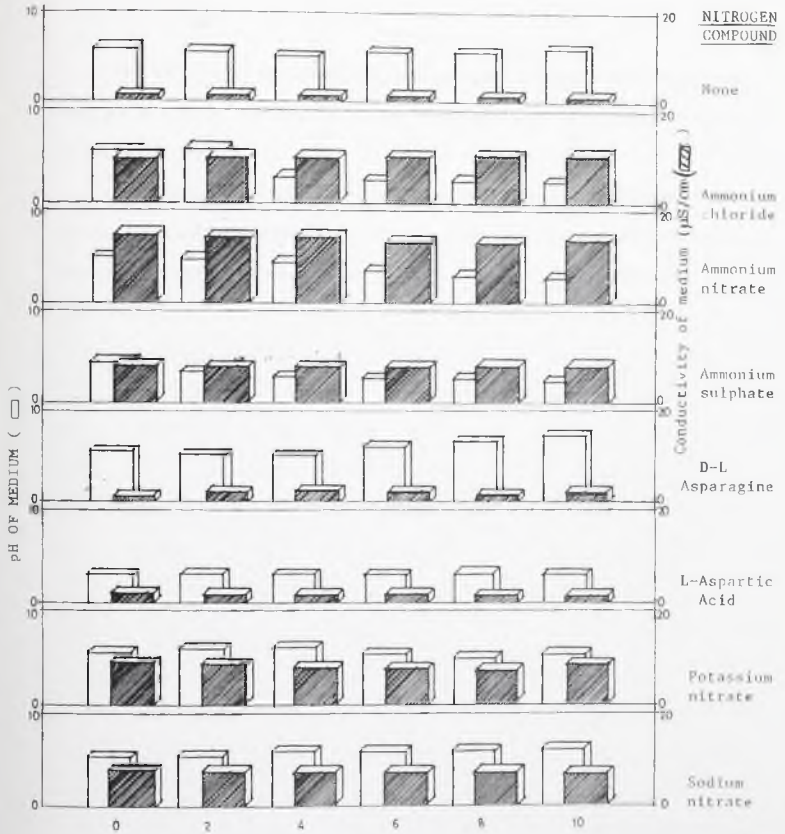


Fig. 23 : Hydrogen ion concentration and conductivity of media with different Nitrogen compounds during growth of C. casiicola at 30 ± 2°C.

The pH of the Potassium nitrate medium, on the other hand, rose from pH 5.5 to 6.2 during the first four days and fell back to pH 5.4 by the 10th day.

The conductivities of the media showed very little change except in the Asparagine medium where it rose from 1.2 to 2.2 uS /cm and in the Sodium nitrate medium where it fell from 8.1 to 7.1 uS /cm.

V. INFLUENCE OF DIFFERENT INORGANIC IONS ON GROWTH OF *C. CASTICOLA*

The different inorganic ions were used at different concentrations as shown in Tables 72, 73, 74, 75 and 76, and their effects cannot, therefore, be compared.

(a) $CaCl_2 . 2H_2O$ (Table 72) supported better growth at concentrations of 14.0 and 29.0 x 10^{-6}M than at 75.0 x 10^{-6}M. Growth was fastest at 29.0 x 10^{-6}M. Details of the statistical analysis are shown in Appendices G_2 (i) and (ii). The pH's of the media rose and then fell back to almost the initial level, while conductivities remained unchanged (Fig. 24).

(b) KCl at concentrations of 8.0 and 12.0 x 10^{-1}M significantly ($p \leq 0.05$) supported greater growth than 4.0 x 10^{-1}M (Table 73; Appendices J_2 (i) and (ii); Plate 3). Both pH and conductivity of the media showed no or very little change (Fig. 25).

(c) K_2SO_4 at a concentration of 5.7 x 10^{-1}M was not significantly ($p \leq 0.05$) a better medium for growth than 11.0 and 17.0 x 10^{-1}M (Table 74; Appendices M_2 (i) and (ii)). In all, the initial pH of 5.0 shifted to pH 6.7 - 6.9, while conductivity hardly changed (Fig. 26).

(e) $MgCl_2$ at a concentration of 10.0 x 10^{-4}M supported greater growth than at 5.0 and 15.0 x 10^{-4}M (Table 75; Plate 4). Details of statistical analysis are shown in Appendices P_2 (i) and (ii). The initial acidic pH's (pH 4.6 - 4.9) became more acidic (pH 3.6 - 4.0) at the end of the incubation period, while the conductivity of the media showed practically no change (Fig. 27).

TABLE 72: Growth of C. casiicola in basal medium containing different amounts of $CaCl_2.2H_2O$ at 30±2°C under normal day night conditions.

Incubation Time (Days)	Mean dry wt (mg)±S.E. of mycelium in media with following $CaCl_2.2H_2O$ concentrations ($X10^{-6}M$)			
	0.0	14.0	29.0	75.0
2	14.0±2.5a	12.0±2.0a	24.0±2.5b	24.0±2.5b
4	70.0±8.4b	40.0±5.5a	170.0±4.5c	28.0±3.7a
6	116.0±5.1a	142.0±8.0a	176.0±8.1b	96.0±6.8a
8	126.0±6.0a	180.0±5.5b	178.0±3.7b	155.0±5.0a
10	195.5±4.8a	240.0±9.2a	242.5±6.3b	215.0±6.5b

By the calculated Scheffe's Confidence Limit values in horizontal rows bearing the same letters are not significantly different at 5% level of probability.

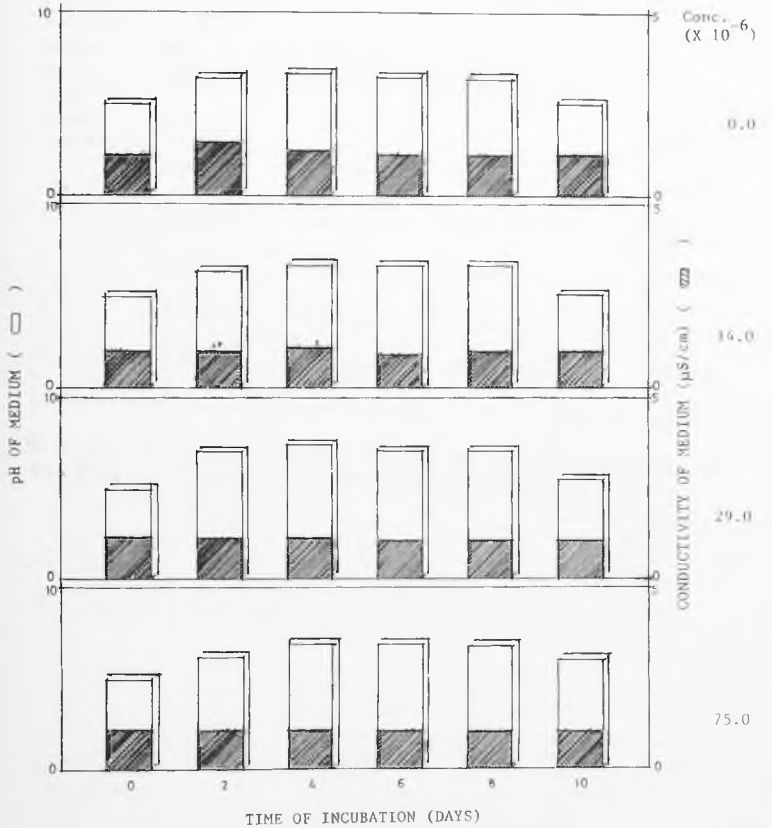


Fig: 24 Hydrogen ion concentration and conductivity of media with different amounts of $CaCl_2.2H_2O$ during growth of C. casiicola at 30± 2°C.

TABLE 73: Growth of C. casiicola in basal medium containing different amounts of KCl at 30±2°C under normal day night conditions.

Incubation Time (Days)	Mean dry weight (mg)±S.E. of mycelium in media with following KCl concentrations ($X10^{-3}M$)			
	0.0	4.0	8.0	12.0
2	24.0±2.5a	36.0±2.5b	44.0±4.0b	44.0±4.0b
4	34.0±2.5a	60.0±3.2b	72.0±2.0c	76.0±2.5d
6	50.0±4.1a	98.0±11.1b	110.0±4.5c	108.0±2.0d
8	72.5±4.8b	185.0±6.52c	54.0±2.5a	196±10.3d
10	62.5±4.8a	157.5±8.5b	200.0±5.8c	197.5±7.5d

By the calculated Scheffe's Confidence Limit values in horizontal rows bearing the same letters are not significantly different at 5% level of probability.

Plate 3. Effect of different concentrations of KCl on growth of C. casiicola at 30°C.
(From left to right: 12.0×10^{-3}M, 8.0×10^{-3}M, 4.0×10^{-3}M and Control). (x1/6).

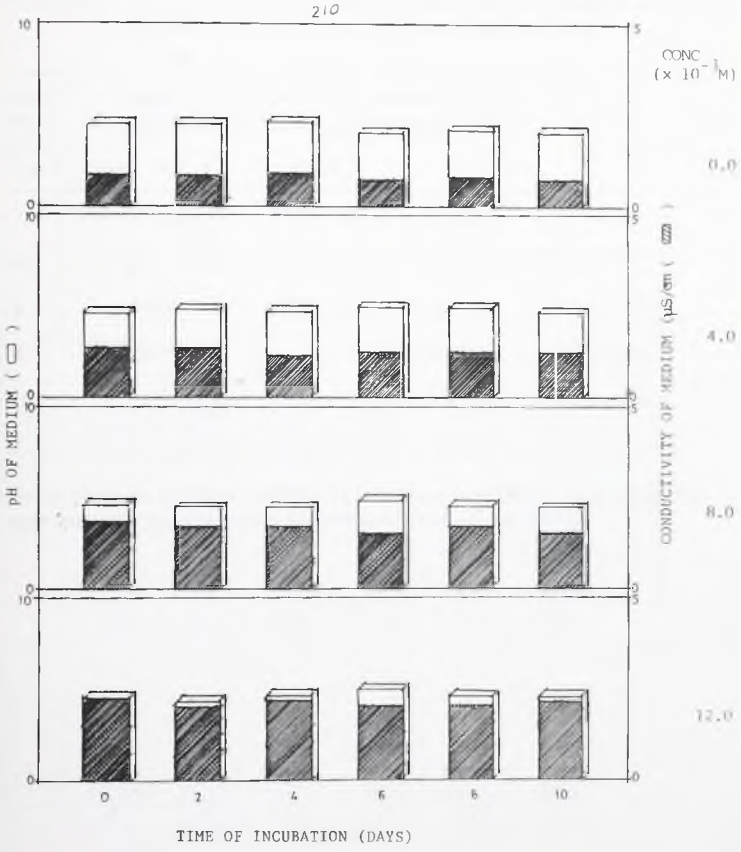


Fig. 25 : Hydrogen ion concentration and conductivity of media with different amounts of KCl during growth of C. casiicola at 30±2°C.

TABLE 74: Growth of C. casiicola in basal medium containing different amounts of K_2SO_4 at 30±2°C under normal day night conditions.

Incubation Time (Days)	Mean dry wt (mg)±S.E. of mycelium in media with following K_2SO_4 concentrations ($X10^{-3}M$)			
	0.0	5.7	11.0	17.0
2	30.0±4.1a	25.0±2.9b	22.5±2.5b	30.0±4.1a
4	86.0±6.8b	62.0±5.8a	80.0±5.5b	90.0±3.2b
6	186.0±7.8a	198.0±5.8a	216.0±7.5b	180.0±4.5a
8	170.0±5.5a	318.0±3.7b	242.0±8.0b	236.0±9.3b
10	142.0±5.8a	254.0±7.0b	276.0±5.1b	264.0±7.5b

By the calculated Scheffe's Confidence Limit values in horizontal rows bearing the same letters are not significantly different at 5% level of probability.

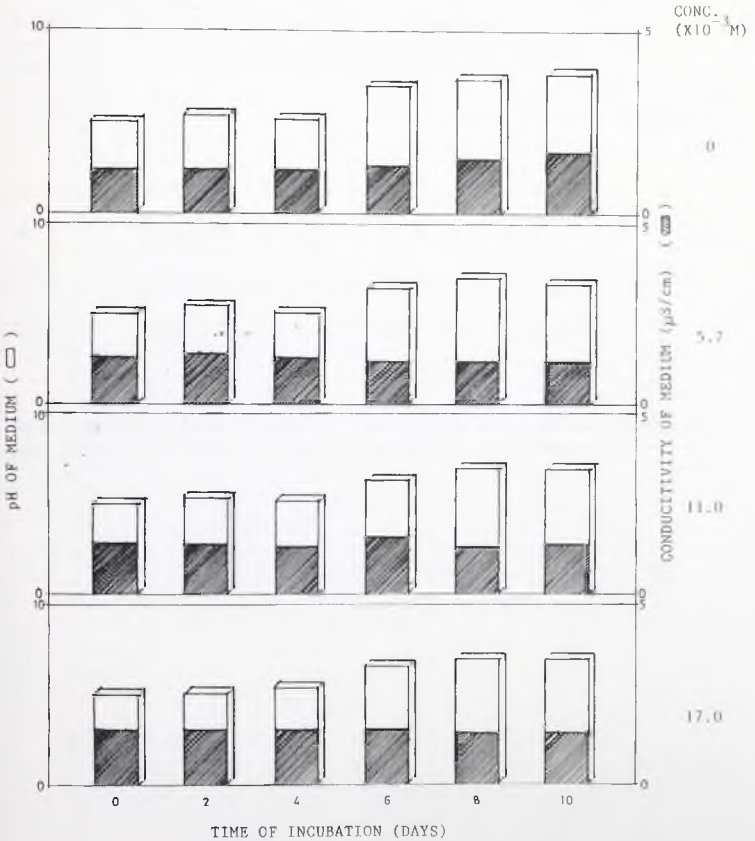


Fig. 26 : Hydrogen ion concentration and conductivity of media with different amounts of K_2SO_4 during growth of C. casiicola at 30±2°C.

TABLE 75: Growth of C. casiicola in basal medium containing different amounts of $MgCl_2$ at 30±2°C under normal day night conditions.

Incubation Time (Days)	Mean dry weight (mg) ±S.E. of mycelium in media with following $MgCl_2$ concentrations ($X10^{-4}M$)			
	0.0	5.0	10.0	15.0
2	30.0±2.0a	32.5±2.5b	32.5±2.5b	37.5±4.8c
4	82.5±4.8a	102.0±2.7b	96.0±2.5b	88.0±3.7c
6	225.0±6.5a	247.5±13.8b	257.5±13.8b	197.5±8.5c
8	207.5±6.5a	220.0±6.5b	242.0±11.6b	198.0±9.7c
10	210.0±6.3b	226.0±4.0b	222.0±4.9b	150.0±8.7c

By the calculated Scheffe's Confidence Limit values in horizontal rows bearing the same letters are not significantly different at 5% level of probability.

Plate 4. Effect of different concentrations of $MgCl_2$ on growth of C. casiicola at 30°C.
(From left to right: Control, 5.0×10^{-4} M, 10.0×10^{-4} M and 15.0×10^{-4} M). (x1/6).

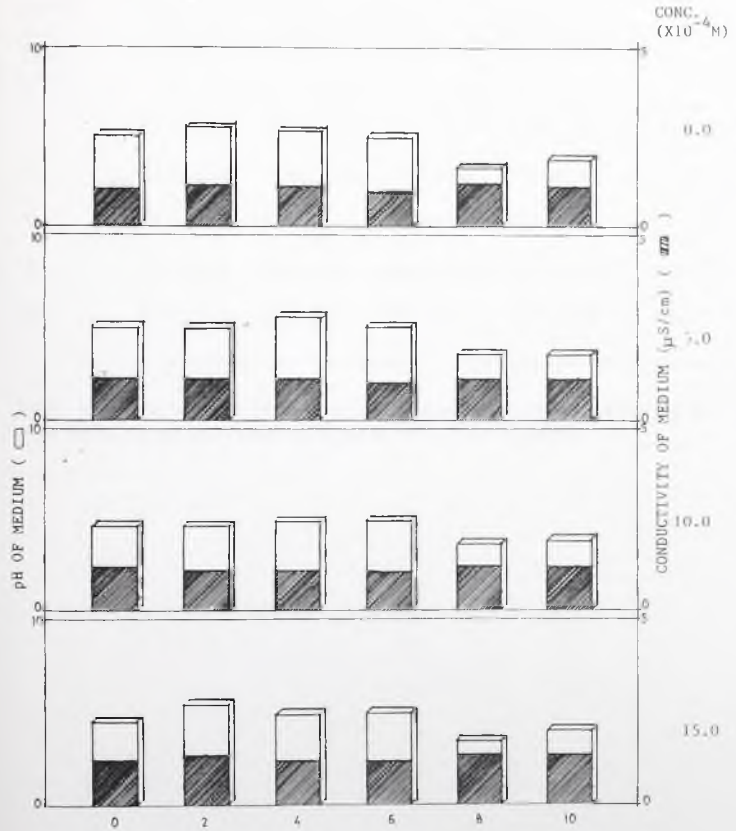


Fig. 27 : Hydrogen in concentration and conductivity of media with different amounts of $MgCl_2$ during growth of C. casiicola at 30± 2°C.

TABLE 76: Growth of C. casiicola in basal medium containing different amounts of $NaH_2PO_4.2H_2O$ at 30±2°C under normal day night conditions.

Incubation Time (Days)	Mean dry wt (mg)±S.E. of mycelium in media with following $NaH_2PO_4.2H_2O$ concentrations (X10-⁴M)			
	0.0	22.0	45.0	65.0
2	22.5±2.5a	22.5±2.5a	22.5±2.5a	32.5±2.5b
4	32.0±2.0a	48.0±2.0b	40.0±4.4c	36.0±4.4c
6	54.0±4.0a	90.0±6.3b	80.0±6.3b	96.0±2.5c
8	74.0±4.0a	98.0±2.0a	116.0±5.1c	126.0±5.1c
10	86.0±5.1b	94.0±5.1c	58.0±5.8a	58.0±3.7a

By the calculated Scheffe's Confidence Limit values in horizontal rows bearing the same letters are not significantly different at 5% level of probability.

(f) NaH_2PO_4. $2H_2O$ at a concentration of 45.0 and 65.0 x 10^{-4}M supported poorer growth than the control and growth at 22.0 x 10^{-4}M was only slightly better than in the control medium (Table 76; Plate 5). Statistical analysis of NaH_2PO_4. $2H_2O$ concentrations are shown in Appendices S_2 (i) and (ii). Changes in the pH's was very small, the initial (pH 4.1 -4.3) and final (pH 4.1 - 4.5) being both acidic. Conductivity of the media also hardly changed (Fig. 28).

Plate 5. Effect of different concentrations of $NaH_2PO_4,2H_2O$ on growth of C. casiicola at 30°C. (From left to right: Control, 22.0×10^{-4} M, 45.0×10^{-4} and 65.0×10^{-4} M). (x1/6).

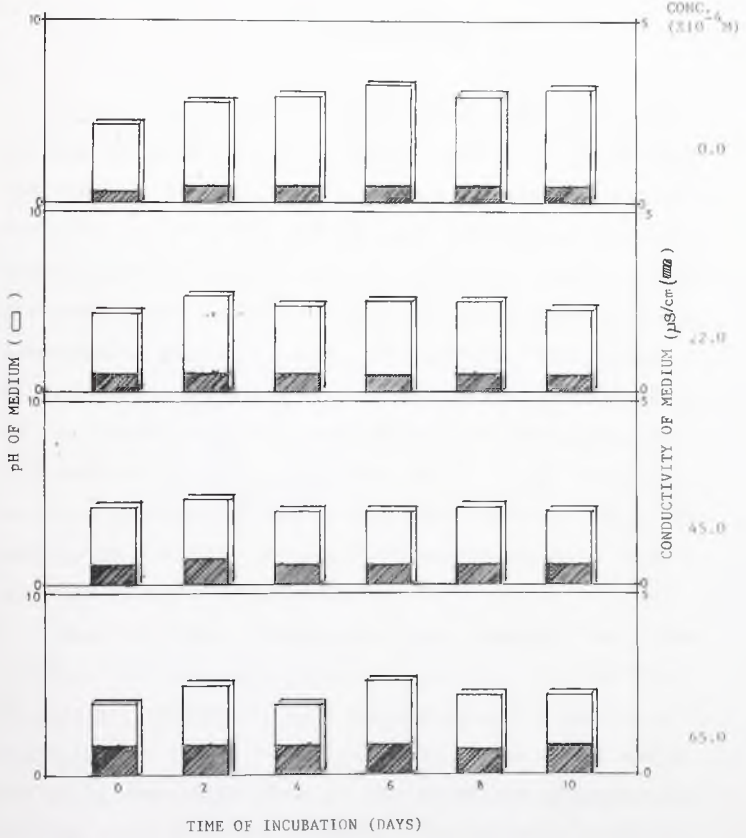


Fig. 28 : Hydrogen ion concentration and conductivity of media with different amounts of $NaH_2PO_4.2H_2O$ during growth of C. casiicola. at 30±2°C.

GENERAL DISCUSSION

Rapid rotting of perishables has been a source of eternal worry to farmers of the tropical and sub-tropical latitudes. In addition to changes caused by internal enzymatic action because of the high moisture content, the high atmospheric temperatures and humidities support high pre-penetration activities of the pathogens and hasten the processes of both penetration and rotting. Sun-drying of products is recognised not only in Ghana but in other parts of the tropics as a long term measure for preserving many perishables for use at a later date. Even then, the products exposed during sun-drying serve as suitable substratum for some fungi and these contaminants form a constant feature of the products.

Some of these contaminants are, however, not 'new arrivals' but are passengers carried over from the field. Concern has, therefore, been often shown of the quality and quantity of field contaminants which to some extent determine the shelf life of the harvested products and keeping value of dried products. The author's attention has been attracted by the dearth of information on contaminant fungi of plants in Ghana, and relevant studies have been duly carried out on four important crop plants, okra, onion, pepper and tomato, examining also, where feasible, the importance of crop variety. Onion bulbs are not processed in Ghana but are stored whole. A small proportion of locally produced tomato fruits is canned.

Okra and pepper fruits are sun-dried before storing. The contaminants of fruits of okra, pepper and tomato are aerial, occurring mainly as spores, while those of onion bulbs in storage are partly subterranean and partly aerial.

Fungal spores in the atmosphere behave as inert particles. They move in all directions under normal air turbulence and sediment only in calm conditions. Deposition may occur by a number of methods, for example, impaction, sedimentation, turbulent deposition, rain-scrubbing and electrostatic deposition. The processes involved have been extensively investigated (Gregory, 1950, 1951; Gregory and Stedman, 1953; Hirst, 1959) and are very well understood. Whatever it is, deposition of spores is a random process. In this investigation, it was assumed that the chances of deposition on the plants and on horizontally placed exposed agar plates would be approximately the same and the results would be comparable. However, it is important to bear in mind that this would be strictly so if spores of foliage facultatitve parasites are able to adhere quickly to leaf surfaces before being lost in 'run-off' water films.

The air-spora at different spots in a locality under the same meteorological conditions would be expected to show closely similar patterns of occurrence. The air-spora at the three sites of spore trapping, namely, the Experimental Plot, University Farm and the Private Farm, all within a radius of one kilometer, however, showed similarities in some aspects and marked differences in

others.

The same fungal species were recorded as the dominant species at all the three sites. These were, in order of decreasing magnitude, Cladosporium herbarum, Fusarium oxysporum, Aspergillus niger, Nigrospora sp. and Curvularia lunata (see Table 8). However, during the two years, (1989 and 1990) when the air-spora was studied at the three sites, very different patterns of occurrence were recorded. Whereas a single peak was recorded in January-February, 1989 at the Experimental Plot, there were two peaks at the University Farm, one in January 1989 and another in February- April, 1990, and a single distinct peak in June 1990 at the Private Farm (see Fig. 8).

Because of the staggered peaks, taking the three sites together, it was not possible to explain the observations in terms of the prevailing climatic conditions (see Figs. 5, 6 and 7). January - February was dry with no rains while the rainy season occurred in April - June (see Fig. 5). An important factor which could have affected the air-spora patterns was the proximity of the exposed agar plates to sources of the spores. It is well known that the majority of spores do not travel far from their point of origin. In calm conditions only about 0.05 per cent of the spores would be expected to travel farther than 100 meters from a source close to the ground; in dull windy weather this increases to about 10 per cent, whilst on a warm sunny day when convection is active the percentage would be higher (Burchill, 1966). Conditions around Legon could belong to

the first and second categories.

A second factor would be the amount of spores released at each site. It is reasonable to assume that the densities of spores released at the different localities would be quite different. A third possible factor is that, operations at these localities, such as mowing which would raise clouds of spores, might have been taking place at different times at the three sites.

The predominance of C. herbarum agrees with results of studies on the air-spora in many countries (Gregory, 1961; Hirst, 1959; Ingold, 1965). The spores of C. herbarum are the commonest in the out-door air-spora: Gregory and Hirst (1957) recorded a maximum concentration of 37,000 spores/m^3 air and Baruah (1961) recorded a maximum of 1.5 million spores/m^3 of air. Plant pathogens which were of fairly high frequencies in the air at the three sites of this investigation were Fusarium oxysporum, Curvularia lunata and Nigrospora sp.

Cercospora species grow with difficulty on agar media. Because of this they hardly ever appeared on agar plates during studies of the air-spora. It was, therefore, not surprising that although no Cercospora sp. was recorded, plants of the three tomato varieties, Heinz, Roma and Wosowoso, were heavily infected by Cercospora sp.(see Fig. 10). Conidia of Cercospora sp. are formed on conidiophores projecting well above the surface of the plant organs they have infected, and trapping spores by methods other than agar plates has demonstrated that abundant dry conidia of

Cercosporas are usually dispersed by wind (eg. Thomas, 1943). Similarily, the powdery mildew, Leiveillula taurica which infected the pepper plants will certainly, not grow on agar media because it is an obligate parasite, and could not, therefore, be trapped in this investigation.

The three varieties of tomato exhibited different degrees of susceptibility to the Cercospora leaf spot disease. Wosowoso variety was less susceptible, especially in the rainy season (see Fig. 9) than the other two varieties. That was a remarkable observation for the two more susceptible varieties, Heinz and Roma, are foreign, and apparently without adequate resistance to local pathogens. It has not been possible to carry investigations here beyond mere recording of the differences in susceptibility of the tomato varieties, and, it will be futile even to speculate on the cause of the resistance shown by the Wosowoso variety. This could be the subject of future investigations. Some of the tomato plants were staked, others were not. The greater rate of infection of unstaked tomato plants (see Fig. 9) was most probably due to the higher humidity conditions within the crowded foliage of the prostrate plants.

There was a clear effect of the weather on incidence of L. taurica during this investigation (see Fig. 10). Infection was severer in the dry season than in the rainy season. Many investigators are of the opinion that in general the powdery mildews spread most rapidly under dry climatic conditions (eg. Cherewick, 1944; Last, 1955b).

But Ayesu-Offei (1966) in his studies in this Department observed the opposite. He reported that incidence of L. taurica on pepper plants was much reduced in the dry weather of the harmattan season. It is noteworthy that while Grainger (1947) also associated higher incidence of Erysiphe graminis with high humidity, Tapke (1953) stated that there was little or no direct relationship between the spread of E. graminis and climatic conditions. The contrasting observations which have been made on the relationship between level of L. taurica infection of pepper and climatic conditions might be related to the germination habit of the conidia. The conidia are able to germinate at humidities ranging from zero to 100% RH (Clerk and Ayesu-Offei, 1967). It is, therefore, possible that the intensity of infection in a standing crop may depend more on the amount of conidia, the infection units, present at any particular time rather than on climatic conditions.

Growth of the pepper plants was assessed by the number of leaves on the plants at successive intervals. Far more leaves were recorded on pepper plants growing in the rainy season (June-August, 1989) than in the harmattan (November, 1988 - February, 1989). The 80, 100 and 120 day-old plants of the rainy season had, respectively, 842, 1226 and 1741 mean number of leaves per plant compared to the corresponding values of 484, 843 and 721 mean number of leaves per plant of the dry season (see Table 7). The plants were under irrigation and so these marked differences could be due to enviromental conditions other

than soil moisture. The higher mildew infection in the dry season could also account partly for the significantly smaller number of leaves. For L.taurica infection caused leaf yellowing and defoliation as was also noticed by Brown (1978).

Extensive studies have been made on the fungal flora of the four crops and of the fruits of okra, pepper and tomato. The phylloplane and fructiplane fungi were directly related to fungal species present in the atmosphere. And so, as with the air-spora, Cladosporium herbarum and Fusarium oxysporum were consistently the predominant species on both the leaf and fruit surfaces, in the rainy season and in the harmattan.

Twenty-three species were isolated from the surface of okra fruits (see Tables 10 and 11), 18 species from pepper fruit surfaces (see Tables 12a and b, 13 and 14) and 27 species from the surface of tomato fruits (see Tables 15a and b, 16, 17, 18a and b, 19 and 20). The numbers of species identified on the surfaces of the leaves of okra, onion, pepper and tomato were, respectively, 20 (see Tables 21, 22 and 23), 12(see Tables 24 and 25), 17 (see Tables 26, 27 and 28) and 23(see Tables 29, 30 and 31). Except in very rare cases, such as Cladosporium herbarum on pepper leaf(see Table 27), more colonies of these species were obtained from the surfaces of both fruits and leaves in the rainy season than in the dry season. Obviously, the higher atmospheric humidities of the rainy season supported phylloplane flora development.

The Agar Plate method does not usually identify the origin of the colonies which develop on the plates. It is most likely that in this investigation they might have grown out of both spores and hyphal fragments. Nutrients are common in exudates of plant organs and fungal germination and growth are supported by these nutrients. The epiphytic mycelia will constitute part of the propagules for growth on the agar plates and the spores they have produced would make up the remaining portion of the propagules. The rainy season provides more suitable enviromental conditions for growth of the phylloplane fungi.

The concentrations of the nutrients of the exudate are not usually high. This is a condition that limits hyphal growth but can stimulate secondary spore formation by germ tubes which had been prevented from continued growth, resulting in rapid production of spores. The production of secondary spores by germ tubes of fungi associated with plants under reduced nutrient conditions have been reported by many workers. These fungi include Cercospora arachidicola (Oso, 1972), Cronartium ribicola (Bega, 1960), Phytophthora palmivora (Manu and Clerk, 1981), Septoria tritici (Jones and Lee, 1974) and phylloplane fungi (Skidmore, 1976).

Skidmore (1976) found that about 5.0 per cent of conidia of Cladosporium herbarum on leaf surfaces regularly produced secondary conidia from short 10-40μm germ tubes within 24 hours of incubation. Botrytis cinerea

conidia produced secondary conidia directly from germ tubes. In many instances, long chains of such spores were formed. These were most abundant when B. cinerea was grown in dual culture with other fungi. Two other fungi, Alternaria alternata and Stemphylium botryosum, also formed secondary spores when the conidia germinated on barley leaves. Thirty-two per cent of A. alternata conidia and 62 per cent of the S. botryosum conidia formed germ tubes terminated by such spores.

The production of secondary spores by these fungi could aid in their survival, particularly in situations where such spores germinate in the phylloplane but environmental or host plant conditions are unfavourable for continued growth. It is possible that these spores are also produced as a reaction to substances present on the leaf surface or phytoalexins induced by spore germination.

The effect of the growing phylloplane fungi on the plants is yet to be widely investigated. Studies of herbaceous plants by Dickinson (1967) and Bainbridge and Dickinson (1972) have indicated that filamentous phylloplane fungi are relatively inactive on undamaged green leaves. Factors which restrict the growth of saprophytic fungi in the phylloplane may include chemical and physical characteristics of the leaf surface and fungitoxic and fungistatic compounds produced inside the leaf. In addition environmental factors may also be limiting. Pugh and Buckley (1971), on the other hand, reported that such fungi were active on green leaves

from the earliest stage of leaf development. Alternaria alternata produces a metabolite that inhibits chlorophyll development, and there is the possibility that some species may act under field conditions to promote senescence. It can be concluded that on actively functioning green leaves, some phylloplane fungi may be harmless, while others may interfere with leaf metabolism and growth. In most instances, however, it is recognised that these fungi become much more active during leaf senescence (Skidmore and Dickinson, 1973). Having identified the phylloplane fungi of these four crops, future studies should screen them and find out those, particularly among the dominant species, which have a depressant effect on leaf function.

Fungi differ in their preference for nutrients. The four crops with different genetical constitution would naturally produce exudates whose constituent nutrients differ both qualitatively and quantitatively. Therefore, although to a large extent the same fungal species were isolated from the different plants, many species did not retain the same rank. Excluding the species which were isolated only occasionally, the members of the richer flora of the rainy season are shown in Tables 77 and 78, in descending order of mean percentage frequency per sampling time taking the three sites together:

TABLE 77: Dominant fungal species on surface of fruits of Okra, Pepper and Tomato, arranged in descending order of percentage frequency

OKRA (Table 10)	PEPPER (Table 12b)	TOMATO (Table 18b)
Fusarium oxysporum	Cladosporium herbarum	Cladosporium herbarum
Cladosporium herbarum	Fusarium oxysporum	Fusarium oxysporum
Aspergillus niger	Aspergillus flavus	Yeast spp.
Aspergillus ochraceus	Rhizopus sp.	Rhizopus sp.
Yeast spp.	Aspergillus niger	Aspergillus niger
Corynespora casiicola	Curvularia lunata	Aspergillus terreus
	Yeast spp.	Nigrospora oryzae
	Nigrospora oryzae	Penicillium cyclopium
		Curvularia lunata

TABLE 78: Dominant fungal species on surface of leaves of Okra, Pepper and Tomato, arranged in descending order of percentage frequency

OKRA (Table 22)	ONION (Table 24)	PEPPER (Table 27)	TOMATO (Table 30)
Cladosporium herbarum	Aspergillus niger	Cladosporium herbarum	Cladosporium herbarum
Fusarium oxysporum	Fusarium oxysporum	Fusarium oxysporum	Fusarium oxysporum
Aspergillus niger	Cladosporium herbarum	Aspergillus niger	Aspergillus niger
Penicillium cyclopium	Rhizopus sp.	Penicillium cyclopium	Aspergillus flavus
Curvularia lunata	Alternaria alternata	Aspergillus terreus	Penicillium cyclopium
Rhizopus sp.	Curvularia lunata	Rhizopus sp.	Alternaria alternata
Aspergillus terreus	Penicillium cyclopium	Curvularia lunata	Rhizopus sp.
Helminthosporium sp.		Corynespora casiicola	Syncephalastrum
Alternaria alternata		Aspergillus flavus	racemosum
Aspergillus flavus		Aspergillus ochraceus	Aspergillus ochraceus
		Syncephalastrum	
		racemosum	
		Alternaria alternata	

Many species were found at different positions depending on the host plant. Even where the same position was occupied, the percentage frequency differed with the plant species. For example, C.herbarum at the top of the lists of species for okra, pepper and onion, the mean percentage frequency at sampling during the rainy season at the University Farm was 42, 37 and 28 (see Tables 22, 27 and 30), respectively.

Apart from the changing position of many species, three important features were noteworthy. First, C. herbarum and F. oxysporum were highly favoured by all the organs. Secondly, the leaves of okra, pepper and tomato supported more species than the fruits, and thirdly, Yeast spp. were favoured by exudates of the fruit but not by leaf exudates.

A comparison of the flora obtained in this study with those of other studies of onion, pepper and tomato leaves elsewhere revealed significant differences. That was not surprising as flora vary from one country to another. Studies for each country, and indeed, each region in a country, are fully justified. Maude et al. (1984) found that Penicillium species and Aspergillus fumigatus were dominant on onion leaf surfaces followed by Aspergillus niger. Aspergillus niger was the predominant fungus in the present study.

The important species isolated from surfaces of leaves of pepper by Sinha (1965) were Alternaria solani, Alternaria tenuissinia, Aspergillus flavus, Aspergillus

niger, Cladosporium cladosporioides, Cunninghamella sp., Curvularia siddiquii, Fusarium moniliforme, Fisidium sp., Heterosporium sp., Mucor hiemalis, Papulospora sp., Penicillium janthinellum, Rhizopus nigricans and Trichoderma koningi.

Tomato leaves studied by Preece and Dickinson (1971) and Sinha (1965) yielded equally different flora from the present one of this study. Their flora was dominated by Alternaria solani, Alternaria tenuissinia, Aspergillus flavus, Aspergillus niger, Choanephora sp., Cladosporium cladosporioides, Cladosporium herbarum, Curvularia siddiquii, Fusarium moniliforme, Mucor sp., Papulospora sp., Penicillium janthinellum, Spicaria sp., Sporotrichum sp., and Trichoderma koningi.

Seven out of 15 fungal species on the tomato fruit surfaces did not pose any danger as pathogens to all the three varieties of tomato. They could not rot the fruits even when introduced into wounds. These were, Aspergillus clavatus, Aspergillus glaucus, Cladosporium herbarum, Helminthosporium sp., Penicillium citrinum, Penicillium funiculosum and Syncephalastrum racemosum (see Table 57). Rotting was caused by Alternaria alternata, Aspergillus terreus, Corynespora casiicola, Curvularia lunata, Fusarium oxysporum, Nigrospora oryzae, Scopulariopsis brevicaulis and Trichothecium roseum (see Table 57). There are several ways by which these pathogenic species could be grouped:

(a) All could infect through the intact tomato fruit skin except N. oryzae which probably did not

possess the requisite enzymes for breaking down the cuticle on the fruit surface.

(b) A. terreus. F. oxysporum. N. oryzae. S. brevicaulis and T. roseum infected fruits of all the three tomato varieties to the same extent. A. alternata and C. casiicola rotted the Heinz and Roma varieties to a greater extent than the Wosowoso variety while the situation was the reverse with regards to infection by C. lunata

(c) Where both types of inoculation resulted in infection, wound - inoculated fruits were rotted faster than surface inoculated fruits. The rate of rotting in the former could be as much as five times that of the latter as with A. terreus, F. oxysporum and S. brevicaulis must be well endowed with the cuticle-digesting enzymes as the rates of rotting of surface-inoculated fruits were only half those of the wound-inoculated fruits.

(d) Of the pathogenic species, F. oxysporum was the most virulent. This is worthy to note as it occurred abundantly on the fruits. Besides, since total spore germination was possible in the extracts of the fruits (see Table 60), both microconidia and mycelium would be equally efficient inocula.

In view of the fact that many fungi could enter the fruits through intact skin, harvested fruits must be washed

immediately with disinfectants before storage. The superior wound- inoculation could be minimized if precautions are taken against bruising of the fruits.

Roots of any plant species also have their associate flora. This population may exist on the root surface, the rhizoplane, or in an interfacial volume between the rootlets and the bulk of the soil, the rhizosphere. It is well documented that the rhizosphere and rhizoplane populations are dependent on the plant for their principal source of energy and nutrients. The plant in turn often also benefits from the association. A classical example which benefits both partners is the pre-penetration association between legume roots and Rhizobium species. Actively growing roots of leguminous plants secrete nutrients and Vitamin B which stimulate the growth of the nodule bacteria. The roots, in turn, are stimulated by polysaccharides of slime of the bacterial cells to secrete Tryptophan which is converted into β-indole-acetic acid (IAA). The IAA causes some of the root hairs of the legume root, but not roots of other plants, to curl - a condition that precedes successful entry of the root hairs by the nodule bacteria (Rovira, 1956).

An event which benefits all sorts of plants is the stimulation of growth of antibiotic-producing micro-organisms which inhibit the growth of parasites with their antibiotics close to the root surface.

On the other hand, the association is known to have ill-effects. Some soil facultative parasites could be

encouraged to grow close to the plant roots.

Notable is the way the effects of the exudates of some plants later take a different turn. Nutman (1956) reported how early legume secretions are stimulatory, while secretions of older roots inhibit infection by the nodule bacteria. It is suggested that the root exudates became inhibitory as their concentrations increase.

But high concentration may not be the only event causing a loss of stimulatory power. Amewowor (1980) recorded a significant decline in the levels of many amino acids secreted by young bambara groundnut plants. Aspartic acid, glutamic acid, glycine, histidine, iso-leucine, threonine and valine present in measurable quantities in exudates of 5 day-old seedlings appeared only in "Trace" quantities in exudates of 8 day-old seedlings, while the roots of the 8 day-old seedlings completely stopped secreting arginine, lysine, phenylalanine, proline and tyrosine.

With all plants, once root hairs and external cells of roots start to die, their decomposition products will affect the microhabitat to, either, the benefit or disadvantage, of the rhizoplane and rhizophere microbial populations.

The course of events in the rhizosphere of okra, pepper and tomato plants was studied from November, 1988 to August, 1989. Practically, the same fungal species were isolated from the non-rhizophere soil of the three sites (see Tables 34, 35 and 36). Altogether, 33 fungal species

were isolated, dominated by the Genus Aspergillus, which was represented by A. clavatus, A. flavus, A. fumigatus, A. glaucus, A. nidulans, A. niger, A. ochraceus and A. terreus. Four of them - A. flavus, A niger, A . ochraceus and A. terreus - were among the dominant species, and infact, A. niger was the most abundant fungal species in the three soils.

Twelve species constituted the dominant species, which could be listed in the following order of decreasing percentage frequency: A. niger, A. terreus, A. ochraceus, Penicillium cyclopium, Fusarium oxysporum, Trichoderma viride, Rhizopus sp., A. flavus, Paecilomyces sp., Syncephalastrum racemosum, Curvularia lunata and Chaetomium globosum. As there was, naturally, only one recording for the non-rhizosphere soil at each sampling time, the same data are reproduced in Tables 34, 35 and 36 for ease of comparison with the rhizosphere flora of the three crops.

For the period of investigation of the rhizosphere mycoflora, the conclusion which could be made on the occurrence of the fungi in the non-rhizosphere soil are:

(a) The populations of A. ochraceus and F. oxysporum were initially high and then declined.

(b) The population of P. cyclopium was low initially and later increased.

(c) The populations of A. flavus, A. niger, Paecilomyces sp. and S. racemosum increased with time and then declined.

(d) A. terreus showed higher population levels at the

beginning and end of the period with a lower population level in-between.

(e) A. fumigatus, Chaetomium globosum and Curvularia lunata were present only occasionally.

F. oxysporum is the only serious soil facultative parasite among the dominant species and its presence at a high level could affect the crops. Although none of the Aspergillus species could be considered as important a parasite as F. oxysporum, they could harm the crop in different ways. Evidence is rapidly accumulating on the deleterious effects of filtrates of Aspergillus species on higher plants. Although most of the active principle are not lethal, growth of the plant may be retarded or malformations would be induced. The exudate of A. niger, for example, caused abscission of leaves and malformations of the stem of seedlings of beans (Curtis, 1958a, 1958b, 1961, 1968) and arrested radicle growth in cocoa (Odamtten and Clerk, 1988). Filtrates of A. flavus caused seedling virescence (Koehler and Woodcock, 1938), while Amewowor (1980) found that A. flavus and A. niger severely inhibited root development and root hair growth, and A. fumigatus suppressed nodulation.

The fungi in the soil were either not affected by the root exudates of okra, pepper and tomato, stimulated or inhibited. P. cyclopium showed a singular response to the exudates of roots of okra and pepper. Between November and February it was stimulated and then inhibited from around

May to August (see Tables 34 and 35). The effects of the root secretions on the rest of the dominant species were as follows:

(a) Okra root secretions stimulated A. niger, A. terreus and S. racemosum; inhibited A. ochraceus and Rhizopus sp. and did not affect A. flavus, F. oxysporum and Paecilomyces sp.

(b) Pepper root secretions stimulated S. racemosum; inhibited A. ochraceus and had no effect on A. flavus, A. fumigatus, A. niger, A. terreus, F. oxysporum, Paecilomyces sp. and Rhizopus sp.

(c) Tomato root secretions stimulated A. niger, A. terreus C. globosum, P. cyclopium and S. racemosum; inhibited A. ochraceus and T. viride and had no effect on A. flavus, C. globosum, F. oxysporum and Paecilomyces sp.

Interestingly, A. ochraceus which was highly stimulated by root exudates of bambara groundnut (Amewowor, 1980) was inhibited in the rhizosphere of all the three plants. Growth of A. niger was promoted in the rhizospheres of okra and tomato. Because of the known harmful effects of its filtrate on some plants, future investigations should examine the response of okra and tomato seedlings.

Chips of fresh okra fruits and whole fresh pepper fruits were either air-dried or solar-dried for 9 days to an Equilibrium Moisture level. As succulent fruits, their initial moisture content was very high. As far as fungal

spores of the atmosphere are concerned, any exposed material, capable of forming a food base, becomes a microhabitat. The quality and quantity of the composition of fungal species which will be established on a particular substratum is determined by the available nutrient and to some extent by the influencing enviromental conditions. The okra chips and pepper fruits before they dried up formed such a microhabitat. There is sufficient evidence to conclude that most of the fungal contaminants which were later isolated were members of the air-spora, because washed and unwashed products were equally contaminated. Washed fruits were freshly contaminated on exposure. The unwashed fruits had fungi which settled on them when they were in the field and when they were exposed to dry in the courtyard of the Botany department (see Table 38).

A major factor controlling the atmospheric spore concentration is rainfall. Rain reduces the number of spores available for aerial dispersal by washing the spores out of the air. Prolonged heavy rainfall might also wash off spores from conidiophores and thereby reduce the number of spores becoming air-borne. On the other hand, a pertinent role of rainfall in the present study might be the raising of atmospheric humidity and subsequent encouragement of spore germination and hyphal growth.

In this investigation, the season, surprisingly, did not influence fungal contamination in any significant way, and the air-dried materials were contaminated to practically the same degree in both seasons. Anyway, since

the moisture content of the materials was high when the propagules landed, atmospheric humidity would virtually be ineffectual. And so, in both seasons, A. flavus, A. niger A. ochraceus, A. terreus, C. herbarum, C. lunata, F. oxysporum, Neurospora crassa, P. cyclopium, Rhizopus sp. and S. racemosum, were isolated from both okra chips and pepper fruits. The populations in the two seasons of each species with the exception of N. crassa, was the same. N. crassa was more abundant in the rainy season.

Solar-drying method generates heat and the temperature might have reached levels unfavourable to some of the fungi. This could be the reason why some of the species, A. ochraceus, N. crassa and S. racemosum were absent on the solar-dried materials.

Unlike the air-spora, A. flavus and A. niger were the dominant species on the okra and pepper fruits. Their nutrients suited A. flavus and A. niger better than C. herbarum and F. oxysporum, the predominant members of the air-spora.

In another set of experiments, dried okra fruit chips and pepper fruits were ground and stored alongside unblended ones in desiccators with an internal atmospheric humidity of either 20 or 85% R.H. Similar preparations were kept exposed in the laboratory. The experiment was repeated in the dry and rainy seasons. Preparations stored in the desiccators would contain fungi which contaminated the chips and fruits during drying and any other contaminants during grinding of the okra chips. Those

exposed in the laboratory would be liable to further contamination. Whatever the storage conditions, A. flavus and A. niger were present on all the products after 28 days. Two other dominant fungi were Cladosporium herbarum and Penicillium cyclopium. Nutrients of the products have been a deciding factor in the success of the contaminants.

Unfortunately, the suitability of the two products to A. flavus A. niger and P. cyclopium should be a source of worry because of their ability to contaminate stored plant products with mycotoxins. The greatest potential for toxigenic mould growth and mycotoxin production will occur with storage of inadequately dried agricultural products and the rewetting of dried and stored products. Experiments in this investigation have shown that the okra and pepper products absorbed water from atmospheres of 20 and 85% R.H. (see Figs. 11 and 12) - rendering them suitable for mould growth. Storage of ground materials creates special problems. Here the protective cuticle of the fruit epicarp and the protective outer testa of the seeds are destroyed and the rich nutrients inside can now be easily colonised by toxigenic moulds. The practice of storing these products in ground form must go with precautions that minimize toxigenic mould growth and mycotoxin synthesis. Two major enviromental factors which could be manipulated are temperature and water activity. Removal of moisture around the dried products with desiccants or dehumidifiers and adjusting the temperature to levels that suppress mycotoxin biosynthesis are some of

the recommended practices. Even the plant genome is known to influence the amount of mycotoxin formed by a fungus which has successfully colonized the crop. Indeed, one possible approach to control mycotoxin formation in plants will be plant breeding programmes, as has been advocated for by Mixon (1977) and Zuber (1977) among others. A. flavus produces aflatoxins which have been more extensively studied than any other mycotoxins. They cause cancer of the liver. Their recognition as potent carcinogens in some animals and in man has made them subjects of government legislation as well as valuable tools in the study of cancer. Aflatoxin in hays and feeds consumed by cattle ultimately find their way into the milk of lactating cattle. A. flavus synthesizes three aflatoxins, namely . Aflatoxins B_1, B_2 and M_1. Aflatoxin M_1 is as acutely toxic as B_1. Lactating mammals consuming feedstuffs contaminated with aflatoxin B_1 or B_2 excrete into their milk aflatoxin M_1 (Stoloff, 1977: Steyn, 1980). Apart from being carcinogenous, aflatoxins are also acute poisons.

Dried pepper fruits and okra fruit chips or the powders of these fruits are very extensively used in West Africa. They deserve far more attention with regards to the incidence of A. flavus than hitherto given to them. Until methods of degrading or detoxifying of aflatoxins have been perfected and can be applied to commercial products, the best ways of prevention of formation of mycotoxins in these products lies in minimizing growth of

A flavus. This could be done by harvesting the fruits, especially pepper which is dried whole, with minimum skin damage, using efficient drying techniques that reduce moisture of the products in a very short time, and preventing re-absorption of moisture by the dried products in storage. These preventive methods could also apply to A. niger which produces oxalic acid and P. cyclopium which synthesizes an array of mycotoxins- Cyclopiazonic acid, Ochratoxin A, Penicillic acid and Penitrem A. The best known among them is Ochratoxin A which causes inflammation of the kidney (nephritis). Meanwhile, the investigation should be extended in the future to examination of the stored products for the presence and levels of aflatoxins. If they are present, the safest method which would exclude contamination of the products with chemicals, viz., biological breakdown of aflatoxins is by using microorganisms such as Flavobacterium aurantiacum (Marth and Doyle, 1979). The level of incidence of A. flavus in the present investigation could not be a guide to the extent of aflatoxin contamination of the products because there are aflatoxin-producing and non-aflatoxin-producing strains of A. flavus.

Irradiation is a newly-introduced method of control of deteriorating fungi of food products. In Ghana it is at the experimental level initiated by the Ghana Atomic Energy Commission, Kwabenya. The results of irradiation tests on bulbs of the two onion varieties, Red Creole and Texas Grano in Tables 45 to 55 are summarized in Fig. 29. The

chart provides a clear picture of the dominant species at the various stages of the tests. The onions were planted in both the dry and rainy seasons in soils treated with either Manure (cowdung) or Manure (cowdung) and Sulphate of Ammonia. Table 6 showed that Texas Grano produced more bulbs both in the dry season (November 1988 - February 1989) and in the rainy season (June - August, 1989) in soils with cowdung only. On the other hand, the yields of Red Creole in the two types of soils during the rainy season were similar, while a higher yield, by about 20 per cent was obtained in the soil with cowdung only in the dry season. It is, therefore, not possible to make a recommendation of general application.

When the bulbs of the two varieties were cured for 30 days, irradiated with Gamma rays of 0.05 Gy and 0.10 Gy dosages and stored for 90 days, they all showed high incidence of A. niger which was the predominant contaminant. It was isolated on all occasions from the cores of the bulbs and the outer three scale leaves. Sometimes, the irradiated bulbs had far greater levels of A. niger contamination than the control-non-irradiated bulbs, as recorded, for example, in Tables 49 and 50. It appeared that irradiation at the dosages used had no effect on A. niger and the other important contaminants. Indeed, irradiated bulbs showed greater levels of contamination by F. oxysporum and P. cyclopium on some occasions (see Tables 47, 48 and 51). On the basis of the results obtained from these tests, irradiation cannot be recommended for the

control of contaminants of stored onion bulbs.

The predominant fungal species on the freshly harvested bulbs of all treatments were A. niger, F. oxysporum and P. cyclopium. The last two species ultimately decreased to low levels in the end, at least, but survived well the 30 days of curing.

It is reassuring that irradiation did not affect the Ascorbic acid content of the bulbs (see Table 55) in case the need will arise to resort to it to control sprouting following the observations recorded in Table 56. Khan and Wahid (1977) had recommended that irradiated bulbs should be stored at 14-16 ^{0}C for effective suppression of sprouting. This suggestion should be considered in any future relevant studies.

Finally, experiments on the growth of a fungus is not uncommon. It is not an exercise to examine the need of the fungus for carbon and nitrogen compound and inorganic salts, because they are all essential for the growth of the fungi. Carbon compounds are needed for structural and functional purposes. They are the principal respiratory substrates. Nitrogen compounds are essential for protein synthesis and for the innumerable enzymes. It is now well established that inorganic salts used by fungi could be divided, as with higher plants, into macro- and micro-nutrients, according to the quantities required by fungi (Cochrane, 1958; Hawker, 1950; Lilly and Barnett, 1951).

The influence of the macro-elements, phosphorus, potassium, magnesium and sulphur individually on growth of

Corynespora casiicola, which has been recorded for the first time on tomato plants in Ghana, during the course of the present investigation has been clearly demonstrated.

Phosphorus is required for the utilization of glucose and is an important constituent of all essential metabolites including nucleotides of adenine, pyridine, flavin and uridine and other co-enzymes like pyridoxal phosphate and thiamine pyrophosphate. It is the basic constituent of all nucleic acids. A very low supply of potassium to fungi is accompanied by poor sugar utilization, and it seems from work with organisms other than fungi that potassium has an essential function in carbohydrate metabolism. Magnesium is required in phosphorylation systems especially in the glycolytic pathways, often acting as a link between substrate, enzyme and co-enzyme. Finally, sulphur is a well known constituent of amino acids, such as methionine, cysteine, and cystine, of the tripeptide glutathione and of the vitamins, thiamine and biotin. Thus, sulphur is incorporated into a variety of all cell materials.

The mineral elements are usually required in very minute quantities by fungi and concentrations of 0.14×10^{-6}M to 9.0×10^{-2}M were therefore tested.

The optimum concentrations of $CaCl_2.2H_2O$, KCl, K_2SO_4, $NaH_2PO_4.2H_2O$ and $MgCl_2$ identified for growth of C. casiicola were 29.0×10^{-6}M, 8.0×10^{-3}M, 5.7×10^{-3}M, 10.0×10^{-4} M and 65.0×10^{-4}M, respectively (see Tables 72, 73, 74, 75 and 76). An interesting observation is that in all

cases the peak growth was attained at 6-8 days and growth then declined. The pH of all the media fell within the suitable pH range of pH 3.77 and pH 7.87 for growth of C casiicola (see Table 66). The ability to grow well over concentration ranges of these salts as well as the broad suitable pH range would enable the fungus to flourish in habitats with fluctuating conditions.

It also showed an optimum temperature of 30 ^{0}C and good growth at 27 ^{0}C (see Table 65), and under normal day-night regime (see Table 68) adapting it to the tropical environment

However, its growth could be limited by the absence of an external supply of thiamine, and the dry weight of the mycelium at a concentration of 100ug/1 was double (144 ug/l) that of the control (70.0 ug/l) without thiamine (see Table 64). C. casiicola did not occur at high frequencies during this study. Possibly, low thiamine levels in plants could have contributed to this.

It was normal that C. casiicola could not use either different carbon-sources or different nitrogen sources to the same extent. Relevant information concerning many other fungal species is well documented in the pertinent literature. Sometimes, the inability of a fungus to use certain compounds may be due to other causes. It is likely that the poor growth of C.casiicola in the Ammonium chloride and Ammonium sulphate may be due either to inability to use an Ammonium compound or the sharp drift to the acidic pH (pH 2.9 - 3.0) on only the 4th day of

incubation (see Table 71 and Fig. 23) or to both. At least, in the field, acidic conditions will be inimical to C. casiicola.

Electrical conductivity of a medium is related to the nature of the various dissolved substances, particularly, their actual and relative concentrations. Freshly distilled water has a conductivity of 0.2 mS/m. Solutions of most inorganic salts, acids and bases are good conductors. Conversely, the dissociation of most organic compounds is very small in comparison with that of inorganic ones or they do not dissociate and they therefore, conduct an electrical current very poorly, if at all.

It was interesting, therefore to note that the natural media (Cassava dextrose broth, Pawpaw extract broth, Potato dextrose broth, Sweet potato dextrose broth and Yeast extract) had low conductivity of less than 2 uS/cm, except V-8 juice with 3.75-4.17 uS/cm conductivity (see Appendix J_1). It would be noted that the conductivity of Tomato juice (see Appendix M_1) was similar to that of V-8 juice which is a mixture of many fruits and vegetables, which might have contained fairly high concentration of inorganic salts.

The conductivity of media containing Ammonium chloride, Ammonium nitrate, Ammonium sulphate, Potassium nitrate and Sodium nitrate (see Appendix C_2) was, as could be expected, high (7.1-14.9 uS/cm). However a low conductivity was recorded, even though sufficiently high

inorganic salts were included in other media as in the case of $CaCl_2.2H_2O$ (see Appendix F_2), KCl (See Appendix I_2). K_2SO_4 (See Appendix L_2), $MgCl_2$ (See Appendix O_2) and $NaH_2PO_4.2H_2O$ (see Appendix R_2). Alkaline pH decreases conductivity (GEMS/Water Operational Guide, 1987) and the high pH values of the media might have reduced the conductivity. This, however, requires further investigation so that the wider variation in the conductivity of the media could be fully understood.

In conclusion, it has been shown that okra, onion, pepper and tomato plants have associate mycoflora while growing in the field. The fungi occurred on leaves, fruits and roots. The specific role of each species on the growth of the plants had not been ascertained except the preliminary studies on infection by selected species. It is reasonable to suggest that the dominant species, in particular, would play roles which had been identified in other relevant studies. Some may be ineffective on the one hand, while others may influence growth on the other, either promoting through their activities or retarding it. At any particular time, the extent of the effect will depend on several factors eg. species of the organisms of the air-spora or the soil which are the sources of the fungi, and physiological state of the species. Apart from the ecological implications of flora, two aspects of considerable interest are the effect on the growth of the plants and on the economic value of the stored products which would undergo various changes - structure, nutrient

value, colour, scent and contamination by mycotoxins - through the activities of the contaminating fungi. The specific role of each of the members of the mycoflora of these crops deserve critical examination.

SUMMARY

1. The monthly rainfall in the dry season, November and December, 1988, and January and February, 1989 was 38, 0, 39 and 0 mm, respectively; and the monthly rainfall of the rainy season, April, May, June and July, 1989 was 88.9 121.8, 154.0 and 54.4 mm, respectively.

2. a. The months of the dry season, November and December, 1988 and January, February and March, 1989 had minimum temperatures of 23.6, 22.8, 21.9 23.9 and 24.2 ^{0}C with maximum temperatures of 31.6, 31.9, 32.5, 33.7 and 33 ^{0}C, respectively.

b. The months of the rainy season, April, May, June and July, 1989 had minimum temperatures of 24.7, 24.0, 23.2 and 23.0 ^{0}C with maximum temperatures of 33.1, 31.5, 29.9 and 28.4 ^{0}C, respectively.

3.(i) Soil Temperatures and Atmospheric humidities and Temperature at the Experimental plot in the dry season:

a. On January 26, 1989, the soil temperatures rose from 25 ^{0}C at 6.00 a.m. to 32.3 ^{0}C at 2.00 p.m. and decreased to 27 ^{0}C at 9.00 p.m. at a depth of 5 cm. The temperatures at a depth of 10 cm. followed the same pattern.

b. For the same times of the day, the respective atmospheric temperatures at 5cm above soil surface were 23.5, 36.0 and 25.8 ^{0}C, respectively, and at 10cm they were 23.6, 33.8 and 25.8 ^{0}C, respectively.

c. The atmospheric relative humidities which were inversely related to the atmospheric temperatures and soil temperatures at 6.00 a.m., 2.00 p.m. and 9.00 p.m. were 96, 62 and 88% RH, respectively.

d. The corresponding values for January 27, 1989, which were all in the same dry season were closely similar to those of January 26, 1989.

(ii) Soil Temperatures and Atmospheric Humidities and Temperatures at the Experimental Plot in the Rainy Season.

a. On June 21, 1989, the soil temperatures rose from 26 ^{0}C at 6.00 a.m. to 32.3 ^{0}C at 2.00 p.m. and decreased to 26.8 ^{0}C at 9.00 p.m. at a depth of 5cm. The temperatures at a depth of 10cm rose from 27 ^{0}C at 6.00 a.m. to 31.5 ^{0}C at 2.00 p.m. and decreased to 27.5 ^{0}C.

b. For the same times of the day, the respective atmospheric temperatures at 5cm above the soil surface were 24, 35 and 24.5 ^{0}C, respectively, and 23.6, 32.0 and 23.5 ^{0}C, respectively, at 10 cm.

c. The atmospheric humidities which were inversely related to the atmospheric temperatures and soil temperatures were 98, 72 and 98 % R.H., respectively, at 6.00 a.m., 2.00 p.m. and 9.00 p.m.

d. The corresponding values for June 22, 1989, July 27, 1989 and July 28, 1989 which were all in the same rainy season were closely similar to those of June 21, 1989.

4. The total yield of 40 plants of each of the three Tomato varieties:

a. Staked and unstaked Heinz varieties produced 235 and 239 fruits, respectively, in the dry season.

b. Staked and unstaked Heinz varieties produced 42 and 34 fruits, respectively, in the rainy season.

c. Staked and unstaked Roma varieties produced 352 and 287 fruits, respectively, in the dry season.

d. Staked and unstaked Roma varieties produced 112 and 100 fruits, respectively, in the rainy season.

e. Staked and unstaked Wosowoso varieties produced 680 and 634 fruits, respectively, in the dry season.

f. Staked and unstaked Wosowoso varieties produced 251 and 207 fruits, respectively, in the rainy season.

5. Incidence of Fruit Cracking:

a. In the dry season, 11.9, 1.1 and 29.6 per cent, of the mature fruits of Heinz, Roma and Wosowoso varieties, respectively of staked plants cracked before harvesting time, while the percentages for unstaked plants were, 11.3, 1.4 and 36.3 per cent, respectively.

b. In the rainy season, 0.0, 1.8 and 15.5 per cent, of the mature fruits of Heinz, Roma and Wosowoso varieties,

respectively, of staked plants cracked before harvesting time, while the respective percentages for unstaked plants were 70.6, 0.0 and 11.6 per cent.

6. Rotting of Tomato Fruits.

a. In the dry season, 3.4, 7.7 and 0.0 per cent of staked plants of Heinz, Roma and Wosowoso varieties, respectively, rotted, compared with corresponding values of 9.2, 7.7 and 0.0 per cent of unstaked plants.

b. In the rainy season, 4.8, 5.4 and 6.0 per cent of fruits of staked plants of Heinz, Roma and Wosowoso varieties, respectively, rotted, compared with corresponding values of 20.6, 13.0 and 3.4 per cent of unstaked plants.

7. Yield of Onion plants with different indicated soil treatments were as follows:

a. Red Creole variety in soil with:

(i) Manure in dry and rainy seasons: 138 and 117 bulbs, respectively.

(ii) Manure and Sulphate of Ammonia in dry

and rainy seasons: 108 and 121 bulbs, respectively.

b. Texas Grano variety in soil with:

(i) Manure in dry and rainy seasons: 119 and 96 bulbs, respectively.

(ii) Manure and Sulphate of Ammonia in dry and rainy seasons: 196 and 110 bulbs, respectively.

8. None of the bulbs of the two Onion varieties in soils with either Manure or Manure and Sulphate of Ammonia treatments rotted in soil in the dry season.

9. In the rainy season, some of the bulbs rotted:

a. The percentage rot of Red Creole and Texas Grano bulbs in soils with Manure treatment was 2.6 and 10.4 per cent, respectively.

b. The percentage rot of Red Creole and Texas Grano bulbs in soils with Manure and Sulphate of Ammonia treatment was 2.5 and 3.6 per cent, respectively.

10. Yield of Okra plants:

a. A total of 131 and 103 fruits, respectively, per

40 plants of Clemson spineless and Local varieties in the dry season

b. A total 736 and 257 fruits, respectively, per 40 plants of Clemson spineless and Local varieties in the rainy season.

11. Yield of Pepper plants:
The total yield per 40 plants in the dry and rainy seasons was 1442 and 3394 fruits, respectively.

12. A low percentage, 2.1 and 3.5 per cent of the pepper fruits in the dry and rainy seasons, respectively.

13. A high percentage of 69.4 per cent of the pepper fruits in the dry season compared with 2.8 per cent in the rainy season was damaged by birds.

14. The air spora of three locations, Experimental Plot, University Farm and Private Farm were recorded from January, 1989 to December, 1990. The pattern of occurrence varied according to the station:

a. At the Experimental Plot, there was a single prominent peak in January, 1989.

b. At the University Farm there were three

prominent peaks in January, 1989, February and April, 1990.

c. At the Private Farm there was a single prominent peak in June,1990.

15. Fungal Species:

a. The predominant species at the Experimental Plot were Cladosporium herbarum and Fusarium oxysporum.

b. The remaining species at the Experimental Plot in order of decreasing abundance were Alternaria alternata, Aspergillus flavus, Aspergillus ochraceus, Aspergillus niger, Aspergillus terreus, Corynespora casiicola, Curvularia lunata, Fusarium sp., Helminthosporium sp., Neurospora sitophila, Nigrospora sp., Penicillium cyclopium, Rhizopus sp., Sterile mycelia, Trichoderma viride and Yeast spp.

c. The predominant species at the University Farm were Cladosporium herbarum and Fusarium oxysporum.

d. The remaining species at the University Farm in order of decreasing abundance were Aspergillus niger, Curvularia lunata, Alternaria alternata, Aspergillus flavus, Aspergillus

ochraceus, Aspergillus terreus, Corynespora casiicola, Fusarium sp., Helminthosporium sp, Nigrospora sp, Penicillium cyclopium, Rhizopus sp., Sterile mycelia, Trichoderma viride and Yeast spp.

e. The predominant species at the Private Farm were Cladosporium herbarum and Fusarium oxysporum.

f. The remaining species at the Experimental Plot in order of decreasing abundance were: Curvularia lunata, Nigrospora sp., Aspergillus niger, Corynespora casiicola, Fusarium sp., Helminthosporium sp., Neurospora sp., Rhizopus sp., Aspergillus flavus, Aspergillus ochraceus, Alternaria alternata, Aspergillus terreus, Penicillium cyclopium, Sterile mycelia, Trichoderma viride and Yeast spp.

16. The tomato plants suffered from Cercospora leaf spot while the pepper plants were heavily infected by the powdery mildew, Leveillula taurica.

17. Cercospora leaf spot developed on tomato plants growing in both dry and rainy seasons and on staked and unstaked plants. At the time of final assessment the disease was, however, high in all cases:

a. Dry Season:

Heinz variety - staked, 100 %, unstaked, 100 %

Roma variety - staked, 100 %, unstaked, 100 %

Wosowoso variety - staked, 100 %, unstaked, 100 %

b. Rainy Season:

Heinz variety - staked, 97.5 %, unstaked, 100%

Roma variety - staked, 100 %, unstaked, 100%

Wosowoso variety - staked, 91.0 %, unstaked, 98.7 %

18. Maximum Leveillula taurica infection in the dry season was 96.2 per cent and in the rainy season was 71.7 per cent.

19. The fungi isolated from the surfaces of fruits of okra, pepper and tomato differed both quantitatively and qualitatively.

a. The number of species isolated from okra, pepper and tomato fruits was 23, 27 and 18, respectively.

b. The predominant species on the fruits were:

Okra - Aspergillus niger, Curvularia lunata, Fusarium oxysporum.

Pepper - Aspergillus flavus, Cladosporium herbarum, and Fusarium oxysporum.

Tomato - Cladosporium herbarum, and Fusarium

oxysporum.

c. The genus Aspergillus was represented by the greatest number of species on each fruit.

Okra : A. flavus, A. nidulans, A. niger, A. ochraceus and A. terreus.

Pepper : A. effusus, A. flavus, A. fumigatus, A. niger, A. ochraceus and A. terreus.

Tomato : A. clavatus, A. flavus, A. fumigatus, A. niger, A. ochraceus and A. terreus.

20. The quality and quantity of phylloplane fungi varied with the crop species. The total number of species on leaves of okra, onion, pepper and tomato was 22, 14, 18 and 24, respectively.

21. The number of species on a particular crop also varied with the location:

a. It was 9, 14 and 12, respectively, on okra plants at the Experimental Plot, University Farm and Private Farm during the dry season, and 17, 18 and 14, respectively, during the rainy season.

b. It was 5, and 9, respectively, on onion plants at the Experimental Plot, University Farm during

the dry season, and 14 and 11, respectively, during the rainy season.

c. It was 12, 14, and 14, respectively, on pepper plants growing during the dry season at the Experimental Plot, University Farm and Private Farm and the number was 16 for all three during the rainy season.

d. It was 12, 10, and 13, respectively, on tomato plants growing during the dry season at the Experimental Plot, University Farm and Private Farm and 22, 18 and 19, respectively, during the rainy season.

22. The dominant phylloplane fungi recorded on the four crops were:

Okra : Cladosporium herbarum, Fusarium oxysporum and Mycelia sterilia.

Onion : Aspergillus niger.

Pepper : Cladosporium herbarum, Fusarium oxysporum and Mycelia sterilia.

Tomato : Cladosporium herbarum, Fusarium oxysporum and Mycelia sterilia.

23. The remaining species in order of decreasing abundance were:

Okra : Aspergillus niger, Aspergillus terreus, Curvularia lunata, Penicillium cyclopium, Nigrospora oryzae, Aspergillus flavus, Alternaria alternata, Fusarium sp., Helminthosporium sp. and Rhizopus sp.

Pepper : Penicillium cyclopium, Curvularia lunata, Aspergillus niger, Corynespora casiicola, Aspergillus ochraceus, Aspergillus flavus, Alternaria alternata, Rhizopus sp., Syncephalastrum racemosum and Aspergillus terreus.

Onion : Fusarium oxysporum, Cladosporium herbarum, Mycelia sterilia, Rhizopus sp., Curvularia lunata, Alternaria alternata, Fusarium sp. and Penicillium cyclopium.

Tomato : Alternaria alternata, Aspergillus niger, Curvularia lunata, Fusarium sp. Aspergillus flavus, Rhizopus sp. Penicillium cyclopium, Aspergillus ochraceus, Syncephalastrum racemosum, Corynespora casiicola and Nigrospora sp.

24. Many fungal species occurred in the soils of the three sites. The dominant species of the non-rhizosphere

soils were:

Experimental Plot : Aspergillus niger and
Fusarium oxysporum

University Farm : Aspergillus niger and
Penicillium cyclopium

Private Farm : Aspergillus niger and
Aspergillus terreus

25. The total numbers of fungi of the non-rhizophere soils were:
Experimental Plot, 13; University Farm, 11 and Private Farm, 15.

26. Compared with the population levels of the non-rhizosphere soil:

Okra root exudates stimulated Aspergillus niger, Paecilomyces sp. and Syncephalastrum racemosum, but suppressed Aspergillus ochraceus, Aspergillus terreus and Trichoderma viride.

Pepper root exudates stimulated Aspergillus flavus, Aspergillus terreus and Fusarium oxysporum, but suppressed Aspergillus ochraceus, Rhizopus sp. and Trichoderma viride.

Tomato root exudates stimulated Aspergillus flavus. Aspergillus niger. Curvularia lunata. Penicillium cyclopium and Syncephalastrum racemosum. but suppressed Aspergillus ochraceus. Aspergillus terreus and Rhizopus sp.

27. The quality of rhizosphere populations was influenced by the time of growth of the plants in the year.

a. The following species in the rhizospheres increased during the dry season:

Okra : Aspergillus ochraceus. Fusarium oxysporum. Paecilomyces sp. and Penicillium cyclopium.

Pepper : Fusarium oxysporum. Paecilomyces sp. and Penicillium cyclopium.

Tomato : Aspergillus ochraceus. Fusarium oxysporum Paecilomyces sp. and Penicillium cyclopium.

b. The following species in the rhizospheres increased during the rainy season:

Okra : Rhizopus sp. and Syncephalastrum racemosum

Pepper : Aspergillus flavus. Aspergillus niger. Rhizopus sp. and Trichoderma viride.

Tomato : Aspergillus flavus. Aspergillus terreus, Rhizopus sp. Syncephalastrum racemosum and Trichoderma viride.

28. Air-dried and solar-dried okra fruit chips and pepper fruits showed different fungal contaminants. The fungi of each produet arranged in order of descending importance were as follows:

a. Okra fruit chips air-dried in the dry season: A. niger, C. herbarum, A flavus, P. cyclopium, F. oxysporum, C. lunata, A.terreus, Rhizopus sp., A. ochraceus, S. racemosum, Mycelia sterilia and Neurospora sp.

b. Okra fruit chips air-dried in the rainy season: A. niger, C. herbarum, A flavus, P. cyclopium, F. oxysporum, C. lunata, Rhizopus sp., A. terreus, Neurospora sp., A. ochraceus, Mycelia sterilia and S. racemosum

c. Okra fruit chips solar-dried in the dry season: A. niger, A. flavus, F. oxysporum, P. cyclopium, C. herbarum, A. terreus and C. lunata.

d. Okra fruit chips solar-dried in the rainy season: A niger, P. cyclopium, A terreus, A. flavus, C. herbarum, C.lunata and F. oxysporum.

e. Pepper fruits air-dried in the dry season: A. niger, C. herbarum, P. cyclopium, A flavus, Rhizopus sp., S. racemosum, C. lunata, F. oxysporum, Mycelia sterilia, Neurospora sp., A. ochraceus and A. terreus.

f. Pepper fruits air-dried in the rainy season: A. niger, P. cyclopium, Rhizopus sp., C. herbarum, A flavus, F. oxysporum, Neurospora sp., C.lunata, S. racemosum, Mycelia sterilia, A. ochraceus and A. terreus.

g. Pepper fruits solar-dried in the dry season: A. niger, A. flavus, Rhizopus sp. and P. cyclopium.

h. Pepper fruits solar-dried in the rainy season: A. niger, A. flavus and P. cyclopium.

29. One gram dried pepper fruits stored at 20 and 85% R.H. and fluctuating humidities between 68 and 81 % R.H.for 28 days gained 0.18, 1.98 amd 1.73 mg, respectively.

30. One gram of pepper powder stored at 20 and 85% R.H. and fluctuating humidities between 68 and 81% R.H. for 28 days gained 0.02, 1.63 and 1.59 mg, respectively.

31. One gram of dried okra fruit chips stored at 20 and 85% R.H. and fluctuating humidities between 68 and 81% R.H. for 28 days gained 0.33, 2.63 and 2.66 mg, respectively.

32. One gram of dried okra fruit powder stored at 20 and 85% R.H. and fluctuating humidities between 68 and 81% R.H. for 28 days gained 0.15, 2.22 and 2.13 mg, respectively.

33. Fungal contaminants of dried okra fruit material stored at different humidities in descending order of frequency were:

Chips at 20% RH : A. niger, P. cyclopium, A. flavus, and S. racemosum.

Chips at 85% RH : A. niger, P. cyclopium, A. flavus, and Yeast spp.

Chips at 68-81% RH : A. flavus, A. niger, P. C. herbarum and S. racemosum.

Powder at 20% RH : P. cyclopium, A. flavus, and A. niger.

Powder at 85% RH : A. niger, P. cyclopium, A. flavus and Yeast spp.

Powder at 68-81% RH : A. niger, P. cyclopium, A. flavus and Yeast spp.

34. Fungal contaminants of dried pepper fruit material stored at different humidities in descending order of frequency were:

Whole fruit at 20% RH : A. flavus, A. niger.

Whole fruit at 85% RH : A. flavus, A. niger.

Whole fruit at 68-81% RH : A. flavus, A. niger and P. cyclopium.

Powder at 20% RH : A.flavus, Rhizopus sp., P. cyclopium, A. niger, A.terreus and C.herbarum

Powder at 85% RH : A.flavus, A.terreus P. cyclopium and A. niger

Powder at 68-81% RH : A. flavus, F. oxysporum, A. niger, C. herbarum and P. cyclopium.

35. The predominant fungus on freshly harvested onion bulbs of Red Creole variety was A. niger whereas F. oxysporum was the predominant species on bulbs of the Texas Grano variety.

36. Bulbs of each variety formed in soils with Manure, and Manure and Sulphate of Ammonia carried quite similar mycoflora.

37. After 30 days' curing C. herbarum. F. oxysporum. Fusarium sp., P. cyclopium and T. viride were found to be the dominant species on Texas Grano bulbs. The dominant species on Red Creole bulbs was Rhizopus sp.

38. Irradiation of the bulbs with Gamma rays at dosages of 0.05 and 0.10 Gy did not prevent fungal growth and A. niger was present on all bulbs 90 days after irradiation.

39. Irradiation of bulbs with Gamma rays at dosages of 0.05 and 0.10 Gy did not show any predictable effect on Ascorbic acid content of the bulbs.

40. Irradiation of bulbs of both varieties of onion with Gamma rays at dosages of 0.05 and 0.10 Gy reduced the incidence of sprouting of the bulbs to different degrees.

41. Infection tests in which tomato fruits were both wound-inoculated and surface-inoculated showed that:

    a. Alternaria alternata, Aspergillus terreus, Corynespora casiicola, Curvularia lunata, Fusarium oxysporum and Scopulariopsis brevicaulis infected the fruit.

    b. Aspergillus clavatus, Aspergillus glaucus, Cladosporium herbarum, Helminthosporium sp., Penicillium citrinum, Penicillium funiculosum and S. racemosum did not cause infection even when inoculated into wounds.

42. Alternaria alternata, Aspergillus terreus, Curvularia lunata, and F. oxysporum rotted Wosowoso variety fruits faster than fruits of Heinz and Roma varieties.

43. S. brevicaulis rotted fruits of Heinz and Roma faster than those of Wosowoso variety.

44. In spore germination tests, using selected fungal species:

    a. Extracts of bulbs of both onion varieties completely inhibited germination of conidia of C. casiicola, C. lunata and T. viride but

stimulated germination of conidia of A. niger and A. flavus.

b. Tomato extracts stimulated germination of conidia of Helminthosporium sp. and C. lunata, and sporangiospores of S. racemosum.

45. Corynespora casiicola grew best in Sweet potato dextrose broth and poorest in V-8 juice. The descending order of performance was:

Sweet potato dextrose > Potato dextrose > Cassava dextrose > Yeast extract > Pawpaw extract > V-8 juice.

46. C. casiicola grew poorly in pepper fruit extract with the mean dry weight of 87.5 mg after 10 days as compared to mean mycelial dry weight of 296.0 mg in tomato fruit extract.

47. C. casiicola required external supply of Thiamine for good mycelial growth. The optimum concentration was 100 ug/l.

48. Other requirements for growth of C. casiicola were:

a. Optimum temperature of 30 ^{0}C.

b. Optimum pH of pH 3.8 - 7.9.

c. Either continuous darkness or 12 hour dark/12 hr light conditions.

d. Carbon sources in the order: Galactose > Maltose > Fructose > Glucose > Mannose > Sucrose > Lactose

e. Nitrogen-sources in the order: Potassium nitrate > D-L Asparagine > Sodium nitrate > L-Aspartic acid < Ammonium nitrate > Ammonium chloride > Ammonium sulphate.

49. Best growth in media with different inorganic salts occurred at different concentrations of the different compounds. The respective optimum concentrations were:

a. $CaCl_2.2H_2O$: 29.0×10^{-6}M in a range of 14.0 - 75.0×10^{-6}M

b. KCl : 8.0×10^{-3}M in a range of 4.0 - 12.0×10^{-3}M

c. K_2SO_4 : 5.7×10^{-3}M in a range of 5.7 - 17.0×10^{-3}M

d. $MgCl_2$: 10.0×10^{-4}M in a range of 5.0 - 15.0×10^{-4}M

e. $NaH_2PO_4.2H_2O$: 65.0×10^{-4}M in a range of 22.0 - 65.0×10^{-4}M

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A P P E N D I C E S

Appendix A

Monthly Temperatures and Rainfall

Date	Month	Maximum Temp. (^{0}C)	Minimum Temp. (^{0}C)	Rainfall (mm)
1988	November	31.6	23.6	39.0
	December	31.9	22.8	26.8
1989	January	32.5	21.9	0
	February	33.7	23.9	0
	March	33.0	24.2	38.1
	April	33.1	24.7	88.9
	May	31.5	24.0	121.8
	June	29.9	23.2	154.0
	July	28.4	23.0	54.4
	August	28.3	22.5	17.3
	September	29.9	22.5	58.4
	October	30.6	23.6	58.3
	November	32.8	24.0	38.0
	December	33.0	23.9	0

Appendix B

Time (Hours)	Soil Temp(°C) 5cm Depth	Soil Temp(°C) 10cm Depth	Atmospheric Temp(°C) 5cm Above soil	Atmospheric Temp(°C) 10cm Above soil	Atmospheric Humidity (% R.H.)	Soil Temp(°C) 5cm Depth	Soil Temp(°C) 10cm Depth	Atmospheric Temp(°C) 5cm Above soil	Atmospheric Temp(°C) 10cm Above soil	Atmospheric Humidity (% R.H.)
Jan 26, 1989						Jan 27, 1989				
6.00	25.0	25.0	23.5	23.6	96	25.2	26.0	23.6	23.6	98
7.00	25.2	26.0	24.0	24.2	94	25.2	26.0	24.2	24.2	92
8.00	25.7	26.0	27.8	26.2	90	25.8	26.0	26.4	27.4	84
9.00	27.1	26.2	29.0	29.4	74	27.3	26.3	28.8	28.8	74
10.00	28.4	27.0	31.4	31.6	62	29.0	27.0	31.8	32.0	64
11.00	29.6	28.0	33.0	33.2	57	30.5	28.0	35.0	34.0	52
12.00	30.5	28.5	35.0	34.6	56	31.5	29.0	32.5	32.0	48
1.00	31.8	29.2	36.5	34.2	50	32.0	29.5	37.5	35.0	50
2.00	32.3	30.0	36.0	33.8	62	33.0	30.0	37.5	33.8	56
3.00	32.2	31.0	34.0	32.4	58	32.9	30.5	36.2	34.2	59
4.00	31.6	30.0	32.2	31.4	63	32.3	30.5	31.5	30.2	66
5.00	30.5	29.5	29.0	28.5	72	30.6	30.0	30.0	29.4	74
6.00	29.1	29.0	26.8	26.8	80	29.4	29.5	27.2	27.0	80
7.00	28.2	28.5	25.8	25.8	87	29.0	29.0	26.3	26.0	82
9.00	27.0	28.0	25.8	25.8	88	27.5	28.0	26.0	26.0	82
Feb. 26, 1989						Feb. 27, 1989				
6.00	23.3	24.3	22.5	23.0	82	24.3	25.0	23.3	23.0	94
7.00	23.4	24.3	23.5	23.0	82	24.3	25.0	23.8	24.0	96
8.00	23.8	24.3	25.5	25.2	78	25.0	25.2	26.5	25.8	90
9.00	24.6	24.3	28.4	28.2	58	26.3	25.8	30.5	28.6	78
10.00	25.8	25.3	34.0	31.2	50	27.8	26.5	35.3	30.4	68
11.00	27.6	26.3	37.5	34.6	22	28.8	27.5	39.5	33.8	48
12.00	29.3	27.0	40.0	37.0	18	31.1	28.8	39.5	34.6	52
1.00	31.1	28.3	41.2	38.8	12	32.3	29.5	39.0	35.0	52
2.00	32.3	29.5	40.8	38.2	13	33.5	30.5	37.5	33.8	54
3.00	32.6	30.0	36.5	34.8	38	33.5	31.0	35.5	33.0	58
4.00	31.9	30.0	33.5	32.6	47	32.8	32.0	32.8	31.2	60
5.00	30.6	30.0	30.0	29.6	58	31.1	30.5	30.0	29.2	64
6.00	28.6	29.0	27.5	27.8	68	29.3	29.8	28.0	27.4	76
7.00	27.5	28.0	26.5	27.0	70	28.3	29.0	26.8	26.8	82
9.00	27.0	26.0	24.0	24.6	76	26.8	27.8	26.2	26.2	84

Appendix C

Time (Hours)	Soil Temp(°C) 5cm Depth	Soil Temp(°C) 10cm Depth	Atmospheric Temp(°C) 5cm Above soil	Atmospheric Temp(°C) 10cm Above soil	Atmospheric Humidity (% R.H.)	Soil Temp(°C) 5cm Depth	Soil Temp(°C) 10cm Depth	Atmospheric Temp(°C) 5cm Above soil	Atmospheric Temp(°C) 10cm Above soil	Atmospheric Humidity (% R.H.)
June 21, 1989						June 22, 1989				
6.00	26.0	27.0	24.0	23.6	98	25.0	26.0	23.0	22.6	98
7.00	26.5	27.0	24.5	24.5	94	25.0	26.0	23.5	23.5	98
8.00	27.3	27.5	26.5	25.4	88	25.5	26.0	26.0	26.0	94
9.00	28.5	28.0	27.5	27.0	82	27.3	26.5	29.0	28.8	84
10.00	30.3	29.0	31.0	30.0	72	29.6	28.0	30.5	30.0	76
11.00	30.5	31.0	32.0	30.5	68	31.3	29.5	31.0	30.5	74
12.00	31.2	31.0	32.0	30.5	72	31.6	30.0	32.5	31.25	70
1.00	33.3	31.2	32.5	30.5	66	31.3	30.5	28.7	28.3	82
2.00	32.3	31.5	35.0	32.0	72	29.6	30.0	27.5	27.3	82
3.00	31.5	31.5	32.0	30.2	76	29.5	29.5	27.5	27.0	86
4.00	30.5	30.8	32.0	30.0	80	29.5	29.5	27.7	27.0	86
5.00	29.3	30.0	29.0	27.8	92	28.8	29.2	26.5	26.0	90
6.00	27.0	28.5	25.0	23.8	98	28.3	28.8	25.2	25.0	92
7.00	27.0	28.0	24.5	23.8	98	27.8	28.0	24.8	25.0	94
9.00	26.8	27.5	24.5	23.5	98	27.8	27.5	24.0	23.6	100
July 28, 1989						July 27, 1989				
6.00	24.8	25.8	23.2	23.2	98	25.5	26.5	23.0	23.0	98
7.00	24.8	25.8	24.0	24.0	98	25.5	26.8	24.0	23.8	98
8.00	25.5	26.0	26.8	27.0	86	26.0	26.8	26.0	26.0	90
9.00	27.3	26.5	29.2	28.0	80	27.3	27.2	29.0	27.4	80
10.00	28.8	27.5	33.5	29.8	74	29.0	28.0	32.0	30.4	74
11.00	30.0	28.5	36.0	30.8	72	29.0	29.0	33.0	30.6	72
12.00	31.1	29.5	34.5	30.6	71	30.8	30.0	33.0	30.6	71
1.00	32.8	30.5	33.8	30.8	72	32.0	31.0	33.8	29.8	70
2.00	33.6	31.5	36.0	29.8	74	32.4	31.5	33.2	29.6	72
3.00	33.8	32.0	34.8	29.2	76	33.0	32.2	34.6	30.2	74
4.00	33.2	32.0	31.5	28.6	78	32.5	32.2	32.0	27.0	82
5.00	31.8	32.0	27.5	25.8	82	31.3	32.0	27.0	26.0	88
6.00	30.0	31.0	26.0	24.6	90	30.0	31.5	26.0	25.0	92
7.00	28.0	29.5	24.5	23.8	96	29.0	30.5	25.5	24.8	92
9.00	26.8	29.5	24.5	23.8	98	28.0	30.0	25.0	24.5	96

Appendix D

Airspora at the Experimental Plot, University Farm and Private Farm trapped monthly from January 1989 to December 1990 on PDA plates.

Time of Trapping		Total No. of fungal colonies (CFU) sampled at the Experimental Plot	University Farm	Private Farm
1989	January	396	175	91
	February	355	140	58
	March	163	71	37
	April	137	112	99
	May	36	63	30
	June	41	60	39
	July	165	136	54
	August	76	89	94
	September	127	115	98
	October	54	104	111
	November	82	81	89
	December	99	97	107
1990	January	166	160	96
	February	96	230	61
	March	101	42	84
	April	144	287	110
	May	28	23	27
	June	88	46	151
	July	44	50	71
	August	84	50	105
	September	115	56	102
	October	63	21	58
	November	59	88	50
	December	65	92	51

Appendix E

Total number of Fungal species in atmosphere of the Experimental Plot, University Farm and Private Farm trapped monthly from January, 1989 to December, 1990 on PDA plates.

Time of Trapping		Number of fungal species identified at the Experimental Plot	University Farm	Private Farm
1989	January	6	3	4
	February	15	8	6
	March	16	4	6
	April	17	6	8
	May	11	6	9
	June	6	9	8
	July	9	10	8
	August	10	9	11
	September	9	6	5
	October	11	12	8
	November	8	10	7
	December	15	12	6
1990	January	11	7	4
	February	13	8	8
	March	12	9	6
	April	6	4	4
	May	8	8	4
	June	15	6	7
	July	13	7	6
	August	12	8	8
	September	9	6	5
	October	9	7	5
	November	11	10	7
	December	8	8	7

Appendix F

Development of leaf infection in different varieties of tomato growing during the dry season from November, 1988 to February, 1989.

Date of Assessment (1988-1989)	Percentage of plants out of a total of 40 with leaf symptoms in each variety					
	Heinz		Roma		Wosowoso	
	Staked	Unstaked	Staked	Unstaked	Staked	Unstaked
November 30	21.6	30.2	11.3	18.4	5.3	11.3
December 10	27.9	37.1	22.2	29.5	8.2	18.6
December 20	35.1	44.2	31.5	38.0	13.4	24.6
December 30	41.8	60.3	44.1	54.6	20.9	30.8
January 9	65.5	81.3	52.6	74.6	56.9	42.4
January 19	83.3	87.0	89.2	93.7	69.6	70.5
January 29	99.4	100	100	99.0	96.7	95.2
Feburary 8	100	100	100	100	99.1	99.3
February 18	100	100	100	100	100	100
March 7	100	100	100	100	100	100

Appendix G

Development of leaf infection in different varieties of tomato growing during the dry season from June to August, 1989.

Date of Assessment (1989)		Percentage of plants out of a total of 40 with leaf symptoms in each variety					
		Heinz		Roma		Wosowoso	
		Staked	Unstaked	Staked	Unstaked	Staked	Unstaked
June	5	2.0	2.5	2.5	2.8	1.5	2.3
June	15	10.0	12.6	12.0	12.0	9.0	16.6
June	25	20.5	30.0	25.0	29.5	12.5	23.8
July	5	34.0	44.5	37.0	45.1	16.7	39.0
July	15	44.5	61.7	48.0	59.6	36.5	56.3
July	25	56.5	76.2	63.0	77.8	45.5	75.6
August	4	68.5	83.4	74.5	87.8	68.2	80.9
August	14	77.5	87.9	85.0	93.8	70.0	86.5
August	24	86.0	94.2	92.0	96.9	79.0	91.7
September	3	93.0	97.4	96.5	99.3	85.5	95.8
September	13	97.5	100	100	100	91.0	98.7

Appendix H

Percentage of pepper plants, out of a total of 40, showing leaf fungal infection during growth in the dry season from November, 1988 to February, 1989 and rainy from June to August, 1989.

Dry Season		Rainy Season	
Date of Assessment	% Infection	Date of Assessment	% Infection
January 2	0.7	June 5	1.8
January 12	4.2	June 15	2.3
January 22	19.9	June 25	17.5
February 1	36.1	July 5	25.4
February 11	50.0	July 15	30.7
February 21	67.7	July 25	41.7
March 3	79.8	August 4	55.1
March 13	89.3	August 14	63.0
March 23	96.2	August 24	70.0
April 2	77.6	September 3	71.7

APPENDIX I

Moisture gained by dried chips and powdered chips of Okra in atmospheres of 20 and 85% RH

Period of Incubation (Days)	Moisture gained (mg) by 1.0g product			
	Fruit Chips		Powder	
	20% RH	85% RH	20% RH	85% RH
2	0.16	1.34	0.10	0.95
4	0.21	1.81	0.12	1.36
6	0.25	2.05	0.12	1.60
8	0.26	2.21	0.13	1.79
10	0.28	2.34	0.14	1.91
14	0.30	2.49	0.15	2.09
21	0.32	2.63	0.15	2.22
28	0.33	2.63	0.15	2.22

APPENDIX J

Moisture gained by dried pepper fruit and powdered pepper fruit in atmospheres of 20 and 85% RH

Period of Incubation (Days)	Moisture gained (mg) by 1.0g product			
	Fruit		Powder	
	20% RH	85% RH	20% RH	85% RH
2	0.13	1.12	0.01	0.89
4	0.16	1.42	0.02	1.16
6	0.17	1.61	0.02	1.35
8	0.18	1.68	0.02	1.45
10	0.18	1.73	0.02	1.54
14	0.18	1.84	0.02	1.63
21	0.18	1.96	0.02	1.63
28	0.18	1.98	0.02	1.63

APPENDIX K

Moisture gained by dried chips and powdered chips of Okra exposed under normal atmospheric conditions

Period of Incubation (Days)	Atmospheric % RH	Moisture gained(mg) by 1.0g product	
		Fruit Chips	Powder
2	80	2.13	1.51
4	77	2.25	1.75
6	72	2.19	1.78
8	80	1.92	1.59
10	81	2.13	1.74
14	80	2.66	2.13
21	78	2.66	2.13
28	80	2.66	2.13

APPENDIX L

Moisture gained by dried fruits and powdered pepper fruit exposed under normal atmospheric conditions

Period of Incubation (Days)	Atmospheric % RH	Moisture gained(mg) by 1.0g Product	
		Fruit Chips	Powder
2	80	1.52	1.32
4	77	1.47	1.35
6	72	1.39	1.28
8	80	1.16	1.07
10	81	1.42	1.33
14	80	1.73	1.59
21	78	1.73	1.59
28	80	1.73	1.59

APPENDIX M (i)

Analysis of variance showing the effect of soil treatment, variety of onions an seasons of planting on occurrence of A.niger on harvested onion bulbs
(Data provided values in Tables 45 and 46)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig level
MAIN EFFECTS	15225.812	6	2537.635	5.183	.0014
Part of Bulb	1005.421	3	335.140	0.684	.5699
Soil Treatment	5.200	1	5.200	0.011	.9198
Onion variety	3421.713	1	3421.713	6.988	.0140
Planting Season	10793.478	1	10793.478	22.044	.0001
RESIDUAL	12240.978	25	489.63911		
TOTAL(CORR.)	27466.790	31			

APPENDIX M (ii)

Multiple range analysis showing the effect of onion varieties on occurrence of A.niger on harvested onions

Onion variety	Count	Average	Homogeneous Groups
Texas Grano	16	8.356	A
Red Creole	16	29.0375	B

APPENDIX M (iii)

Multiple range analysis showing the effect of seasons of planting on occurrence of A.niger on harvested onions

Season of planting	Count	Average	Homogeneous Groups
Dry Season	16	0.3312	A
Rainy Season	16	37.0625	B

Figures with the same letters are not significantly different

APPENDIX N (i)

Analysis of variance showing the effect of soil treatment, variety of onions and seasons of planting on occurrence of F.oxysporum on harvested onion bulbs

(Data provided values in Tables 45 and 46)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig level
MAIN EFFECTS	19750.070	6	3291.6783	7.983	.0001
Part of Bulb	678.156	3	226.0521	0.548	.6540
Soil Treatment	3867.601	1	3867.6012	9.380	.0052
Onion variety	6044.501	1	6044.5013	14.659	.0008
Planting Season	9159.811	1	9159.8113	22.214	.0001
RESIDUAL	10308.429	25	412.33715		
TOTAL(CORR.)	30058.499	31			

APPENDIX N (ii)

Multiple range analysis showing the effect of onion varieties on occurrence of F.oxysporum on harvested onions

Onion variety	Count	Average	Homogeneous Groups
Red Creole	16	22.15	A
Texas Grano	16	49.6375	B

APPENDIX N (iii)

Multiple range analysis showing the effect of seasons of planting on occurrence of F.oxysporum on harvested onions

Season of planting	Count	Average	Homogeneous Groups
Rainy Season	16	18.975	A
Dry Season	16	52.8125	B

APPENDIX N (iv)

Multiple range analysis showing the effect of soil treatment on occurrence of F.oxysporum on harvested onion bulbs

Soil treatment	Count	Average	Homogeneous Groups
Manure	16	24.9	A
Manure and Sulphate of Ammonia	16	46.89	B

Figures with the same letters are not significantly different

APPENDIX O (i)

Analysis of variance showing the effect of soil treatment, variety of onions and seasons of planting on occurrence of Fusarium sp. on harvested onion bulbs

(Data provided values in Tables 45 and 46)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig level
MAIN EFFECTS	5013.5738	6	835.5956	5.779	.0007
Part of Bulb	1117.7262	3	372.5754	2.577	.0763
Soil Treatment	67.8612	1	67.8612	0.469	.5068
Onion variety	424.8612	1	424.8612	2.939	.0989
Planting Season	3403.1250	1	3403.1250	23.537	.0001
RESIDUAL	3614.5950	25	144.58380		
TOTAL(CORR.)	86288.1688	31			

APPENDIX O (ii)

Multiple range analysis showing the effect of seasons of planting on occurrence of Fusarium sp. harvested onion bulbs

Season of planting	Count	Average	Homogeneous Groups
Rainy Season	16	0.156	A
Dry Season	16	20.7812	B

Figures with the same letters are not significantly different

APPENDIX P (i)

Analysis of variance showing the effect of soil treatment, variety of onions and seasons of planting on occurrence of *P. cyclopium* on harvested onion bulbs

(Data provided values in Tables 45 and 46)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig level
MAIN EFFECTS	9718.7594	6	1619.7932	4.710	.0025
Part of Bulb	5469.0759	3	1823.0253	5.301	.0057
Soil Treatment	789.0378	1	789.0378	2.294	.1424
Onion variety	676.2003	1	676.2003	1.966	.1731
Planting Season	2784.4453	1	2784.4453	8.097	.0087
RESIDUAL	8597.5328	25	343.90131		
TOTAL(CORR.)	18316.292	31			

APPENDIX Q (i)

Analysis of variance showing the effect of soil treatment, variety of onions and seasons of planting on occurrence of Yeast spp. on harvested onion bulbs

(Data provided values in Tables 45 and 46)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig level
MAIN EFFECTS	1792.9925	6	298.83208	2.761	.0337
Part of Bulb	626.2913	3	208.76375	1.929	.1508
Soil Treatment	219.4512	1	219.45125	2.027	.1668
Onion variety	574.6050	1	574.60500	5.308	.0298
Planting Season	372.6450	1	372.64500	3.443	.0754
RESIDUAL	2706.0863	25	108.24345		
TOTAL(CORR.)	4499.0788	31			

APPENDIX Q (ii)

Multiple range analysis showing the effect of seasons of planting on occurrence of Yeast spp. harvested onion bulbs

Onion Variety	Count	Average	Homogeneous Groups
Texas Grano	16	3.006	A
Red Creole	16	11.48	B

Figures with the same letters are not significantly different

APPENDIX R (i)

Analysis of variance showing the effect of soil treatment, variety of onions and seasons of planting on occurrence of Alternaria alternata on cured and irradiated onion bulbs (Data provided values in Tables 47-50)

Sources of variation	Sum of squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	201.87875	8	25.234844	2.151	.0392
Planting season	35.77042	1	35.770417	3.049	.0843
Onion Variety	80.66667	1	80.666667	6.875	.0103
Irrad. dosage	48.45583	2	24.227917	2.065	.1330
Soil Treatment	26.88167	1	26.881667	2.291	.1337
Part of bulb	10.10417	3	3.368056	0.287	.8346
RESIDUAL	1020.7546	87	11.732811		
TOTAL(CORR.)	1222.6333	95			

APPENDIX R (ii)

Multiple range analysis showing the effect of varieties of onions on occurrence of A. alternata on cured and irradiated onion bulbs

Onion Variety	Count	Average	Homogeneous Groups
Red Creole	48	0.1000000	A
Texas Grano	48	1.9333333	B

Figures with the same letters are not significantly different

APPENDIX S (i)

Analysis of variance showing the effect of soil treatment, variety of onions and seasons of planting on occurrence of A. niger on cured and irradiated onion bulbs
(Data provided values in Tables 47-50)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig level
MAIN EFFECTS	45892.480	8	5736.560	4.777	.0001
Planting season	228.167	1	228.167	0.190	.6686
Onion Variety	41151.602	1	41151.602	34.268	.0000
Irrad. dosage	2169.870	2	1084.935	0.903	.4089
Soil Treatment	63.050	1	63.050	0.053	.8217
Part of bulb	2279.791	3	759.930	0.633	.5958
RESIDUAL	2706.0863	25	108.24345		
TOTAL(CORR.)	4499.0788	31			

APPENDIX S (ii)

Multiple range analysis showing the effect of varieties of onions on occurrence of A.niger cured and irradiated for onion bulbs

Onion Variety	Count	Average	Homogeneous Groups
Texas Grano	48	33.493750	A
Red Creole	48	74.902083	B

Figures with the same letters are not significantly different

APPENDIX T (i)

Analysis of variance showing the effect of soil treatment, variety of onions and seasons of planting on occurrence of C. herbarum on cured and irradiated onion bulbs

(Data provided values in Tables 47-50)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig level
MAIN EFFECTS	3774.4823	8	471.8103	7.736	.0001
Planting season	256.7604	1	256.7604	4.210	.0432
Onion Variety	3057.7838	1	3057.7838	50.137	.0000
Irrad. dosage	296.6369	2	148.3184	2.423	.0938
Soil Treatment	4.5067	1	4.5067	0.074	.7893
Part of bulb	158.7946	3	52.9315	0.868	.4610
RESIDUAL	5306.0540	87	60.989126		
TOTAL(CORR.)	9080.5363	95			

APPENDIX T (ii)

Multiple range analysis showing the effect of varieties of onions on occurrence of C. herbarum on cured and irradiated onion bulbs.

Onion Variety	Count	Average	Homogeneous Groups
Red Creole	48	0.100000	A
Texas Grano	48	11.387500	B

APPENDIX T (iii)

Multiple range analysis showing the effect of seasons of planting on occurrence of C.herbarum on cured and irradiated onion bulbs

Season Planting	Count	Average	Homogeneous Groups
Dry Season	48	4.1083333	A
Rainy Season	48	7.379167	B

Figures with the same letters are not significantly different

APPENDIX U (i)

Analysis of variance showing the effect of soil treatment. variety of onions and seasons of planting on occurrence of F. oxysporum on cured and irradiated onion bulbs.

(Data provided values in Tables 47-50)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig level
MAIN EFFECTS	21872.051	8	2734.006	9.725	.0000
Planting season	36.138	1	36.138	0.129	.7246
Onion Variety	17245.801	1	17245.801	61.345	.0000
Irrad. dosage	2134.771	2	1067.385	3.797	.0262
Soil Treatment	3.118	1	3.118	0.011	.9175
Part of bulb	2452.224	3	817.408	2.908	.0391
RESIDUAL	24458.009	87	281.12654		
TOTAL(CORR.)	46330.060	95			

APPENDIX U (ii)

Multiple range analysis showing the effect of soil varieties of onions on occurrence of F. oxysporum on cured and irradiated onion bulbs

Onion Variety	Count	Average	Homogeneous Groups
Red Creole	48	0.514583	A
Texas Grano	48	27.320833	B

APPENDIX U (iii)

Multiple range analysis showing the effect of irradiation on occurrence of F.oxysporum on cured and irradiated onion bulbs

Irradiation Dosage (Gy)	Count	Average	Homogeneous Groups
0.05	32	10.021875	A
0.00	32	11.178125	A
0.10	32	20.553125	A

Figures with the same letters are not significantly different

APPENDIX V (i)

Analysis of variance showing the effect of soil treatment, variety of onions and seasons of planting on occurrence of Fusarium sp. on cured and irradiated onion bulbs

(Data provided values in Tables 47-50)

Sources of variation	Sum of squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	558.83250	8	69.85406	6.780	.0000
Planting season	2.25094	1	2.25094	0.218	.6464
Onion Variety	250.58344	1	250.58344	24.321	.0000
Irrad. dosage	5.56938	2	2.78469	0.270	.7638
Soil Treatment	2.97510	1	2.97510	0.289	.5981
Part of bulb	297.45365	3	99.15122	9.623	.0000
RESIDUAL	896.37406	87	10.30315		
TOTAL(CORR.)	1455.2066	95			

APPENDIX V (ii)

Multiple range analysis showing the effect of varieties of onions on occurrence of Fusarium sp. on cured and irradiated onion bulbs

Onion Variety	Count	Average	Homogeneous Groups
Red Creole	48	0.1000000	A
Texas Grano	48	3.33125	B

Figures with the same letters are not significantly different

APPENDIX W (i)

Analysis of variance showing the effect of soil treatment, variety of onions and seasons of planting on occurrence of P.cyclopium on cured and irradiated onion bulbs
(Data provided values in Tables 47-50)

Sources of variation	Sum of squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	11097.217	8	1387.1521	4.275	.0002
Planting season	9.375	1	9.3750	0.029	.8672
Onion Variety	8797.510	1	8797.5104	27.113	.0000
Irrad. dosage	463.523	2	231.7617	0.714	.4929
Soil Treatment	11.900	1	11.9004	0.037	.8506
Part of bulb	1814.908	3	604.9693	1.864	.1416
RESIDUAL	28229.173	87	324.47325		
TOTAL(CORR.)	39326.390	95			

APPENDIX W (ii)

Multiple range analysis showing the effect of varieties of onions on occurrence of P. cyclopium on cured and irradiated onion bulbs

Onion Variety	Count	Average	Homogeneous Groups
Red Creole	48	0.1000000	A
Texas Grano	48	19.245833	B

Figures with the same letters are not significantly different

APPENDIX X (i)

Analysis of variance showing the effect of soil treatment, variety of onions and seasons of planting on occurrence of Rhizopus sp. on cured and irradiated onion bulbs

(Data provided values in Tables 47-50)

Sources of variation	Sum of squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	8733.2817	8	1091.6602	3.460	.0017
Planting season	846.0938	1	846.0938	2.682	.1051
Onion Variety	4950.7538	1	4950.7538	15.692	.0002
Irrad. dosage	2735.3925	2	1367.6962	4.335	.0160
Soil Treatment	173.3437	1	173.3437	0.549	.4685
Part of bulb	27.6979	3	9.2326	0.294	.9932
RESIDUAL	27448.925	87	315.50488		
TOTAL(CORR.)	36182.206	95			

APPENDIX X (ii)

Multiple range analysis showing the effect of varieties of onions on occurrence of Rhizopus sp. on cured and irraidiated onion bulbs

Onion Variety	Count	Average	Homogeneous Groups
Texas Grano	48	0.100000	A
Red Creole	48	14.462500	B

APPENDIX X (iii)

Multiple range analysis showing the effect of irradiation on occurrence of Rhizopus sp. on cured and irradiated onion bulbs

Irradiation Dosage (Gy)	Count	Average	Homogeneous Groups
0.10	32	0.100000	A
0.05	32	8.85625	AB
0.00	32	12.887500	B

Figures with the same letters are not significantly different

APPENDIX Y (i)

Analysis of variance showing the effect of soil treatment, variety of onions and seasons of planting on occurrence of T.viride on cured and irradiated onion bulbs

(Data provided values in Tables 47-50)

Sources of variation	Sum of squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	7234.1533	8	904.2692	4.759	.0001
Planting season	406.7267	1	406.7267	2.14	.1470
Onion Variety	2348.2817	1	2348.2817	12.359	.0007
Irrad. dosage	3105.7433	2	1552.8717	8.173	.0006
Soil Treatment	1287.7350	1	1287.7350	6.777	.0109
Part of bulb	85.6667	3	28.5556	0.150	.9292
RESIDUAL	16530.485	87	190.00557		
TOTAL(CORR.)	23764.638	95			

APPENDIX Y (ii)

Multiple range analysis showing the effect of varieties of onions on occurrence of T.viride on cured and irradiated onion bulbs

Onion Variety	Count	Average	Homogeneous Groups
Texas Grano	48	0.1000000	A
Red Creole	48	9.9916667	B

APPENDIX Y (iii)

Multiple range analysis showing the effect of irradiation on occurrence of T. viride on cured and irradiated onion bulbs

Irradiation Dosage (Gy)	Count	Average	Homogeneous Groups
0.10	32	0.100000	A
0.00	32	2.025000	A
0.05	32	13.012500	B

APPENDIX Y (iv)

Multiple range analysis showing the effect of Manure and Manure and Sulphate of Ammonia on occurrence of T. viride on cured and irradiated bulbs

Soil Treatment	Count	Average	Homogeneous Groups
Manure and Sulphate of Ammonia	48	1.3833333	A
Manure	48	8.7083333	B

Figures with the same letters are not significantly different

APPENDIX Z (i)

Analysis of variance showing the effect of soil treatment variety of onions and seasons of planting on occurrence of Aspergillus flavus on cured irradiated and stored (Data provided values in Tables 47-51)

Sources of variation	Sum of squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	503.63729	8	62.95466	2.310	.0270
Planting season	366.21094	1	366.21094	13.436	.0004
Onion Variety	5.85094	1	5.85094	0.215	.6492
Irrad. dosage	7.15750	2	3.57875	0.131	.8771
Soil Treatment	65.17510	1	65.17510	2.391	.1256
Part of bulb	59.24281	3	19.74760	0.725	.5400
RESIDUAL	2371.2443	87	27.255681		
TOTAL(CORR.)	2874.8816	95			

APPENDIX Z (ii)

Multiple range analysis showing the effect of planting seasons on occurrence of A.flavus on cured,irradiated and stored onion bulbs

Seasons of planting	Count	Average	Homogeneous Groups
Dry Season	48	0.8562500	A
Rainy Season	48	4.7625000	B

Figures with the same letters are not significantly different

APPENDIX A_1 (i)

Analysis of variance showing the effect of soil treatment, variety of onions and seasons of planting on occurrence of Aspergillus niger on cured irradiated and stored onion bulbs (Data provided values in Tables 51-54)

Sources of variation	Sum of squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	8842.9167	8	1105.3646	4.381	.0002
Planting season	5002.5938	1	5002.5938	19.825	.0000
Onion Variety	1183.0104	1	1183.0104	4.688	.0331
Irrad. dosage	157.9375	2	78.9688	0.313	.7321
Soil Treatment	720.5104	1	720.5104	2.855	.0947
Part of bulb	1778.8646	3	592.9549	2.350	.0780
RESIDUAL	21953.240	87	252.33609		
TOTAL(CORR.)	30796.156	95			

APPENDIX A_1 (ii)

Multiple range analysis showing the effect of planting seasons on occurrence of A.niger on cured irradiated and stored onion bulbs

Seasons of planting	Count	Average	Homogeneous Groups
Rainy Season	48	75.687500	A
Dry Season	48	90.125000	B

APPENDIX A_1 (iii)

Multiple range analysis showing the effect of varieties of onions on occurrence of A.niger on cured,irradiated and stored onion bulbs

Onion variety	Count	Average	Homogeneous Groups
Texas Grano	48	79.395833	A
Red Creole	48	86.416667	B

Figures with the same letters are not significantly different

APPENDIX B_1(i)

Analysis of variance showing the effect of soil treatment, variety of onions and seasons of planting on occurrence of Curvularia lunata on cured irradiated and stored onion bulbs (Data provided values in Tables 51-54)

Sources of variation	Sum of squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	45.737292	8	5.717161	1.754	.0973
Planting season	25.420417	1	25.420417	7.799	.0064
Onion Variety	0.135000	1	0.135000	0.041	.4814
Irrad. dosage	6.458958	2	3.229479	0.991	.3754
Soil Treatment	8.520417	1	8.520417	2.614	.1095
Part of bulb	5.202500	3	1.734167	0.532	.6615
RESIDUAL	283.56104	87	3.2593223		
TOTAL(CORR.)	329.29833	95			

APPENDIX B_1(ii)

Multiple range analysis showing the effect of planting seasons on occurrence of C.lunata on cured irradiated and stored onion bulbs

Seasons of planting	Count	Average	Homogeneous Groups
Dry Season	48	0.1812500	A
Rainy Season	48	1.2104167	B

Figures with the same letters are not significantly different

APPENDIX C_1 (i)

Analysis of variance showing the effect of soil treatment, variety of onions and seasons of planting on occurrence of Rhizopus sp. on cured, irradiated and stored onion bulbs
(Data provided values in Tables 51-54)

Sources of variation	Sum of squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	1284.1983	8	160.52479	4.435	.0002
Planting season	601.0004	1	601.00042	16.603	.0001
Onion Variety	201.2604	1	201.26042	5.560	.0206
Irrad. dosage	305.1458	2	152.57292	4.215	.0179
Soil Treatment	168.0104	1	168.01042	4.641	.0340
Part of bulb	8.7813	3	2.92708	0.081	.9703
RESIDUAL	3149.2813	87	36.198635		
TOTAL(CORR.)	4433.4796	95			

APPENDIX C_1 (ii)

Multiple range analysis showing the effect of planting seasons on occurrence of Rhizopus sp. on cured, irradiated and stored onion bulbs

Seasons of planting	Count	Average	Homogeneous Groups
Dry Season	48	0.1000000	A
Rainy Season	48	5.1041667	B

APPENDIX C_1 (iii)

Multiple range analysis showing the effect of varieties of onions on occurrence of Rhizopus sp. on cured, irradiated and stored onion bulbs

Onion variety	Count	Average	Homogeneous Groups
Red Creole	48	1.1541667	A
Texas Grano	48	4.0500000	A

APPENDIX C_1 (iv)

Multiple range analysis showing the effect of soil treatment on occurrence of Rhizopus sp. on cured, irradiated and stored onion bulbs

Soil Treatment	Count	Average	Homogeneous Groups
Manure	48	1.2791667	A
Manure and Sulphate of Ammonia	48	3.9250000	A

APPENDIX C_1 (v)

Multiple range analysis showing the effect of irradiation treatment on occurrence of Rhizopus sp. on cured, irradiated and stored onion bulbs

Irradiation dosage (Gy)	Count	Average	Homogeneous Groups
0.00	48	1.1437500	A
0.05	48	1.5500000	A
0.10	48	5.1125000	A

Figures with the same letters are not significantly different

APPENDIX D_i (i)

Analysis of variance showing the effect of soil treatment, variety of onions and seasons of planting on occurrence of Syncephalastrum racemosum cured, irradiated and stored onion bulbs

(Data provided values in Tables 51-54)

Sources of variation	Sum of squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	325.65875	8	40.70734	6.907	.0000
Planting season	198.66260	1	198.66260	33.707	.0000
Onion Variety	24.70510	1	24.70510	4.192	.0436
Irrad. dosage	61.73896	2	30.86948	5.238	.0071
Soil Treatment	9.81760	1	9.81760	1.666	.2003
Part of bulb	30.73448	3	10.244	1.738	.1651
RESIDUAL	512.76865	87	5.8938925		
TOTAL(CORR.)	838.42740	95			

APPENDIX D_i (ii)

Multiple range analysis showing the effect of planting seasons on occurrence of S. racemosum on cured. irradiated and stored onion bulbs

Seasons of planting	Count	Average	Homogeneous Groups
Dry Season	48	0.1000000	A
Rainy Season	48	2.9770833	B

APPENDIX D_i (iii)

Multiple range analysis showing the effect of varieties of onions on occurrence of S. racemosum on cured, irradiated and stored onion bulbs

Onion variety	Count	Average	Homogeneous Groups
Red Creole	48	1.0312500	A
Texas Grano	48	2.0458333	B

Figures with the same letters are not significantly different

APPENDIX D_1 (iv)

Multiple range analysis showing the effect of irradiation treatment on occurrence of S. racemosum on cured, irradiated and stored onion bulbs

Irradiation dosage (Gy)	Count	Average	Homogeneous Groups
0.00	48	0.7062500	A
0.10	48	1.2875000	AB
0.05	48	2.6218750	B

Figures with the same letters are not significantly different

APPENDIX E_1 (i)

Analysis of variance showing the effect of soil treatment, variety of onions and seasons of planting on occurrence of Trichoderma viride on cured, irradiated and stored onion bulbs (Data provided values in Tables 51-54)

Sources of variation	Sum of squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	149.42188	8	18.677734	4.381	.0062
Planting season	51.33375	1	51.333750	8.018	.0058
Onion Variety	25.21500	1	25.215000	3.938	.0504
Irrad. dosage	18.23687	2	9.118437	1.424	.2463
Soil Treatment	23.60167	1	23.601667	3.686	.0581
Part of bulb	31.03458	3	10.344861	1.616	.1915
RESIDUAL	557.02438	87	6.4025790		
TOTAL(CORR.)	706.44625	95			

APPENDIX E_1 (ii)

Multiple range analysis showing the effect of planting seasons on occurrence of T.viride on cured, irradiated and stored onion bulbs

Seasons of planting	Count	Average	Homogeneous Groups
Dry Season	48	0.100000	A
Rainy Season	48	1.562500	B

APPENDIX E_1 (iii)

Multiple range analysis showing the effect of varieties of onions on occurrence of T.viride on cured, irradiated and stored onion bulbs

Onion variety	Count	Average	Homogeneous Groups
Red Creole	48	0.3187500	A
Texas Grano	48	1.3437500	B

APPENDIX E_1 (iv)

Multiple range analysis showing the effect of soil treatment on occurrence of T.viride on cured,irradiated and stored onion bulbs

Soil Treatment	Count	Average	Homogeneous Groups
Manure and Sulphate of Ammonia	48	0.3354167	A
Manure	48	1.3270833	B

Figures with the same letters are not significantly different

APPENDIX F_1 (i)

Analysis of variance showing the effect of soil treatment, variety of onions and seasons of planting on occurrence of Yeast spp. on cured,irradiated and stored onion bulbs
(Data provided values in Tables 51-54)

Sources of variation	Sum of squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	1.5285417	8	0.1910677	2.380	.0228
Planting season	0.3266667	1	0.3266667	4.069	.0468
Onion Variety	0.3266667	1	0.3266667	4.069	.0468
Irrad. dosage	0.2139583	2	0.1069792	1.332	.2691
Soil Treatment	0.0337500	1	0.0337500	0.420	.5254
Part of bulb	0.6275000	3	0.2091667	2.605	.0569
RESIDUAL	6.9847917	87	0.0802850		
TOTAL(CORR.)	8.5133333	95			

APPENDIX F_1 (ii)

Multiple range analysis showing the effect of planting seasons on occurrence of Yeast spp. on cured,irradiated and stored onion bulbs

Seasons of planting	Count	Average	Homogeneous Groups
Rainy Season	48	0.1000000	A
Dry Season	48	0.2166667	A

APPENDIX F_1 (iii)

Multiple range analysis showing the effect of varieties of onions on occurrence of Yeast spp. on cured,irradiated and stored onion bulbs

Onion variety	Count	Average	Homogeneous Groups
Red Creole	48	0.1000000	A
Texas Grano	48	0.2166667	A

Figures with the same letters are not significantly different

APPENDIX G_1

Growth of lesions in Tomato Fruits inoculated with Alternaria alternata, Aspergillus terreus, Corynespora casiicola and Cladosporium herbarum and incubated at 27°C for 10 days

Inoculum	Tomato Variety	Type of inoculation	Mean Rot Diameter (mm) after 2 days	4 days	6 days	8 days	10 days
Alternaria alternata	Heinz	Surface	7.5 ± 0.1	12.5 ± 0.1	18.5 ± 0.5	22.0	24.5 ± 0.5
		Wound	9.0	18.5 ± 0.5	29.5 ± 1.0	37.5	60.0 ± 0.5
	Roma	Surface	7.3 ± 0.1	10.3 ± 0.1	12.5 ± 0.5	13.5	15.0
		Wound	9.0	15.0	18.5 ± 0.5	27.5	36.0 ± 0.5
	Woso-woso	Surface	9.0	14.5 ± 0.5	21.5 ± 0.5	24.5	27.0
		Wound	10.0	22.0	36.5 ± 1.0	41.5	70.0 ± 0.5
Aspergillus terreus	Heinz	Surface	6.0	8.5 ± 0.1	9.0 ± 0.1	10.5 ± 0.5	15.0
		Wound	6.5 ± 0.1	21.0	46.5 ± 0.5	62.0 ± 1.0	75.5 ± 1.5
	Roma	Surface	6.0	8.5 ± 0.1	8.5 ± 0.1	9.0	13.0
		Wound	8.0	23.0	41.5 ± 0.5	48.3 ± 0.4	59.5 ± 0.5
	Woso-woso	Surface	5.0	8.5 ± 0.1	12.0	17.5 ± 0.5	28.5 ± 0.1
		Wound	6.5 ± 0.1	22.5 ± 0.5	59.5 ± 0.5	75.0 ± 1.0	82.0 ± 0.5

Appendix 6$_1$ Contd.

Corynespora cassiicola	Heinz	Surface	6.3 ± 0.1	10.0	16.0	18.5 ± 0.5	21.0
		Wound	7.0	13.0	28.5 ± 0.1	60.0 ± 1.0	64.0 ± 1.0
	Roma	Surface	6.3	9.6 ± 0.1	15.3 ± 0.3	17.0	19.0
		Wound	6.0	12.3 ± 0.1	36.0 ± 0.1	54.0 ± 1.0	65.5 ± 0.5
	Woso-woso	Surface	6.0	11.3 ± 0.1	17.0	19.0	22.0
		Wound	9.0	14.0	21.0	67.5 ± 0.5	69.0 ± 1.0
Cladosporium herbarum	Heinz	Surface	3.0	4.0	5.0	6.0	6.0
		Wound	4.0	6.0	6.0	7.5	75.5 ± 0.1
	Roma	Surface	3.5	3.5	5.0	5.0	6.0
		Wound	3.5	4.5	5.0	5.5 ± 0.1	6.5 ± 0.1
	Wosc-woso	Surface	3.5	4.0	5.0	6.0	6.0
		Wound	5.5	7.5 ± 0.1	9.0	9.0	9.0

APPENDIX B_1

Growth of lesions in Tomato Fruits inoculated with Curvularia lunata, Fusarium oxysporum, Nigrospora oryzae and Scopulariopsis brevicaulis at 27°C for 10 days

Inoculum	Tomato Variety	Type of Inoculation	Mean Rot Diameter (mm) after 2 days	4 days	6 days	8 days	10 days
Curvularia lunata	Heinz	Surface	4.0	4.5 ± 0.1	8.5 ± 0.1	13.0	16.5 ± 0.1
		Wound	5.5	6.5 ± 0.1	10.5 ± 0.1	22.5± 0.5	29.5 ± 0.5
	Roma	Surface	3.5	4.0	7.0	11.0	12.0
		Wound	5.0	5.0	8.0	17.5± 0.5	21.5 ± 0.5
	Woso-woso	Surface	4.0	5.5	11.5 ± 0.5	14.5 ± 0.1	18.5 ± 0.5
		Wound	6.0	27.5 ± 0.5	38.5 ± 0.5	54.0 ± 1.0	62.0 ± 1.0
Fusarium oxysporum	Heinz	Surface	7.0	12.0	24.0	26.0	38.0 ± 0.5
		Wound	19.0	27.5 ± 0.5	53.0 ± 1.0	70.0± 1.0	92.0 ± 1.0
	Roma	Surface	8.0	10.0	20.0	25.5 ± 0.5	45.5 _ 0.5
		Wound	21.0 ± 0.5	28.5 ± 0.5	54.5 ± 1.0	74.5 ± 0.5	84.0 ± 1.0
	Woso-woso	Surface	9.0	19.0	30.0	47.0 ± 0.5	68.0 ± 1.0
		Wound	17.0	35.0 ± 0.5	79.0 ± 1.0	83.0 ± 1.0	94.0 ± 1.0

Appendix M_1 Contd.

Nigrospora oryzae	Heinz	Surface	3.0	3.0	3.0	3.0	3.0
		Wound	4.3	23.5 ± 0.5	62.5 ± 0.5	75.0 ± 1.0	80.0 ± 1.0
	Roma	Surface	3.0	3.0	3.0	3.0	3.0
		Wound	3.3	24.0 ± 0.5	57.5 ± 0.5	68.0 ± 1.0	73.5 ± 0.5
	Woso-woso	Surface	3.0	3.0	3.0	3.0	3.0
		Wound	6.0	23.5 ± 0.5	68.5 ± 0.5	72.0 ± 1.0	79.5 ± 0.5
Scopulariopsis brevicaulis	Heinz	Surface	8.5 ± 0.1	13.5 ± 0.5	15.0	21.5 ± 0.5	36.5 ± 0.5
		Wound	13.5 ± 0.5	28.0	42.0 ± 1.0	63.0 ± 1.0	67.0 ± 1.0
	Roma	Surface	8.5 ±0.1	12.0	13.0	13.0	13.0
		Wound	21.0 ± 0.5	31.5 ± 0.5	40.5 ± 0.5	46.0 ± 0.5	52.5 ± 0.5
	Woso-woso	Surface	8.5	15.0	17.5 ± 0.5	29.5 ± 0.5	37.5 ± 0.5
		Wound	11.5 ± 0.1	20.0	37.0 ± 1.0	59.8 ± 0.4	65.5 ± 1.0

Appendix I_1

Hydrogen ion concentration of different natural media during growth of *C. casiicola* at 30±2°C

Broth	pH after following days of incubation					
	0	2	4	6	8	10
Cassava Dextrose	5.6	6.1	7.5	7.9	7.8	7.8
Pawpaw Extract	5.5	6.3	7.4	7.8	8.0	8.2
Potato Dextrose	5.9	6.1	7.5	7.6	7.6	7.6
Sweet Potato Dextrose	5.7	5.9	7.3	7.6	7.5	7.5
V-8	4.2	4.3	4.6	4.3	8.0	8.3
Yeast Extract	5.6	6.7	7.7	8.4	8.6	8.6

Appendix J_1

Conductivity of media with different Natural media during growth of C. casiicola at 30±2°C.

Broth	Conductivity (uS/cm) after following days of incubation					
	0	2	4	6	8	10
Cassava Dextrose	1.23	0.79	0.74	0.80	0.81	0.86
Pawpaw Extract	1.62	1.05	1.06	1.07	1.12	1.22
Potato Dextrose	1.87	1.56	1.31	1.39	1.34	1.45
Sweet Potato Dextrose	0.88	1.16	1.12	1.06	1.02	1.05
V-8	3.75	3.89	3.81	3.45	3.98	4.17
Yeast Extract	1.37	1.35	1.83	2.14	1.95	1.94

APPENDIX K_1 (i)

Analysis of variance of the data in Table 62 showing the effect of different natural media on vegetative growth of C. casiicola at 30± 2o C under day/night condition

Sources of variation	Sum of Sources	d f	Mean square	F-ratio	Sig. Level
MAIN EFFECTS	701082.88	11	63734.807	39.142	.0000
Natural media	479264.23	5	95852.847	58.866	.0000
Incubation time	249277.18	4	62319.296	38.272	.0000
Replicates	83.03	2	41.514	0.025	.9748
RESIDUAL	127008.24	78	1628.3108		
TOTAL(CORR.)	828091.12	89			

APPENDIX K_1 (ii)

Multiple range analysis showing the effect of different natural media on vegetative growth of C. casiicola at 30+2 C under day/night condition. (Note the differences between Scheff Averages for the different broths)

Broth	Count	Average	Homogeneous Groups
Pawpaw extract	15	60.0000	A
Yeast extract	15	61.3333	A
V-8	14	64.28571	A
Cassava dextrose	15	143.26667	B
Potato dextrose	16	198.06250	C
Sweet Potato dextrose	15	236.60000	C

Figures with the same letters are not significantly different

Appendix L_1

Hydrogen ion concentration of culture media extracts of onion bulbs and fruits of pepper and tomato during growth of C. casiicola at 30±2°C

Culture media of extracts	pH after following days of incubation					
	0	2	4	6	8	10
Onion bulb	5.5	5.5	5.5	5.5	6.8	7.9
Pepper fruit	5.2	5.2	5.2	5.3	5.4	5.7
Tomato fruit	4.3	4.3	4.4	4.5	4.9	5.6

Appendix M_1

Conductivity of culture media of extracts of onion bulbs and fruits of pepper and tomato during growth of C. casiicola at 30±2°C

Culture media of extracts	Conductivity (uS/cm) after following days of incubation					
	0	2	4	6	8	10
Onion bulb	2.4	2.4	2.0	1.3	1.1	1.4
Pepper fruit	2.5	2.5	2.4	2.4	2.3	2.5
Tomato fruit	5.5	5.6	5.2	4.7	4.8	4.9

APPENDIX N_1 (i)

Analysis of variance of data presented in Table 63 showing the effect of extracts of onion bulb, pepper and tomato fruits on vegetative growth of C.casiicola at 30± 2°C under day-night condition .

Sources of variation	Sum of Sources	d.f	Mean variation	F-ratio	Sig. level
MAIN EFFECTS	718172.27	10	71817.23	30.092	0.0000
Extracts	249654.51	2	124827.25	52.303	0.0000
Incubation time	468429.55	4	117107.39	49.068	0.0000
Replicates	88.21	4	22.05	0.009	0.9998
RESIDUAL	152743.68	64	2386.6200		
TOTAL(CORR.)	870915.95	74			

APPENDIX N_1 (ii)

Multiple range analysis showing the effect of the extracts of onion bulb,pepper and tomato fruits on vegetative growth of C.casiicola at 30+2 C under day-night condition.

Extract	Count	Average	Homogeneous Groups
Pepper fruit	25	70.3200	A
Tomato fruit	25	183.2000	B
Onion bulb	25	200.4000	B

Figures with the same letters are not significantly different

Appendix O_1

Hydrogen ion concentration of Sweet Potato Dextrose Broth at different temperatures during growth of C. casiicola

Temperatures	pH after following days of incubation					
^0C	0	2	4	6	8	10
10	5.9	6.5	6.9	6.5	6.1	6.1
23	5.9	6.7	7.3	7.3	6.9	7.0
27	5.9	6.7	7.4	7.3	7.0	7.0
30	5.9	6.8	7.4	7.2	6.9	7.0
35	5.9	6.5	6.8	6.3	5.7	6.0

Appendix P_1

Conductivity of Sweet Potato Dextrose Broth at different temperatures during growth of C. casiicola

Temperatures ^0C	Conductivity (uS/cm) after following days of incubation					
	0	2	4	6	8	10
10	1.68	1.50	1.47	1.42	1.36	1.47
23	1.68	1.49	1.34	1.30	1.29	1.27
27	1.68	1.47	1.23	1.26	1.28	1.36
30	1.68	1.41	1.60	1.19	1.22	1.29
35	1.68	1.52	1.59	1.67	1.75	1.88

APPENDIX Q1 (i)

Analysis of variance showing the effect of different temperatures on vegetative growth of C.casiicola at in Sweet Potato dextrose broth under day-night condition

(Data provided values in Table 65)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig. level
MAIN EFFECTS	211122.67	10	21112.267	9.476	.0000
Temperatures	150994.67	4	37748.667	16.943	.0000
Incubation time	58861.33	4	14715.333	6.605	.0002
Replicates	1266.67	2	633.333	.284	.7535
RESIDUAL	142592.00	64	2228.000		
TOTAL(CORR.)	353714.67	74			

APPENDIX Q1 (ii)

Multiple range analysis showing the effect of different temperatures on vegetative growth of C.casiicola in Sweet Potato Dextrose under day-night condition.

Temperatures (°C)	Count	Average	Homogeneous Groups
10	15	90.00000	A
35	15	158.00000	B
27	15	190.66667	BC
23	15	199.33333	BC
30	15	217.33333	D

Figures with the same letters are not significantly different

APPENDIX R_1 (i)

Analysis of variance showing the effect of buffered basal media at different initial pH's on vegetative growth of C. casiicola at 30± 2° C under normal day-night regime (Data provided values in Table 66)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig. level
MAIN EFFECTS	1077812.6	14	76986.61	85.981	.0000
pH	443231.8	7	63318.82	70.716	.0000
Incubation time	633539.3	3	211179.78	235.852	.0000
Replicates	1041.5	4	260.38	0.291	.8838
RESIDUAL	129831.78	145	895.39155		
TOTAL(CORR.)	1207644.4	155			

APPENDIX R_1 (ii)

Multiple range analysis showing the effect of buffered media of different initial pH's on vegetative growth of C. casiicola at 30± 2°C under day-night regime.

Initial pH	Count	Average	Homogeneous Groups
2.61	20	134.75000	A
8.80	20	200.50000	B
3.09	20	202.25000	B
7.87	20	228.15000	BC
3.77	20	255.90000	CD
4.57	20	285.40000	DE
6.49	20	288.00000	DE
5.67	20	298.55000	E

Figures with the same letters are not significantly different

Appendix S_1

Hydrogen ion concentration of culture media during growth of C. casiicola under different light conditions at 30±2°C

Light Conditions	pH after following days of incubation					
	0	2	4	6	8	10
Continuous Light	5.3	5.4	5.6	7.4	7.6	7.2
Continuous Dark	5.3	5.4	5.5	7.5	7.0	7.3
12 hours light/ 12 hours dark	5.3	5.4	6.0	7.5	7.4	7.1

Appendix T_1

Conductivity of culture media during growth of C. casiicola under different light conditions at 30±2°C

Light Conditions	Conductivity (uS/cm) after following days of incubation					
	0	2	4	6	8	10
Continuous Light	1.56	1.40	1.26	1.17	1.15	1.13
Continuous Dark	1.56	1.39	1.25	1.11	1.19	1.14
12 hours light/ 12 hours dark	1.56	1.37	1.26	1.13	1.12	1.10

APPENDIX U_1 (i)

Analysis of variance showing the effect of different light condtions on vegetative growth of C. casiicola in Sweet Potato Dextrose at 30± 2 °C

(Data provided values in Table 68)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig. level
MAIN EFFECS	1723448.7	10	172344.87	59.404	.0000
Light regimes	55058.6	2	27529.32	9.489	.0002
Incubation time	1652348.2	4	413087.05	142.384	.0000
Replicates	16041.5	4	4010.45	1.382	.2500
RESIDUAL	185678.61	64	2901.2283		
TOTAL(CORR.)	1909127.3	74			

APPENDIX U_1 (ii)

Multiple range analysis showing the effect of buffered media of different light conditions on vegetative growth of C. casiicola in Sweet Potato Dextrose broth at 30± 2°C

Light Conditions	Count	Average	Homogeneous Groups
Continuous light	25	269.20000	A
Continuous darkness	25	313.60000	B
12hr light/ 12hr dark	25	334.12000	B

Figures with the same letters are not significantly different

Appendix V_1

Hydrogen ion concentration of culture media with different carbon compounds at 1% concentration during growth of C. casiicola at 30±2°C

Carbon	pH after following days of incubation				
Compound	0	4	6	8	10
Fructose	4.8	7.7	5.1	4.3	3.8
Galactose	4.9	4.6	4.4	6.2	6.7
Glucose	5.6	4.9	5.2	6.9	7.5
Lactose	5.2	8.7	8.6	8.3	8.3
Maltose	4.9	8.2	7.6	7.0	5.6
Mannose	5.0	4.1	4.1	4.0	4.4
Sucrose	5.2	5.7	5.7	5.7	5.6
None	5.3	8.7	8.7	8.5	8.5

Appendix VI

Conductivity of culture media with different carbon compounds at 1% concentration during growth of C. casiicola at 30±2°C

Carbon Compound	Conductivity (uS/cm) after following days of incubation				
	0	4	6	8	10
Fructose	1.1	1.9	1.4	1.2	1.1
Galactose	1.1	1.1	1.0	1.1	1.3
Glucose	1.2	1.2	1.0	1.3	1.7
Lactose	1.1	2.3	2.1	2.0	2.0
Maltose	1.1	2.4	1.9	1.3	1.0
Mannose	1.1	1.8	1.7	1.4	1.5
Sucrose	1.1	1.0	1.0	0.9	0.9
None	1.1	2.4	2.2	2.0	2.0

APPENDIX X_1 (i)

Analysis ofvariance showing the effect of basal medium containing different Carbon compounds at concentration of 1% (w/v) on vegetative growth of C. casiicola at 30± 2°C under normal day/night condition

(Data provide values in Table 69)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig. level
MAIN EFFECTS	70389.250	14	5027.804	36.784	.0000
Carbon compounds	32008.175	7	4572.596	33.453	.0000
Incubation time	38346.675	3	12782.225	93.515	.0000
Replicates	34.400	4	8.600	.063	.9926
RESIDUAL	19819.525	145	136.68638		
TOTAL(CORR.)	90208.775	159			

APPENDIX X_1 (ii)

Multiple range analysis showing the effect of basal medium containing different carbon compounds at concentrations of 1%(w/v) on vegetative growth of C. casiicola in Sweet Potato Dextrose at 30± 2°C under normal day-night condition

Carbon sources	Count	Average	Homogeneous Groups
Lactose	20	20.500000	A
Control	20	22.000000	AB
Sucrose	20	31.100000	ABC
Mannose	20	35.500000	BCD
Fructose	20	40.500000	CDE
Glucose	20	48.000000	DE
Maltose	20	51.500000	EF
Galactose	20	64.600000	F

Figures with the same letters are not significantly different

Appendix Y_1

Hydrogen ion concentration of culture media with different amounts of Glucose during growth of C. casiicola at 30±2°C

Glucose Concentrations (%)	pH after following days of incubation					
	0	2	4	6	8	10
None	5.2	6.3	8.1	8.4	8.6	8.4
15	5.6	5.7	5.8	5.9	6.2	5.9
20	5.8	5.9	4.9	5.0	5.2	5.2
30	5.5	5.6	5.8	5.7	5.8	5.9

Appendix Z_1

Conductivity of culture media with different amounts of Glucose during growth of Corynespora casiicola at 30±2°C

Glucose Concentration (%)	Conductivity (uS/cm) after following days of incubation					
	0	2	4	6	8	10
None	1.0	1.2	2.4	2.5	2.3	2.3
15	1.1	1.1	1.1	1.1	1.1	1.1
20	1.1	1.1	1.1	1.0	1.0	1.0
30	1.0	1.1	1.1	1.1	1.1	1.1

APPENDIX A_2 (i)

Analysis of variance showing the effect of basal medium containing different amounts of Glucose on vegetative growth of C. casiicola at 30 +2°C under normal day/night condition (Data provided values in Table 70)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig. level
MAIN EFFECTS	185431.81	11	16857.438	40.422	.0000
Glucose conc.(%)	61045.62	3	20348.540	48.793	.0000
Incubation time	124266.96	4	31066.740	74.494	.0000
Replicates	119.23	4	29.809	0.071	.9905
RESIDUAL	36699.445	88	417.03915		
TOTAL(CORR.)	222131.26	99			

APPENDIX A_2 (ii)

Multiple range analysis showing the effect of basal medium containing different amounts of Glucose on vegetative growth of C. casiicola at 30±2° C under normal day-night condition

Glucose conc. (%)	Count		Homogeneous Groups
0.0	25	29.500000	A
1.5	25	71.900000	B
2.0	25	86.120000	BC
3.0	25	93.200000	C

Figures with the same letters are not significantly different

Appendix β_1

Hydrogen ion concentration of media with different Nitrogen compounds during growth of C. casiicola at 30±2°C

Nitrogen Compounds	pH after following days of incubation					
	0	2	4	6	8	10
None	5.6	5.4	5.3	5.5	5.6	6.1
Ammonium Chloride	5.4	5.6	2.9	2.6	2.5	2.4
Ammonium nitrate	5.0	4.7	4.3	3.6	3.1	2.8
Ammonium sulphate	4.4	3.6	3.0	2.8	2.8	2.6
D-L Asparagine	5.7	5.3	5.4	6.3	6.8	7.6
L-Aspartic Acid	3.1	3.0	3.0	3.0	3.1	3.1
Potassium nitrate	5.5	5.9	6.2	5.4	5.0	5.4
Sodium nitrate	5.4	5.5	5.9	5.8	5.9	6.3

Appendix C_2

Conductivity of media with different Nitrogen Compounds during growth of C. casiicola at 30±2°C

Nitrogen Compounds	Conductivity (uS/cm) after following days of incubation					
	0	2	4	6	8	10
None	1.2	1.2	1.2	1.2	1.1	1.0
Ammonium Chloride	9.6	9.6	9.7	9.9	10.4	10.2
Ammonium nitrate	14.9	14.2	14.3	13.6	13.2	14.4
Ammonium sulphate	8.3	8.0	8.1	8.2	8.3	8.3
D-L Asparagine	1.2	2.4	2.8	2.1	1.6	2.2
L-Aspartic Acid	2.0	1.9	1.8	1.8	1.8	1.7
Potassium nitrate	9.2	8.9	8.5	8.4	8.4	8.8
Sodium nitrate	8.1	7.8	7.5	7.5	7.3	7.1

APPENDIX D_2 (i)

Analysis of variance showing the effect of basal medium containing different Nitrogen compounds on vegetative growth of C. casiicola at 30± °C under normal day-night condition (Data provided values in Table 71)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig. level
MAIN EFFECTS	916926.20	15	61128.41	102.795	.0000
Nitrogen compounds	98359.76	7	14051.39	23.629	.0000
Incubation time	817893.675	4	204473.32	343.847	.0000
Replicates	673.400	4	168.29	0.283	.8887
RESIDUAL	109418.04	184	594.66326		
TOTAL(CORR.)	1026344.2	199			

APPENDIX D_2 (ii)

Multiple range analysis showing the effect of basal medium containing different Nitrogen compounds on vegetative growth of C. casiicola at 30± 2° C under normal day-night condition

Nitrogen compounds	Count	Average	Homogeneous Groups
Ammonium Sulphate	25	95.52000	A
Ammonium Chloride	25	124.30000	B
Control	25	140.40000	BC
Ammonium Nitrate	25	150.40000	BCD
L-Aspartic	25	151.20000	BCD
Sodium Nitrate	25	152.20000	CD
D-L Asparagine	25	163.52000	CD
Potassium Nitrate	25	169.40000	D

Figures with the same letters are not significantly different

Appendix F_1

Hydrogen ion concentration of media with different amounts of $CaCl_2.2H_2O$ during growth of C. casiicola at 30±2°C

$CaCl_2.2H_2O$ Concentration ($X10^{-6}M$)	pH after following days of incubation					
	0	2	4	6	8	10
0.0	4.9	6.4	6.7	6.5	6.3	5.0
14.0	5.0	6.3	6.7	6.6	6.7	5.1
29.0	4.9	6.5	6.8	6.5	6.5	5.3
75.0	5.0	6.2	6.9	6.8	6.7	5.8

Appendix F_2

Conductivity of media with different amounts of $CaCl_2.2H_2O$ during growth of C. casiicola at 30±2°C

$CaCl_2.2H_2O$ Concentration ($x10^{-6}M$)	Conductivity (uS\cm) after following days of incubation					
	0	2	4	6	8	10
0.0	1.1	1.4	1.2	1.1	1.1	1.1
14.0	1.0	1.0	1.1	0.9	1.0	1.0
29.0	1.1	1.1	1.1	1.0	1.0	1.0
75.0	1.1	1.1	1.1	1.0	1.0	1.0

APPENDIX G_2 (i)

Analysis of variance showing the effect of basal medium containing different amounts of $CaCl_2.2H_2O$ on vegetative growth of C. casiicola at 30± 2° C under normal day-night condition

(Data provided values in Table 72)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig. level
MAIN EFFECTS	528068.94	11	48006.27	68.800	.0000
$CaCl_2.2H_2O$	46107.32	3	15369.11	22.026	.0000
Incubation time	481285.06	4	120321.26	172.438	.0000
Replicates	676.56	4	169.14	0.242	.9905
RESIDUAL	61403.420	88	697.76614		
TOTAL(CORR.)	589472.36	99			

APPENDIX G_2 (ii)

Multiple range analysis showing the effect of basal medium containing different amounts of $CaCl_2.2H_2O$ on vegetative growth of C. casiicola at 30± 2° C under day-night condition

$CaCl_2.2H_2O$ Conc. ($x10^6$M)	Count	Average	Homogeneous Groups
0.0	25	103.28000	A
75.0	25	103.60000	A
14.0	25	122.80000	A
29.0	25	156.00000	B

Figures with the same letters are not significantly different

Appendix H_1

Hydrogen ion concentration of media with different concentration of KCl during growth of C. casiicola at 30±2°C

KCl Concentration ($X10^{-3}M$)	pH after following days of incubation					
	0	2	4	6	8	10
0.0	4.5	4.5	4.6	4.0	4.2	4.0
4.0	4.6	4.8	4.7	4.9	4.8	4.6
8.0	4.6	4.5	4.5	4.8	4.6	4.5
12.0	4.6	4.4	4.7	5.0	4.6	4.6

Appendix I_1

Conductivity of media with different amounts of KCl during growth of C. casiicola at 30±2°C

KCl Concentration	Conductivity (uS/cm) after following days of incubation					
($x10^{-3}M$)	0	2	4	6	8	10
0.0	0.8	0.8	0.9	0.7	0.8	0.7
4.0	1.3	1.3	1.1	1.2	1.2	1.2
8.0	1.8	1.7	1.7	1.6	1.7	1.6
12.0	2.3	2.1	2.2	2.1	2.1	2.2

APPENDIX J_2 (i)

Analysis of variance showing the effect of basal medium containing different amounts of KCl on vegetative growth of C. casiicola at 30± 2°C under normal day/night condition (Data provided values in Table 73)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig. level
MAIN EFFECTS	389259.27	11	35387.206	47.489	.0000
KCl	106530.75	3	35510.250	47.655	.0000
Incubation time	282326.76	4	70581.690	94.720	.0000
Replicates	401.76	4	100.440	0.135	.9691
RESIDUAL	65574.040	88	745.15955		
TOTAL(CORR.)	454833.31	99			

APPENDIX J_2 (ii)

Multiple range analysis showing the effect of basal medium containing different amounts of KCl on vegetative growth of C. casiicola at 30± 2° C under day-night condition

KCl Conc. ($x10^3$M)	Count	Average	Homogeneous Groups
0.0	25	50.12000	A
4.0	25	105.64000	B
12.0	25	123.56000	BC
8.0	25	135.00000	C

Figures with the same letters are not significantly different

Appendix K_7

Hydrogen ion concentration of media with different amounts of K_2SO_4 during growth of C. casiicola at 30±2°C.

K_2SO_4 Concentration ($X10^{-3}M$)	pH after following days of incubation					
	0	2	4	6	8	10
0.0	5.0	5.4	5.2	6.5	7.4	7.7
5.7	5.0	5.4	5.1	6.4	7.0	6.7
11.0	5.0	5.3	5.2	6.3	6.9	6.9
17.0	5.0	5.1	5.3	6.5	6.9	6.9

Appendix L_7

Conductivity of media with different amounts of K_2SO_4 during growth of C. casiicola at 30±2°C

K_2SO_4 Concentration ($x10^{-3}M$)	Conductivity (uS/cm)) after following days of incubation					
	0	2	4	6	8	10
0.0	1.2	1.2	1.2	1.3	1.5	1.7
5.7	1.3	1.4	1.3	1.2	1.2	1.2
11.0	1.4	1.4	1.3	1.6	1.3	1.4
17.0	1.5	1.5	1.5	1.5	1.4	1.4

APPENDIX M_2 (i)

Analysis of variance showing the effect of basal medium containing different amounts of K_2SO_4 on vegetative growth of C. casiicola at 30± 2°C under normal day-night condition (Data provided values in Table 74)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig. level
MAIN EFFECTS	782433.14	11	71130.29	63.106	.0000
K_2SO_4	36663.12	3	12221.04	10.842	.0000
Incubation time	744785.76	4	186196.44	165.192	.0000
Replicates	984.26	4	246.07	0.218	.9276
RESIDUAL	99189.420	88	1127.1525		
TOTAL(CORR.)	881622.56	99			

APPENDIX M_2 (ii)

Multiple range analysis showing the effect of basal medium containing different amounts of K_2SO_4 on vegetative growth of C. casiicola at 30± 2° C under day-night condition

K_2SO_4 Conc. ($\times 10^3$M)	Count	Average	Homogeneous Groups
0.0	25	122.80000	A
17.0	25	158.00000	B
11.0	25	167.56000	B
5.7	25	171.40000	B

Figures with the same letters are not significantly different

Appendix N

Hydrogen ion concentration of media with different amounts of $MgCl_2$ during growth of C. casiicola at 30±2°C

$MgCl_2$ Concentration ($\times 10^{-4}$ M)	pH after following days of incubation					
	0	2	4	6	8	10
0.0	5.0	5.5	5.3	4.9	3.3	3.8
5.0	4.9	4.9	5.6	5.1	3.6	3.6
10.0	4.7	4.7	4.9	5.0	3.7	3.9
15.0	4.6	5.4	4.8	5.1	3.4	4.0

Appendix O

Conductivity of media with different amounts of $MgCl_2$ during growth of C. casiicola at 30±2°C

$MgCl_2$ Concentration ($\times 10^{-4}$ M)	Conductivity (uS/cm) after following days of incubation					
	0	2	4	6	8	10
0.0	1.0	1.1	1.1	0.9	1.2	1.1
5.0	1.1	1.1	1.1	1.0	1.1	1.1
10.0	1.2	1.1	1.1	1.1	1.2	1.2
15.0	1.2	1.3	1.2	1.2	1.3	1.3

APPENDIX P_2 (i)

Analysis of variance showing the effect of basal medium containing different amounts of $MgCl_2$ on vegetative growth of C. casiicola at 30± 2° C under day-night condition (Data provided values in Table 75)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig. level
MAIN EFFECTS	691151.86	11	62831.99	162.335	.0000
$MgCl_2$	63203.68	3	2106.89	5.443	.0018
Incubation time	683910.76	4	170977.74	441.744	.0000
Replicates	920.24	4	230.06	0.594	.6676
RESIDUAL	34060.580	88	387.05205		
TOTAL(CORR.)	725212.44	99			

APPENDIX P_2 (ii)

Multiple range analysis showing the effect of basal medium containing different amounts of $MgCl_2$ on vegetative growth of C. casiicola at 30± 2° C under day-night condition

$MgCl_2$ Conc. ($x10^4$M)	Count	Average	Homogeneous Groups
0.0	25	150.68000	A
15.0	25	155.52000	AB
5.0	25	165.72000	AB
10.0	25	170.72000	B

Figures with the same letters are not significantly different

Appendix Q

Hydrogen ion concentration of media with different amounts of $NaH_2PO_4.2H_2O$ during growth of C. casiicola at 30±2°C

$NaH_2PO_4.2H_2O$ Concentration (X10⁻¹ M)	pH after following days of incubation					
	0	2	4	6	8	10
0.0	4.3	5.6	5.8	6.5	5.8	6.2
22.0	4.3	5.3	4.7	4.9	4.8	4.5
45.0	4.2	4.7	3.9	4.0	4.2	4.1
65.0	4.1	5.0	4.2	5.3	4.4	4.4

Appendix R

Conductivity of media with different amounts of $NaH_2PO_4.2H_2O$ during growth of C. casiicola at 30±2°C

$NaH_2PO_4.2H_2O$ Concentration (×10⁻¹ M)	Conductivity (uS/cm) after following days of incubation					
	0	2	4	6	8	10
0.0	0.3	0.4	0.4	0.4	0.4	0.4
22.0	0.5	0.5	0.5	0.4	0.5	0.4
45.0	0.6	0.7	0.6	0.6	0.6	0.6
65.0	0.8	0.8	0.8	0.8	0.7	0.8

APPENDIX S_2 (i)

Analysis of variance showing the effect of basal medium containing different amounts of $NaH_2PO_4 . 2H_2O$ on vegetative growth of C. casiicola at 30± 2°C under normal day-night condition

(Data provided values in Table 76)

Sources of variation	Sum of Sources	d.f	Mean square	F-ratio	Sig. level
MAIN EFFECTS	82419.00	11	7492.636	29.446	.0000
$NaH_2PO_4 . 2H_2O$	4307.00	3	1435.667	5.642	.0014
Incubation time	77546.00	4	19386.500	76.188	.0000
Replicates	566.00	4	141.500	0.556	.6951
RESIDUAL	22392.00	88	254.45455		
TOTAL(CORR.)	104811.00	99			

APPENDIX S_2 (ii)

Multiple range analysis showing the effect of basal medium containing different amounts of $NaH_2PO_4 . 2H_2O$ on vegetative growth of C. casiicola at 30± 2° C under day-night condition

$NaH_2PO_4 . 2H_2O$ Conc. ($x10^4$M)	Count	Average	Homogeneous Groups
0.0	25	52.800000	A
45.0	25	62.800000	AB
22.0	25	68.000000	B
65.0	25	69.6000000	B

Figures with the same letters are not significantly different

Table 8: Major fungal species in atmospheres of the Experimental Plot, University Farm and Private Farm trapped monthly from January, 1989 to December 1990 on PDA plates.

% Frequency occurence (to the nearest whole number) of species at the stations¹

Months/Species	Alternaria alternata 1 2 3	Aspergillus flavus 1 2 3	Aspergillus ochraceus 1 2 3	Aspergillus niger 1 2 3	Aspergillus terreus 1 2 3	Cladosporium herbarum 1 2 3	Corynespora cassiicola 1 2 3	Curvularia lunata 1 2 3	Fusarium oxysporum 1 2 3
January	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	96 97 87	0 0 0	0 0 0	2 2 2
February	1 0 0	0 0 0	2 4 2	1 5 2	3 0 0	86 77 78	0 0 0	0 3 0	1 5 7
March	3 0 0	0 0 0	1 0 0	1 4 3	2 0 0	76 83 56	4 0 0	2 0 6	3 12 13
April	2 0 2	1 0 0	4 0 6	5 1 1	1 0 0	65 66 69	1 0 2	7 13 5	2 5 2
May	3 0 0	0 0 0	0 0 0	9 2 2	3 0 0	44 87 50	3 0 0	6 2 0	17 3 26
June	6 0 0	0 2 0	0 0 0	0 3 0	0 0 0	50 36 33	4 0 0	14 15 6	14 9 30
July	9 0 0	2 0 0	3 3 0	3 0 0	0 0 0	59 57 56	5 7 19	10 9 0	11 13 12
August	0 0 0	0 2 0	1 3 0	25 33 5	0 2 0	45 35 46	0 0 10	5 0 0	7 5 19
September	0 0 0	5 2 6	0 0 0	62 76 65	2 0 0	21 23 6	0 0 0	4 0 0	3 3 4
October	0 0 0	5 1 6	0 0 6	6 0 3	2 0 0	46 34 36	4 1 0	11 8 12	6 5 16
November	0 0 5	1 0 5	1 0 12	12 0 14	0 0 0	60 45 38	0 0 0	3 13 3	18 26 14
December	0 2 5	0 0 5	0 0 0	1 19 14	0 0 0	63 47 38	0 0 0	3 10 6	20 4 15
January	0 0 0	1 0 0	0 0 0	0 2 2	0 0 0	38 74 38	0 0 0	0 0 0	3 10 1
February	3 0 0	2 0 0	0 0 0	1 0 0	0 6 0	62 81 38	2 0 3	0 0 1	10 10 5
March	4 4 0	1 1 0	0 0 0	1 1 0	0 0 0	44 40 49	0 0 10	2 3 4	19 19 4
April	0 0 0	0 0 0	0 0 0	1 0 3	0 0 0	71 80 83	0 0 0	1 10 4	26 15 5
May	1 15 0	0 0 0	0 0 0	2 4 0	0 0 0	37 22 60	3 7 4	4 2 8	34 41 47
June	0 0 0	0 0 0	0 0 0	8 0 0	0 0 0	38 57 66	3 3 0	5 0 3	11 21 17
July	3 10 22	0 0 0	0 0 0	0 2 3	0 0 0	53 44 73	0 0 0	7 0 3	8 2 14
August	3 0 0	15 0 0	3 0 0	1 4 1	0 0 0	53 55 39	3 0 0	0 0 0	17 30 12
September	2 0 0	0 1 0	0 0 0	2 2 2	0 0 0	82 24 79	1 6 0	0 0 3	8 38 14
October	3 0 0	0 3 0	0 0 0	2 3 2	0 0 0	46 24 50	3 3 0	8 0 0	26 35 14
November	0 0 0	1 0 0	0 0 0	5 0 2	0 0 0	55 49 40	5 1 0	5 3 0	16 35 20
December	0 4 3	2 0 0	0 0 0	0 0 1	0 0 0	42 54 49	0 0 0	12 12 3	40 29 24

Months/Species	Fusarium species 1 2 3	Helminthosporium species 1 2 3	Neurospora sitophila 1 2 3	Nigrospora species 1 2 3	Penicillium cyclopium 1 2 3	Rhizopus species 1 2 3	Mycelia Sterilia 1 2 3	Trichoderma viride 1 2 3	Yeast spp. 1 2 3
January	0 0 0	0 0 0	0 1 0	0 0 0	0 0 0	0 0 0	0 0 3	0 0 0	0 0 0
February	1 0 0	0 0 0	0 1 0	1 4 2	0 0 0	0 0 0	0 0 2	0 0 0	0 0 0
March	1 0 0	0 0 0	1 1 1	3 0 7	0 0 0	0 3 0	1 0 10	0 0 0	1 0 0
April	1 0 2	1 0 5	1 1 0	2 8 2	0 0 0	0 0 0	1 0 0	0 0 0	0 0 0
May	0 0 5	0 0 7	0 0 0	9 5 4	0 0 0	1 0 3	0 0 0	0 0 0	2 0 1
June	0 0 19	0 17 11	3 0 0	12 0 0	0 0 0	0 2 0	0 0 0	0 0 0	0 0 0
July	0 0 0	5 11 0	0 0 0	3 0 7	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0
August	0 0 0	5 0 0	0 0 0	0 0 0	1 1 0	0 0 2	0 0 0	0 11 6	0 0 0
September	0 0 0	0 0 0	0 0 0	0 0 1	0 0 0	0 0 0	0 0 0	0 1 3	0 0 0
October	10 0 6	0 4 6	0 1 0	10 7 12	0 0 0	1 1 1	0 0 0	0 1 0	0 0 0
November	0 0 0	0 1 2	7 1 0	0 3 5	0 0 0	1 1 0	0 0 0	4 5 0	0 6 0
December	1 0 2	0 2 0	0 2 58	2 1 0	0 0 0	0 1 0	3 0 0	0 1 0	0 0 0
January	0 0 0	1 0 0	0 14 0	0 2 0	3 0 0	1 8 0	3 0 0	0 0 0	37 0 1
February	0 0 0	0 0 0	18 2 0	1 1 0	3 0 3	0 0 0	2 0 0	0 0 0	10 0 0
March	0 0 4	3 1 0	0 0 9	2 12 0	1 2 0	0 0 1	1 0 0	0 0 0	20 16 0
April	0 4 0	0 0 0	0 1 0	1 0 0	0 0 0	0 0 1	0 0 0	0 0 0	0 0 0
May	0 0 0	0 0 0	0 0 0	0 0 0	3 2 0	0 0 0	0 0 0	0 9 0	17 0 0
June	7 0 0	3 0 0	0 0 0	2 3 2	3 0 4	0 0 0	0 0 0	0 0 0	19 0 5
July	6 0 0	3 0 2	0 1 0	10 3 3	1 0 0	0 0 0	1 0 0	0 5 0	0 0 0
August	0 0 0	0 6 0	0 1 1	2 1 9	3 9 19	1 0 1	2 0 0	0 0 3	0 0 0
September	0 0 0	0 0 0	3 8 1	3 3 3	0 3 0	1 1 0	0 0 0	0 0 0	0 0 0
October	0 2 0	0 0 0	1 15 1	1 2 4	3 0 0	0 0 0	0 0 0	0 0 0	0 0 0
November	0 0 0	4 0 0	0 0 0	5 4 3	0 2 0	2 1 1	0 0 0	4 0 0	0 0 0
December	0 0 0	0 3 0	2 3 7	2 3 3	0 1 1	0 1 1	0 0 0	0 0 0	0 5 0

1. Experimental Plot
2. University Farm
3. Private Farm

TABLE 12a: Fungal species on surface of fruits of pepper plants growing in the dry season (November 1988- Februrary 1989) at three different localities at Legon and Madina

Plot/Farm	Part of fruit	Date of Assessment (1989)	Percentage Frequency									
			Aspergillus flavus	Aspergillus niger	Aspergillus terreus	Cladosporium herbarus	Curvularia lunata	Fusarium oxysporum	Mycelia sterilia	Nigrospora oryzae	Rhizopus species	Yeast spp.
Experimental Plot	Epicarp Surface	Jan. 3	0	0	0	73	0	17	0	0	0	0
		Jan.18	0	0	0	98	0	2	0	0	0	0
		Feb. 6	0	0	0	58	0	42	0	0	0	0
	Calyx	Jan. 3	0	0	0	33	0	39	0	0	26	2
		Jan.18	0	0	13	40	0	36	0	0	8	6
		Feb. 6	0	0	0	46	0	0	0	0	0	0
University Farm	Epicarp Surface	Jan. 3	15	0	0	62	0	14	0	0	9	0
		Jan.18	5	8	0	46	0	20	2	0	10	9
		Feb. 6	12	13	0	16	9	19	4	0	15	12
	Calyx	Jan. 3	0	0	0	0	0	80	0	0	20	0
		Jan.18	0	0	0	64	0	30	0	0	6	0
		Feb. 6	0	0	0	71	0	0	0	0	29	0
Private Farm	Epicarp Surface	Jan. 3	29	0	0	63	0	0	0	0	0	0
		Jan.18	15	0	0	34	0	46	0	0	4	0
		Feb. 6	10	0	0	90	0	0	0	0	0	0
	Calyx	Jan. 3	0	0	18	33	0	0	0	0	49	0
		Jan.18	12	11	0	57	0	0	0	0	22	0
		Feb. 6	21	0	7	73	0	0	0	0	0	0

TABLE 12b: Fungal species on surface of fruits of pepper plants growing in the rainy season (June - September, 1989) at three different localities at Legon and Madina

Plot/Farm	Part of Fruit	Date of Assessment (1989)	Percentage Frequency									
			Aspergillus flavus	Aspergillus niger	Aspergillus terreus	Cladosporium herbarum	Curvularia lunata	Fusarium oxysporum	Mycelia sterilia	Nigrospora oryzae	Rhizopus species	Yeast spp.
Experimental Plot	Epicarp Surface	Jul. 5	0	52	0	27	41	12	0	3	1	0
		Jul.14	42	6	2	10	0	0	0	0	0	40
		Jul.27	4	22	6	27	2	15	0	0	5	15
		Aug.14	9	7	0	37	7	14	2	0	10	0
		Sept.3	0	24	0	45	11	0	0	0	17	0
	Calyx	Jul. 5	11	0	9	25	0	26	0	0	14	11
		Jul.14	2	57	3	0	0	3	0	0	3	0
		Jul.27	5	61	4	5	0	3	0	0	3	17
		Aug.14	0	0	0	4	0	30	0	0	9	58
		Sept.3	0	0	10	10	0	37	0	0	19	24
University Farm	Epicarp Surface	Jul. 5	28	1	0	0	7	45	5	0	1	0
		Jul.14	11	1	0	22	7	23	7	11	8	3
		Jul.27	24	3	0	18	10	12	3	11	10	8
		Aug.14	20	0	0	17	14	22	13	5	9	0
		Sept.3	12	9	0	9	10	31	7	0	13	0
	Calyx	Jul. 5	0	0	0	0	0	71	0	0	29	0
		Jul.14	17	6	17	30	0	0	0	0	30	0
		Jul.27	5	0	0	0	0	44	0	0	8	49
		Aug.14	0	0	3	28	0	19	0	0	16	0
		Sept.3	0	0	5	25	0	15	0	0	16	28
Private Farm	Epicarp Surface	Jul. 5	0	0	0	75	0	13	0	0	12	0
		Jul.14	13	0	0	72	0	0	0	0	15	0
		Jul.27	0	0	0	78	0	0	0	0	10	0
		Aug.14	13	0	0	48	0	11	0	0	29	0
		Sept.3	20	0	0	49	0	19	0	0	5	0
	Calyx	Jul. 5	0	0	0	83	0	0	0	0	20	0
		Jul.14	7	0	0	37	0	0	0	0	7	0
		Jul.27	0	0	26	60	0	0	0	0	10	0
		Aug.14	12	0	8	66	0	0	0	0	14	0
		Sept.3	0	0	9	78	0	0	0	0	12	0

TABLE 15a: Fungal species on surface of fruits of Wosowoso variety of Tomato plants growing in the dry season (November, 1988 - February, 1989) at three different localities at Legon and Madina

Plot/Farm	Part of fruit	Date of Assessment (1989)	Percentage Frequency											
			Alternaria alternata	Aspergillus flavus	Aspergillus niger	Cladosporium herbarum	Corynespora cassiicola	Curvularia lunata	Fusarium oxysporum	Fusarium species	Geotrichum species	Mucor species	Rhizopus species	Yeast
Experimental Plot	Epicarp Surface	Jan. 3	0	0	0	19	0	0	11	8	4	0	0	45
		Jan.18	0	0	0	37	0	0	34	5	14	0	5	0
		Feb. 6	0	0	0	28	0	0	19	26	34	0	0	0
	Calyx	Jan. 3	0	0	0	54	0	0	46	0	0	0	0	0
		Jan.18	0	0	0	72	0	0	27	8	0	0	54	0
		Feb. 6	0	0	0	0	0	0	46	0	0	0	0	0
University Farm	Epicarp Surface	Jan. 3	0	0	8	0	0	0	0	0	31	0	29	31
		Jan.18	0	0	13	8	0	0	28	0	23	0	14	7
		Feb. 6	0	0	41	0	0	0	1	0	0	0	60	0
	Calyx	Jan. 3	0	0	0	72	0	0	28	0	0	0	0	0
		Jan.18	0	0	0	85	0	0	7	0	0	1	6	0
		Feb. 6	0	0	0	71	0	0	22	0	0	0	2	0
Private Farm	Epicarp Surface	Jan. 3	0	0	0	32	0	0	46	0	4	0	9	0
		Jan.18	0	0	19	18	0	3	28	6	12	0	14	0
		Feb. 6	0	0	0	31	0	0	29	0	0	0	18	0
	Calyx	Jan. 3	0	0	5	34	0	0	15	0	0	0	9	0
		Jan.18	0	0	0	60	0	0	32	0	0	0	6	0
		Feb. 6	0	0	0	58	0	0	29	0	0	0	13	0

TABLE 15b Fungal species on surface of fruits of Wosowoso variety of tomato plants growing in the dry season (November, 1988 - February, 1989) and in the rainy season (June - September, 1989) at three different localities at Legon and Madina

Plot/Farm	Part of fruit	Date of Assessment (1989)	Percentage frequency					
			Alternaria alternata	Aspergillus flavus	Asperzillus niger	Cladosporium herbarum	Corynespora cassiicola	Curvularia lunata
		1985						
Experimental Plot	Epicarp Surface	Jul 5	0	0	0	0	0	7
		Jul 14	0	2	1	0	1	0
		Jul 27	1	0	4	43	1	3
		Aug 14	0	3	3	35	0	0
		Sept 3	0	0	0	6	2	12
	Calyx	Jul 5	0	6	0	0	0	0
		Jul 14	0	0	0	7	9	0
		Jul 27	0	0	0	22	0	0
		Aug 14	0	0	0	31	0	0
		Sept 3	0	0	4	34	0	0
University Farm	Epicarp Surface	Jul 5	0	6	10	4	0	0
		Jul 14	9	2	8	0	0	0
		Jul 27	6	18	12	0	0	0
		Aug 14	0	0	10	21	5	2
		Sept 3	0	0	0	0	0	0
	Calyx	Jul 5	0	0	0	38	0	0
		Jul 14	0	0	0	46	0	0
		Jul 27	0	4	3	37	0	0
		Aug 14	0	0	0	39	0	0
		Sept 3	0	0	2	0	0	0
Private Farm	Epicarp Surface	Jul 5	3	0	55	6	0	0
		Jul 14	4	0	34	9	4	0
		Jul 27	4	8	0	21	0	0
		Aug 14	0	0	0	18	0	0
		Sept 3	4	0	20	16	2	4
	Calyx	Jul 5	0	0	4	0	0	0
		Jul 14	0	0	0	36	0	5
		Jul 27	0	3	0	38	0	0
		Aug 14	0	0	0	31	0	1
		Sept 3	0	0	6	34	0	

Fusarium oxysporus	Fusarium sp.	Geotrichum spp.	Mucor spp.	Rhizopus sp.	Yeast spp.
27	21	19	0	0	19
27	1	39	0	0	16
17	3	13	0	3	19
30	19	12	0	2	0
53	8	8	0	0	11
27	0	0	2	0	64
32	1	0	0	38	14
49	0	0	0	4	25
52	6	0	1	7	0
43	0	0	7	0	0
22	0	4	0	16	36
18	0	6	0	4	38
7	0	19	1	6	41
38	0	13	2	5	16
36	0	16	2	5	0
29	0	0	0	7	26
33	0	0	0	9	12
36	0	0	8	4	17
31	0	0	0	0	35
54	0	0	5	10	30
27	5	0	0	0	9
34	0	11	0	5	0
56	0	0	0	10	0
41	8	23	0	8	0
45	1	0	0	8	0
34	0	0	0	0	62
32	0	0	0	0	32
42	0	0	0	12	0
30	0	0	0	5	34
31	0	0	0	7	21

TABLE 18a: Fungal species on surface of fruits of three tomato varieties growing in the dry season (November, 1988- February, 1989) at three different localities at the Experimental Plot at Legon.

Tomato variety	Part of fruit	Date of Assessment (1989)	Percentage frequency															
			Aspergillus flavus	Aspergillus niger	Aspergillus terreus	Cladosporium herbarum	Curvularia lunata	Fusarium oxysporum	Fusarium species	Geotrichum species	Mycelia sterilia	Nigrospora oryzae	Penicillium cyclopium	Pullularia pullulans	Rhizopus species	Scopulariopsis brevicaulis	Yeast spp.
Heinz	Epicarp	Jan. 3	0	0	0	57	0	0	14	7	0	0	0	0	7	7	7	0
	Surface	Jan.18	0	0	0	53	0	0	16	17	0	0	0	0	7	6	6	0
		Feb. 6	0	0	0	48	0	0	11	0	0	0	0	0	0	9	0	25
	Calyx	Jan. 3	0	0	0	84	0	0	14	0	0	0	0	0	0	2	0	0
		Jan.18	0	0	0	83	0	0	17	0	0	0	0	0	0	0	0	0
		Feb. 6	0	0	0	0	0	0	36	0	0	0	0	58	0	7	0	0
Ibsa	Epicarp	Jan. 3	0	0	0	39	0	0	37	0	0	0	0	0	21	0	12	0
	Surface	Jan.18	0	0	0	23	0	0	36	0	0	0	0	0	20	10	10	0
		Feb. 6	0	0	0	41	0	0	33	0	0	0	0	0	21	5	0	0
	Calyx	Jan. 3	0	0	0	10	0	0	90	0	0	0	0	0	0	0	0	0
		Jan.18	0	0	0	48	0	0	50	0	0	0	0	0	0	0	0	0
		Feb. 6	0	0	0	0	0	0	95	0	0	0	0	0	0	5	0	0
Roma	Epicarp	Jan. 3	0	0	0	19	0	0	11	7	4	0	0	0	1	0	7	45
	Surface	Jan.18	0	0	0	37	0	0	31	5	14	0	0	0	6	5	6	0
		Feb. 6	0	0	0	28	0	0	19	22	24	0	0	0	7	0	0	0
	Calyx	Jan. 3	0	0	0	54	0	0	46	0	0	0	0	0	0	0	0	0
		Jan.18	0	0	0	73	0	0	27	0	0	0	0	0	0	0	0	0
		Feb. 6	0	0	0	0	0	0	46	0	0	0	0	0	0	54	0	0

TABLE 18b: Fungal species on surface of fruits of three tomato varieties growing in the rainy season (June - September 1989) localities at the Experimental Plot at Legon.

Plot/Farm	Part of fruit	Date of Assessment (1989)	Percentage frequency															
			Aspergillus flavus	Aspergillus niger	Aspergillus terreus	Cladosporium herbarum	Corynespora cassiicola	Curvularia lunata	Fusarium oxysporum	Fusarium species	Geotrichum species	Mycelia sterilia	Nigrospora oryzae	Penicillium cyclopium	Pullularia pullulans	Rhizopus species	Scopulariopsis brevicaulis	Yeast spp.
Heinz	Epicarp Surface	Jul. 5	0	0	0	21	0	0	11	0	16	4	0	0	4	4	0	19
		Jul.14	24	11	9	24	0	0	12	0	0	0	13	3	0	1	0	0
		Jul.27	8	10	14	18	1	0	9	0	15	1	11	0	0	7	0	0
		Aug.14	0	12	0	17	0	0	16	0	14	3	0	1	0	19	0	5
		Sept.3	0	0	0	34	1	0	26	0	38	0	0	2	0	0	0	0
	Calyx	Jul. 5	0	0	0	63	0	0	31	0	0	0	0	0	0	6	0	0
		Jul.14	0	0	0	63	0	0	26	0	0	0	0	9	0	0	0	0
		Jul.27	3	0	8	62	0	0	19	0	0	0	0	0	0	7	0	0
		Aug.14	0	5	0	51	0	0	26	0	0	0	7	0	0	1	0	0
		Sept.3	0	0	0	52	0	0	48	0	0	0	0	16	0	0	0	0
Roma	Epicarp Surface	Jul. 5	12	10	0	18	0	0	14	0	0	0	0	4	0	7	0	31
		Jul.14	0	0	5	13	0	13	20	0	9	0	0	2	0	12	0	27
		Jul.27	10	19	0	12	5	5	17	0	0	0	23	0	0	10	0	9
		Aug.14	0	10	13	10	0	0	19	0	21	0	21	5	0	12	0	5
		Sept.3	14	6	19	37	0	0	22	0	0	0	0	2	0	0	0	0
	Calyx	Jul. 5	0	0	0	54	0	0	33	0	0	0	0	0	0	13	0	0
		Jul.14	0	0	0	43	0	0	48	0	0	0	0	0	0	10	0	0
		Jul.27	0	0	0	36	0	0	39	0	0	0	0	0	0	5	0	0
		Aug.14	4	0	26	26	0	0	24	0	0	0	0	0	0	40	0	0
		Sept.3	0	12	0	0	0	0	48	0	0	0	3	14	0	13	0	0
Wosowoso	Epicarp Surface	Jul. 5	0	0	0	0	0	7	26	0	19	0	0	9	0	0	0	20
		Jul.14	2	1	2	0	1	0	27	0	39	0	0	0	0	0	0	16
		Jul.27	0	4	1	43	0	3	17	0	12	0	0	0	0	3	0	19
		Aug.14	3	3	0	35	1	0	30	0	12	0	0	0	0	2	0	0
		Sept.3	0	0	0	6	2	12	53	0	8	0	0	15	0	0	0	33
	Calyx	Jul. 5	6	0	0	0	0	0	27	0	0	0	0	0	0	0	0	64
		Jul.14	0	0	0	7	9	0	32	0	0	0	0	0	0	38	0	14
		Jul.27	0	0	0	22	0	0	49	0	0	0	0	0	0	4	0	25
		Aug.14	0	0	0	31	0	0	52	0	0	0	0	0	0	7	0	0
		Sept.3	0	4	0	34	0	0	43	0	0	0	0	0	0	0	0	0

TABLE 21: Phylloplane fungal species of the Local variety of Okra plants growing in the dry season (Nov., 1988 - Feb., 1989) at three different localities at Legon and Madina.

Plot/Farm	Date of Assessment (1989)	Percentage Frequency												
		Alternaria alternata	Aspergillus flavus	Aspergillus niger	Aspergillus terreus	Cladosporium herbarum	Curvularia lunata	Fusarium oxysporum	Fusarium sp.	Helminthosporium sp.	Mycelia sterilia	Nigrospora oryzae	Penicillium cyclopium	Rhizopus sp.
Experimental Plot	Jan., 10	0	0	0	0	29	14	21	0	0	36	0	0	0
	" 24	0	0	0	0	73	7	17	0	0	27	0	0	0
	Feb., 7	0	0	56	0	23	4	8	0	0	12	1	0	0
	" 21	0	0	4	0	4	8	0	0	0	0	10	0	0
	" 28	0	0	58	0	36	0	6	0	0	0	0	0	0
University Farm	Jan., 10	0	0	0	0	39	0	47	0	0	15	0	0	0
	" 24	0	0	0	0	32	0	48	0	0	20	0	0	0
	Feb., 7	0	0	16	5	37	7	28	5	0	0	0	0	0
	" 21	5	4	16	0	37	5	17	5	0	13	3	0	0
	" 28	0	0	0	15	65	8	0	0	0	0	13	0	0
Private Farm	Jan., 10	0	13	0	0	0	7	50	0	17	0	0	0	11
	" 24	0	5	0	0	0	5	29	8	12	28	2	0	9
	Feb., 7	0	4	0	0	21	0	47	0	3	20	0	4	0
	" 21	0	2	0	0	24	8	33	13	0	14	0	6	0
	" 28	0	0	0	0	18	7	37	12	12	19	3	1	0

TABLE 22: Phylloplane fungal species of the Local variety of Okra plants growing in the rainy season (June - Sept., 1989) at three different localities at Legon and Madina

Plot/Farm	Date of Assessment (1989)	Percentage Frequency												
		Alternaria alternata	Aspergillus flavus	Aspergillus niger	Aspergillus terreus	Cladosporium herbarum	Curvularia lunata	Fusarium oxysporum	Fusarium sp.	Helminthosporium sp.	Mycelia sterilia	Nigrospora oryzae	Penicillium cyclopium	Rhizopus sp.
Experimental Plot	June, 6	0	9	0	15	21	12	10	0	13	0	5	9	0
	July 14	10	0	45	0	0	0	42	0	0	0	0	0	2
	" 28	0	0	19	0	19	0	35	0	0	0	0	0	20
	Aug. 11	0	0	1	0	9	6	23	0	4	28	6	14	0
	" 25	0	0	10	0	20	0	35	0	6	0	0	4	
University Farm	June. 6	0	0	0	11	32	10	27	0	6	12	2	0	0
	July 14	0	0	0	11	45	0	24	3	0	12	0	0	0
	" 28	5	2	7	0	46	0	14	0	0	5	0	11	5
	Aug. 11	0	4	14	7	43	7	14	1	7	0	1	0	0
	" 25	1	2	12	0	43	7	16	0	0	0	0	14	2
Private Farm	June, 6	0	0	0	6	47	4	31	0	0	10	0	2	0
	July 14	5	0	5	0	33	6	25	0	8	14	0	3	0
	" 28	0	1	8	8	36	3	16	4	0	11	6	0	1
	Aug. 11	0	0	15	8	29	12	24	0	0	12	0	0	3
	" 25	0	0	15	0	32	0	28	0	5	14	0	2	0

TABLE 26: Phylloplane fungal species of pepper plants growing in the dry season (Nov., 1988 - Feb., 1989) at three different localities at Legon and Madina.

Plot/Farm	Date of Assessment (1989)	Percentage Frequency												
		Alternaria alternata	Aspergillus flavus	Aspergillus niger	Aspergillus ochraceus	Aspergillus terreus	Cladosporium herbarum	Corynespora casiicola	Curvularia lunata	Fusarium oxysporum	Mycelia sterilia	Penicillium cyclopium	Rhizopus sp.	Syncephalastrum racemosum
Experimental Plot	Jan.. 10	0	13	0	0	0	25	0	13	11	37	0	0	0
	" 24	4	0	0	0	0	30	4	18	19	26	0	0	0
	Feb.. 7	0	0	0	0	0	26	0	5	16	38	0	0	0
	" 21	0	0	0	0	0	28	0	17	10	62	0	0	0
	" 28	0	0	0	0	0	29	0	5	10	55	0	0	0
University Farm	Jan.. 10	0	6	0	0	0	33	0	14	51	0	0	0	0
	" 24	0	0	0	0	0	38	0	13	42	8	0	0	0
	Feb.. 7	0	4	0	0	0	32	5	0	4	0	10	8	3
	" 21	2	6	0	0	0	37	0	4	38	7	13	0	0
	" 28	5	0	18	0	0	47	5	9	0	20	0	0	0
Private Farm	Jan.. 10	17	7	0	0	8	24	0	8	17	17	0	2	0
	" 24	0	11	6	0	0	33	0	9	19	23	0	0	0
	Feb.. 7	0	21	10	0	6	28	0	0	26	0	8	0	1
	" 21	6	18	0	0	0	21	0	1	38	11	1	3	0
	" 28	5	0	1	0	0	22	0	0	46	20	0	0	0

TABLE 27: Phylloplane fungal species of pepper plants growing in the rainy season (June - Sept., 1989) at three different localities at Legon and Madina.

Plot/Farm	Date of Assessment (1989)	Percentage Frequency												
		Alternaria alternata	Aspergillus flavus	Aspergillus niger	Aspergillus ochraceus	Aspergillus terreus	Cladosporium herbarum	Corynespora cassiicola	Curvularia lunata	Fusarium oxysporum	Nycelia sterilia	Penicillium cyclopium	Rhizopus sp.	Synecephalastrum racemosum
Experimental Plot	June. 6	0	0	0	13	0	0	0	0	58	0	23	15	0
	July. 14	0	3	22	13	0	16	0	0	27	11	0	0	0
	" 28	0	0	25	0	0	13	9	0	40	12	0	0	0
	Aug. 11	0	0	35	0	19	10	6	0	0	23	0	0	0
	" 25	0	0	24	0	0	25	0	0	13	29	8	8	4
University Farm	June, 6	0	0	0	0	0	43	3	6	37	14	0	0	0
	July, 14	0	0	7	2	7	35	0	5	32	5	7	0	0
	" 28	0	0	8	0	5	25	6	8	24	1	0	18	3
	Aug. 11	0	2	5	1	0	41	1	0	34	0	0	14	1
	" 25	1	0	29	0	3	42	0	0	0	0	23	0	0
Private Farm	June, 6	0	0	14	0	0	37	1	11	12	14	8	3	0
	July, 14	0	7	5	0	7	31	1	5	12	19	2	1	1
	" 28	5	11	9	6	0	33	0	1	13	19	1	0	0
	Aug. 11	0	14	0	0	0	31	2	6	18	28	1	0	0
	" 25	0	0	21	0	25	41	0	4	0	0	0	4	4

TABLE 29: Phylloplane fungal species of Wosowoso variety of Tomato plants growing in the dry season (Nov., 1988 - Feb., 1989) at three different localities at Legon and Madina.

Plot/Farm	Date of Assessment (1989)	Percentage Frequency													
		Alternaria alternata	Aspergillus flavus	Aspergillus niger	Aspergillus ochraceus	Cladosporium herbarum	Corynespora casiicola	Curvularia lunata	Fusarium oxysporum	Fusarium sp.	Mycelia sterilia	Nigrospora oryzae	Penicillium cyclopium	Rhizopus sp.	Syncephalastrum racemosum
Experimental Plot	Jan.. 10	4	0	0	0	30	7	0	0	22	35	0	0	0	4
	" 24	2	0	0	0	17	5	6	0	5	40	0	0	24	0
	Feb.. 7	7	0	0	0	29	0	10	0	14	40	0	0	0	0
	" 21	4	0	0	0	36	0	0	8	0	30	0	10	0	0
	" 28	0	0	0	0	49	0	0	25	0	20	0	6	0	0
University Farm	Jan.. 10	0	0	58	0	39	0	0	0	0	0	0	0	4	0
	" 24	8	0	0	0	47	0	4	16	0	12	0	0	2	5
	Feb.. 7	5	0	0	0	71	0	1	0	3	14	0	0	4	0
	" 21	0	0	0	0	78	0	3	16	2	0	0	0	0	0
	" 28	5	0	5	0	70	0	0	16	0	0	5	0	0	2
Private Farm	Jan.. 10	3	0	24	0	16	0	0	29	0	27	0	0	0	0
	" 24	16	0	15	0	11	0	0	17	0	22	0	0	15	4
	Feb.. 7	17	3	0	0	30	0	2	23	0	32	0	3	0	0
	" 21	7	4	0	2	30	0	1	35	2	11	0	6	0	0
	" 28	0	10	3	0	32	0	0	36	0	12	0	0	4	0

TABLE 30: Phylloplane fungal species of Wosowoso variety of Tomato plants growing in the rainy season (Jul - Sept., 1989) at three different localities at Legon and Nadina.

Plot/Farm	Date of Assessment (1989)	Percental Frequency													
		Alternaria alternata	Aspergillus flavus	Aspergillus niger	Aspergillus casiicola	Cladosporium herbarum	Corynespora casiicola	Curvularia lunata	Fusarium oxysporum	Fusarium sp.	Mycelia sterilia	Nigrospora oryzae	Penicillium cyclopium	Rhizopus sp.	Syncephalastrum racemosum
Experimental Plot	June, 6	0	9	13	9	39	0	0	18	6	7	0	8	3	0
	July, 14	11	8	0	11	31	6	0	16	6	0	0	4	0	0
	" 28	0	11	59	0	0	2	6	23	5	0	0	3	0	0
	Aug. 11	4	0	36	0	38	1	11	0	0	0	7	0	0	0
	" 25	0	13	20	0	47	0	0	24	1	6	0	0	0	5
University Farm	June, 6	0	7	25	5	24	0	0	0	7	9	0	8	8	0
	July, 14	0	6	0	8	26	5	13	29	2	0	0	11	0	0
	" 28	4	8	0	0	37	0	23	45	9	5	5	0	0	4
	Aug. 11	5	0	29	0	21	0	5	0	0	0	2	7	3	0
	" 25	8	0	14	2	34	2	0	42	5	0	0	0	0	3
Private Farm	June, 6	0	0	21	4	27	0	5	27	0	5	0	5	5	0
	July, 14	0	0	21	0	29	0	8	32	0	6	0	0	3	2
	" 28	5	1	13	1	26	1	9	22	2	10	0	5	5	0
	Aug. 11	1	0	17	4	25	0	2	28	3	14	4	5	1	0
	" 25	0	0	26	0	40	0	0	22	0	11	1	0	0	0

Table 34: Major fungal species isolated, from November, 1988 to August, 1989, from the rhizospheres of okra plants grown at three different locations and from the corresponding non-rhizosphere soils.

	% Frequency occurrence (to the nearest whole number) of species at the three stations																																	
	Aspergillus flavus			Aspergillus niger			Aspergillus ochraceus			Aspergillus terreus			Fusarium oxysporum			Paecilomyces sp.			Penicillium cyclopium			Rhizopus sp.			Syncephalastrum racemosum			Trichoderma viride							
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3				
RHIZOSPHERE SOIL																																		
1988																																		
November	0	0	0	0	10	8	0	0	0	20	26	18	24	31	28	0	0	0	42	28	38	0	0	0	0	0	0	12	4	5				
December	11	11	0	0	20	12	10	5	28	23	10	0	16	10	34	0	14	4	26	16	11	0	0	0	0	0	0	7	12	5				
1989																																		
January	5	0	0	35	0	0	0	8	9	0	26	17	0	8	26	0	29	5	54	26	38	0	0	0	0	0	0	1	0	0				
February	0	0	0	16	54	39	0	11	7	40	0	16	6	5	0	13	5	0	21	21	31	1	1	0	0	0	0	0	0	0				
March	21	9	0	17	31	2	0	9	0	41	9	0	6	7	22	0	0	0	14	29	0	1	5	8	0	0	0	0	0	68				
April	11	4	3	28	41	0	0	5	0	31	12	36	7	11	23	3	7	18	11	6	4	3	6	1	4	3	0	2	3	11				
May	1	0	5	36	27	10	0	0	0	5	22	14	6	8	0	5	12	0	27	11	9	6	12	3	10	4	1	4	0	53				
June	6	6	8	51	31	60	0	0	2	0	20	8	0	4	5	0	14	0	1	3	3	19	10	2	23	4	1	0	4	8				
July	9	24	6	65	33	34	0	0	0	4	11	12	3	0	0	0	0	0	2	2	4	7	12	2	6	7	19	3	9	20				
August	12	16	4	67	29	33	0	0	2	3	19	37	1	2	6	0	0	0	1	7	15	4	9	0	11	9	0	0	5	1				
NON-RHIZOSPHERE SOIL																																		
1988																																		
November	2	6	1	11	12	23	20	19	16	31	17	13	15	12	15	5	8	12	8	10	6	1	1	0	0	0	2	4	11	6				
December	1	0	0	8	5	21	22	25	5	35	14	11	17	16	26	0	0	0	0	7	0	0	0	0	0	0	0	6	25	3				
1989																																		
January	0	0	0	13	14	12	20	40	10	63	0	16	2	4	0	0	30	47	0	7	0	0	0	0	0	0	0	2	0	0				
February	0	0	23	28	25	29	16	18	7	10	15	0	6	0	0	11	10	4	15	17	20	0	0	0	0	0	0	6	2	0				
March	6	65	0	35	7	12	12	3	0	0	0	13	4	3	10	0	0	0	30	18	0	0	3	10	0	0	0	9	0	52				
April	0	0	5	25	13	18	15	25	20	0	0	5	3	14	11	0	0	1	5	0	11	4	17	8	3	6	1	42	22	16				
May	8	0	0	31	27	46	11	0	0	11	2	8	4	0	2	0	0	0	18	4	24	3	67	10	4	0	2	4	0	6				
June	0	4	24	0	16	38	0	0	0	40	11	2	3	2	0	4	0	0	0	8	2	0	42	21	1	0	4	0	8	9				
July	2	3	6	22	26	77	0	0	0	34	14	6	2	1	0	0	0	0	23	11	5	0	23	0	1	0	0	15	10	0				
August	1	2	6	9	21	1	5	1	2	42	26	68	4	2	8	9	0	1	20	27	7	0	15	0	0	0	0	11	0	6				

1. Experimental plot 2. University Farm 3. Private Farm

Table 35: Major fungal species isolated, from November, 1988 to August, 1989, from the rhizospheres of pepper plants grown at three different locations and from the corresponding non-rhizosphere soils.

	% Frequency occurrence (to the nearest whole number) of species at the three stations																																									
	Aspergillus flavus			Aspergillus fumigatus			Aspergillus niger			Aspergillus ochraceus			Aspergillus terreus			Fusarium oxysporum			Paecilomyces sp.			Penicillium cyclopium			Rhizopus sp.			Synchephalastrum racemosum			Trichoderma viride											
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3								
RHIZOSPHERE SOIL																																										
1988																																									
November	0	3	2	0	0	0	0	4	5	6	0	0	48	14	31	29	21	12	1	7	0	9	46	42	0	0	0	1	0	0	2	0	3								
December	0	0	0	0	0	0	0	1	3	3	0	0	53	8	36	41	31	7	0	4	0	0	49	51	0	0	0	0	0	0	3	0	0								
1989																																									
January	0	8	7	0	3	4	36	2	8	2	7	0	0	31	14	8	0	22	13	38	30	30	7	12	0	0	0	0	0	0	8	0	0								
February	0	0	0	0	0	0	29	87	64	2	8	7	0	0	12	0	0	4	43	0	0	20	0	11	0	0	2	0	0	0	0	0	0								
March	45	5	2	26	6	1	24	67	55	0	0	1	3	0	0	1	1	8	0	0	0	0	5	2	0	8	3	0	0	4	1	8	24								
April	23	0	1	0	0	1	36	14	1	3	69	0	16	0	48	2	4	11	0	0	14	12	0	17	2	6	0	1	4	0	2	6	2								
May	7	0	8	0	0	0	60	26	43	0	0	0	11	6	22	3	4	0	0	0	0	0	6	26	6	26	0	5	4	0	10	26	0								
June	13	8	18	0	0	0	58	32	1	0	2	0	0	13	50	5	3	7	0	0	0	0	9	31	17	14	0	2	0	0	0	1	0								
July	6	20	6	0	0	1	41	31	17	0	0	0	12	16	57	3	0	9	2	4	0	0	8	10	3	0	0	13	14	0	18	0	0								
August	0	11	4	0	0	0	21	31	10	0	0	2	67	30	61	8	0	4	0	0	0	0	0	7	0	3	0	2	19	1	1	3	9								
NON-RHIZOSPHERE SOIL																																									
1988																																									
November	2	6	1	0	0	0	11	12	23	20	19	16	31	17	13	15	12	15	5	8	12	8	10	6	1	1	0	0	0	2	4	11	6								
December	1	0	0	2	1	0	8	5	21	22	25	5	35	14	11	17	16	26	0	0	0	0	7	0	0	0	0	0	0	0	6	25	3								
1989																																									
January	0	0	0	0	0	8	13	14	12	20	40	10	63	0	16	2	4	0	0	30	47	0	7	0	0	0	0	0	0	0	2	0	0								
February	0	0	23	0	0	0	28	25	29	16	18	7	10	15	0	6	0	0	11	10	4	15	17	20	0	0	0	0	0	0	6	2	0								
March	6	65	0	0	0	0	35	7	12	12	3	0	0	0	13	4	3	10	0	0	0	30	18	0	0	3	10	0	0	0	9	0	52								
April	0	0	5	0	0	2	25	13	18	15	25	20	0	0	5	3	14	11	0	0	1	5	0	11	4	17	8	3	6	1	42	22	16								
May	8	0	0	3	0	0	31	27	46	11	0	0	11	2	8	4	0	2	0	0	0	18	4	24	3	67	10	4	0	2	4	0	6								
June	0	4	24	2	0	0	0	16	38	0	0	0	40	11	2	3	2	0	4	0	0	0	8	2	0	42	21	1	0	4	0	8	9								
July	2	3	6	1	0	6	22	26	77	0	0	0	34	14	6	2	1	0	0	0	0	23	11	5	0	23	0	1	0	0	15	10	0								
August	1	2	6	0	0	0	9	21	1	5	1	2	42	26	68	4	2	8	9	0	1	20	27	7	0	15	0	0	0	0	11	0	6								

1. Experimental plot 2. University Farm 3. Private Farm

Table 36: Major fungal species isolated, from November, 1988 to August, 1989, from the rhizospheres of tomato plants (Moscovoso variety) grown at three different locations and from the corresponding non-rhizosphere soils.

	% Frequency occurrence (to the nearest whole number) of species at the three stations																																								
	Aspergillus flavus			Aspergillus niger			Aspergillus ochraceus			Aspergillus terreus			Chaetomium globosum			Curvularia lunata			Fusarium oxysporum			Paecilomyces sp.			Penicillium cyclopium			Rhizopus sp.			Syncephalastrum racemosum			Trichoderma viride		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
RHIZOSPHERE SOIL																																										
1988																																										
November	0	0	2	26	23	31	1	27	14	26	6	21	1	0	2	0	11	0	16	12	11	17	2	1	11	17	11	0	0	2	0	0	0	6	3	2						
December	0	0	0	48	18	35	0	24	16	0	0	18	7	0	0	0	15	0	18	15	10	19	3	0	0	20	14	0	0	4	0	0	0	8	5	0						
1989																																										
January	0	23	6	49	0	10	0	10	0	0	0	0	0	0	0	0	0	13	0	0	3	1	18	8	47	33	29	0	0	27	0	0	0	2	15	1						
February	0	9	0	7	26	83	0	20	0	19	8	6	5	2	0	0	4	2	2	0	1	9	16	4	57	29	4	0	0	0	0	2	0	1	4	0						
March	7	0	8	15	43	35	6	58	0	26	0	12	0	5	1	0	0	0	5	19	10	8	0	0	26	11	18	4	2	6	2	0	0	1	0	3						
April	8	2	4	21	19	19	0	0	0	29	0	36	0	0	0	0	0	0	9	6	9	0	1	0	16	7	22	5	4	0	10	3	0	2	0	8						
May	3	7	3	69	56	5	1	0	0	7	0	0	0	0	0	1	4	0	0	0	4	0	0	0	4	27	1	0	5	13	0	0	0	4	0	34						
June	3	11	13	40	43	40	0	0	0	15	13	2	1	0	0	0	0	0	6	4	0	8	0	0	11	9	19	3	9	8	3	0	3	4	6	13						
July	6	34	6	49	22	41	0	0	0	11	7	1	0	0	0	0	0	0	1	0	0	0	0	0	12	2	13	6	3	0	6	4	17	7	26	2						
August	40	25	10	40	36	14	0	0	0	3	7	51	0	0	0	0	0	0	0	0	8	0	0	0	13	19	13	2	7	0	2	3	0	0	3	3						
NON-RHIZOSPHERE SOIL																																										
1988																																										
November	2	6	1	11	12	23	20	19	16	31	17	13	0	0	0	0	0	0	15	12	15	5	8	12	8	10	6	1	1	0	0	0	2	4	11	5						
December	1	0	0	6	5	21	22	25	5	35	14	11	0	0	14	0	0	0	17	16	26	0	0	0	0	7	0	0	0	0	0	0	0	6	25	3						
1989																																										
January	0	0	0	13	14	12	20	40	10	63	0	16	0	0	0	2	0	8	2	4	0	0	30	47	0	7	0	0	0	0	0	0	0	2	0	0						
February	0	0	23	28	25	29	16	18	7	10	15	0	0	0	7	0	5	0	6	0	0	11	10	4	15	17	20	0	0	0	0	0	0	6	2	0						
March	6	65	0	35	7	12	12	3	0	0	0	13	0	0	0	0	0	6	4	3	10	0	0	0	30	18	0	0	3	10	0	0	0	9	0	52						
April	0	0	5	25	13	19	15	25	20	0	0	5	0	0	0	0	0	0	3	14	11	0	0	1	5	0	11	4	17	8	3	6	1	42	22	16						
May	8	0	0	31	27	46	11	0	0	11	2	8	0	0	2	1	0	0	4	0	2	0	0	0	18	4	24	3	67	10	4	0	2	4	0	6						
June	0	4	24	0	16	38	0	0	0	40	11	2	0	0	0	0	0	0	3	2	0	9	0	0	0	8	2	0	42	21	1	0	4	0	8	9						
July	2	3	6	22	26	77	0	0	0	34	14	6	0	0	0	0	0	0	2	1	0	0	0	0	23	11	5	0	23	0	1	0	0	15	10	0						
August	1	2	6	9	21	1	5	1	2	42	26	68	0	0	0	0	0	0	4	2	8	9	0	1	20	27	7	0	15	0	0	0	0	11	0	5						

1. Experimental Plot 2. University Farm 3. Private Farm

Table 37: Major fungal species isolated, from November, 1988 to August, 1989, from the rhizospheres of three tomato varieties, Heinz, Roma and Wosowoso, grown at the Experimental Plot at Legon and from the non-rhizosphere soil.

% Frequency occurrence (to the nearest whole number) of species at the three stations

RHIZOSPHERE SOIL

	Aspergillus flavus			*Aspergillus niger*			*Aspergillus ochraceus*			*Aspergillus terreus*			*Chaetomium* sp.			*Curvularia lunata*		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1988																		
November	19	26	1	10	10	37	0	0	0	12	18	15	0	0	0	6	3	0
December	21	35	0	13	14	43	0	1	0	6	7	0	3	0	20	9	4	20
1989																		
January	25	24	0	33	32	49	0	2	0	0	23	0	0	6	0	0	0	0
February	0	23	0	40	25	7	0	0	0	6	21	19	9	4	8	0	0	8
March	34	24	12	20	28	15	9	2	0	2	21	26	0	0	0	5	1	0
April	8	8	8	18	18	19	0	0	0	29	24	29	0	0	0	0	0	0
May	17	8	9	62	83	75	1	0	1	1	1	6	0	0	0	1	0	0
June	1	2	9	17	59	40	0	0	0	0	1	15	0	0	1	0	0	1
July	3	0	6	58	25	49	0	0	0	3	20	11	0	0	0	0	0	0
August	27	16	40	54	[illegible]	40	0	0	0	2	10	3	0	0	0	0	0	0

	Fusarium oxysporum			*Paecilomyces* sp.			*Penicillium cyclopium*			*Rhizopus* sp.			*Syncephalastrum racemosum*			*Trichoderma viride*		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1988																		
November	16	2	12	8	13	8	23	26	21	0	0	0	0	0	0	3	2	[illegible]
December	20	0	18	20	13	19	0	20	0	0	0	0	0	0	0	7	5	[illegible]
1989																		
January	2	3	0	2	0	1	32	1	47	0	0	0	0	0	0	1	2	2
February	9	2	2	3	3	9	24	22	60	0	0	0	0	0	0	3	0	[illegible]
March	6	1	5	0	0	8	30	15	26	2	4	4	0	0	0	4	0	[illegible]
April	9	9	9	0	0	0	18	18	20	5	5	5	10	10	10	2	2	2
May	0	0	0	0	0	0	2	0	4	1	4	0	0	0	0	15	4	4
June	54	13	6	7	0	10	1	10	11	4	1	3	13	14	3	0	0	[illegible]
July	0	16	1	0	7	0	0	2	12	11	9	6	3	18	6	20	[illegible]	[illegible]
August	0	1	0	0	0	0	0	6	13	1	8	2	4	8	2	10	0	0

NON-RHIZOSPHERE SOIL

	Aspergillus flavus	*Aspergillus niger*	*Aspergillus ochraceus*	*Aspergillus terreus*	*Chaetomium* sp.	*Curvularia lunata*	*Fusarium oxysporum*	*Paecilomyces* sp.	*Penicillium cyclopium*	*Rhizopus* sp.	*Syncephalastrum racemosum*	*Trichoderma viride*
1988												
November	2	11	20	31	0	0	15	5	8	1	0	4
December	1	8	22	35	0	2	17	0	0	0	0	6
1989												
January	0	13	20	63	0	0	2	0	0	0	0	2
February	0	28	16	10	0	0	6	11	15	0	0	6
March	6	35	12	0	0	0	4	0	30	0	0	9
April	0	25	15	0	0	1	3	0	5	4	3	42
May	8	31	11	11	0	0	4	0	18	3	4	4
June	0	0	0	40	0	0	3	4	0	0	1	0
July	2	22	0	34	0	0	2	0	23	0	1	15
August	1	9	5	42	0	0	4	9	20	0	0	11

1. Heinz variety 2. Roma variety 3. Wosowoso variety

Table 38 : Fungi isolated from Okra fruit chips and Pepper fruits after Air- and Solar-Drying for 9 days during rainy and dry seasons

Time of Drying	Type of Drying	Fruit Preparation	% Frequency occurrence (to the nearest whole number) of species											
			Aspergillus flavus	Aspergillus niger	Aspergillus ochraceus	Aspergillus terreus	Cladosporium herbarum	Curvularia lunata	Fusarium oxysporum	Neurospora crassa	Penicillium cyclopium	Rhizopus sp.	Syncephalastrum racemosum	Mycelia sterilia
June 15-June 24, 1990	Air-Drying	Okra washed	10	47	6	3	6	5	5	3	8	5	0	5
		Okra unwashed	11	39	0	8	16	4	6	3	9	4	0	0
		Pepper washed	10	21	0	0	14	5	8	6	18	14	3	1
		Pepper unwashed	5	29	0	0	15	3	5	3	15	20	4	1
	Solar-Drying	Okra washed	5	60	0	17	0	0	0	0	17	0	0	0
		Okra unwashed	8	48	0	3	17	7	6	0	11	0	0	0
		Pepper washed	32	57	0	0	0	0	0	0	11	0	0	0
		Pepper unwashed	26	54	0	0	0	0	0	0	20	0	0	0
Nov. 26-Dec. 6, 1989	Air-Drying	Okra washed	14	38	0	0	10	8	13	0	13	1	0	0
		Okra unwashed	18	16	4	8	24	6	5	0	12	2	4	1
		Pepper washed	20	33	0	0	21	0	0	0	16	9	2	0
		Pepper unwashed	14	24	0	0	21	5	2	1	16	20	3	1
	Solar-Drying	Okra washed	0	100	0	0	0	0	0	0	0	0	0	0
		Okra unwashed	14	37	0	8	10	6	14	0	12	0	0	0
		Pepper washed	33	56	0	0	0	0	0	0	0	11	0	0
		Pepper unwashed	22	59	0	0	0	0	0	0	9	9	0	0

Table 45: Fungal flora at harvesting of onion bulbs of Red Creole and Texas Grano varieties grown in the dry season (Nov. 1988 - Feb. 1989) in soils treated with manure, or manure and Sulphate of Ammonia.

Onion Variety	Soil Treatment	Part of bulb	% Frequency occurrence (to the nearest whole number) of species													
			Alternaria alternata	Aspergillus clavatus	Aspergillus flavus	Aspergillus niger	Cladosporium herbarum	Curvularia lunata	Fusarium oxysporum	Fusarium sp.	Penicillium chrysogenum	Penicillium cyclopium	Rhizopus species	Syncephalastrum racemosum	Trichoderma viride	Yeast spp.
Red Creole	Manure + Sulphate of ammonia	1	0	0	0	1	10	0	31	53	0	1	0	0	0	5
		2	0	0	0	0	0	0	46	31	0	8	0	0	0	15
		3	0	0	0	0	0	0	34	26	0	30	0	0	0	10
		c	0	0	0	0	0	0	50	0	0	50	0	0	0	0
	Manure	1	0	0	0	1	8	0	26	38	0	0	0	0	0	26
		2	0	0	0	0	0	0	46	8	0	0	0	0	0	46
		3	0	0	0	0	0	0	51	18	0	10	0	0	0	21
		c	0	0	0	0	0	0	25	50	0	25	0	0	0	0
Texas Grano	Manure + Sulphate of ammonia	1	0	0	4	2	0	0	52	33	0	4	0	0	0	1
		2	0	0	0	0	0	0	98	0	0	0	0	0	0	1
		3	0	0	0	0	0	0	100	0	0	0	0	0	0	0
		c	0	0	0	0	0	0	100	0	0	0	0	0	0	0
	Manure	1	0	0	0	0	8	0	27	41	1	10	1	0	0	21
		2	0	0	0	0	0	0	60	19	0	9	0	0	0	13
		3	0	0	0	0	0	0	49	15	0	25	0	0	0	11
		c	0	0	0	0	0	0	50	0	0	50	0	0	0	0

*1. Outermost scale leaf; 2. 2nd scale leaf from the outside; 3. 3rd scale leaf from the outside; C: central core

Table 46: Fungal flora at harvesting of onion bulbs of Red Creole and Texas Grano varieties grown in the rainy season (April, 1989 - June, 1989) in soils treated with manure, or manure and Sulphate of Ammonia.

Onion Variety	Soil Treatment	Part of bulb	% Frequency occurrence (to the nearest whole number) of species													
			Alternaria alternata	Aspergillus clavatus	Aspergillus flavus	Aspergillus niger	Cladosporium herbarum	Curvularia lunata	Fusarium oxysporum	Fusarium sp.	Penicillium chrysogenum	Penicillium cyclopium	Rhizopus species	Syncephalastrum racemosum	Trichoderma viride	Yeast spp.
Red Creole	Manure + Sulphate of ammonia	1	0	0	2	46	1	0	10	0	0	2	0	0	0	41
		2	0	0	0	98	1	0	0	0	0	1	0	0	0	0
		3	0	0	0	97	1	0	0	0		2	0	0	0	0
		c	0	0	0	13	0	0	17	0	0	61	9	0	0	0
	Manure	1	0	0	0	71	1	0	17	0	0	4	0	0	0	10
		2	0	0	0	87	4	0	1	0	0	8	0	0	0	0
		3	0	0	11	37	2	0	0	1	0	49	0	0	0	0
		c	0	0	19	13	13	0	0	0	0	47	0	0	0	9
Texas Grano	Manure + Sulphate of Ammonia	1	0	0	0	5	1	0	64	0	0	30	1	0	0	0
		2	0	0	0	1	1	0	87	0	0	11	0	0	0	0
		3	0	0	0	28	6	0	8	0	0	58	0	0	0	0
		c	0	0	0	14	0	0	53	0	0	34	0	0	0	0
	Manure	1	0	0	3	19	10	0	42	0	0	13	1	0	0	0
		2	0	0	0	13	4	0	4	0	0	68	0	0	0	0
		3	0	0	0	12	6	0	0	0	0	82	0	0	0	0
		c	0	0	0	39	3	0	0	0	0	51	3	0	0	0

*1. Outermost scale leaf; 2. 2nd scale leaf from the outside; 3. 3rd scale leaf from the outside; C: central core

Table 47: Fungal flora at harvesting of onion bulbs of Red Creole variety grown in the dry season (Nov. 1988 - Feb. 1989), cured after harvesting for 30 days and irradiated at 0.05 and 0.10 Gy.

Soil treatment	Irradiation Dosage (Gy)	Part of bulb	% Frequency occurrence (to the nearest whole number) of species													
			Alternaria alternaria	Aspergillus clavatus	Aspergillus flavus	Aspergillus niger	Cladosporium herbarum	Curvularia lunata	Fusarium oxysporum	Fusarium sp.	Penicillium chrysogenum	Penicillium cyclopium	Rhizopus sp.	Syncephalastrum racemosum	Trichoderma viride	Yeast spp.
Manure + Sulphate of ammonia	0	1	0	0	1	12	6	0	60	11	0	10	0	0	0	0
		2	0	0	0	95	0	0	5	0	0	0	0	0	0	0
		3	0	0	0	92	0	0	8	0	0	0	0	0	0	0
		c	0	0	0	33	0	0	67	0	0	0	0	0	0	0
	0.05	1	0	0	0	27	16	0	29	14	0	14	0	0	0	0
		2	0	0	0	20	13	0	10	11	0	46	0	0	0	0
		3	0	0	0	44	10	0	10	6	0	30	0	0	0	0
		c	0	0	0	34	0	0	40	0	0	26	0	0	0	0
	0.10	1	0	0	0	19	12	0	18	13	0	38	0	0	0	0
		2	0	0	0	0	32	0	43	0	0	25	0	0	0	0
		3	0	0	0	20	20	0	30	0	0	30	0	0	0	0
		c	0	0	0	33	34	0	0	0	0	33	0	0	0	0
Manure	0	1	1	0	0	29	27	0	25	13	1	0	0	0	0	0
		2	0	0	0	96	0	0	3	0	0	1	0	0	0	0
		3	3	0	0	83	0	0	1	0	0	13	0	0	0	0
		c	11	0	0	63	0	0	26	0	1	10	0	0	0	0
	0.05	1	0	0	0	5	16	0	74	5	0	0	0	0	0	0
		2	0	0	0	10	33	0	20	0	0	29	0	0	0	0
		3	0	0	0	25	13	0	12	0	0	50	0	0	0	0
		c	0	0	0	0	0	0	0	0	0	100	0	0	0	0
	0.10	1	0	0	0	5	19	0	75	1	0	0	0	0	0	0
		2	0	0	0	24	33	0	43	0	0	0	0	0	0	0
		3	0	0	0	38	35	0	27	0	0	0	0	0	0	0
		c	0	0	0	9	15	0	15	0	0	0	0	0	0	0

Table 48: Fungal flora of onion bulbs of Texas Grano variety plants grown in the dry season (Nov. 1988 - Feb. 1989), cured after harvesting for 30 days and irradiated at 0.05 and 0.10 Gy.

Soil Treatment	Irradiation Dosage (Gy)	Part of bulb	% Frequency occurrence (to the nearest whole number) of species													
			Alternaria alternata	Aspergillus clavatus	Aspergillus flavus	Aspergillus niger	Cladosporium herbarum	Curvularia lunata	Fusarium oxysporum	Fusarium sp.	Penicillium chrysogenum	Penicillium cyclopium	Rhizopus species	Syncephalastrum racemosum	Trichoderma viride	Yeast spp.
Manure + Sulphate of ammonia	0	1	1	0	0	74	6	0	16	2	0	0	0	0	0	1
		2	0	0	0	86	0	0	10	4	0	0	0	0	0	0
		3	4	0	0	71	6	0	9	0	0	10	0	0	0	0
		c	24	0	0	35	17	0	0	0	0	24	0	0	0	0
	0.05	1	4	0	0	13	13	0	53	13	4	0	0	0	0	0
		2	0	0	0	2	15	0	33	0	0	50	0	0	0	0
		3	0	0	0	0	0	0	6	0	0	94	0	0	0	0
		c	0	0	0	0	0	0	0	0	0	100	0	0	0	0
	0.10	1	16	0	0	12	20	0	31	15	3	13	0	0	0	0
		2	15	0	0	10	15	0	50	0	0	10	0	0	0	0
		3	10	0	0	30	10	0	30	0	0	20	0	0	0	0
		c	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manure	0	1	0	0	0	74	6	0	16	4	0	0	0	0	0	0
		2	0	0	0	85	18	0	3	0	0	0	0	0	0	0
		3	0	0	0	60	21	0	4	0	0	15	0	0	0	0
		c	0	0	0	35	10	0	24	0	0	31	0	0	0	0
	0.05	1	0	0	2	4	23	0	66	5	0	0	0	0	0	0
		2	0	0	0	30	0	0	10	10	0	40	0	0	0	10
		3	0	0	0	37	0	0	25	8	0	30	0	0	0	0
		c	0	0	0	0	0	0	75	0	0	25	0	0	0	0
	0.10	1	0	0	0	22	6	0	54	18	0	0	0	0	0	0
		2	0	0	0	51	4	0	33	4	0	8	0	0	0	0
		3	0	0	0	60	4	0	27	3	0	6	0	0	0	0
		c	0	0	0	0	0	0	100	0	0	0	0	0	0	0

Table 49: Fungal flora at harvesting of onion bulbs of Red Creole variety plants grown in the rainy season (April, - June, 1989), cured after harvesting for 30 days and irradiated at 0.05 and 0.10 Gy.

Soil Treatment	Irradiation Dosage (Gy)	Part of bulb	% Frequency occurrence (to the nearest whole number) of species													
			Alternaria alternaria	Aspergillus clavatus	Aspergillus flavus	Aspergillus niger	Cladosporium herbarum	Curvularia lunata	Fusarium oxysporum	Fusarium sp.	Penicillium chrysogenum	Penicillium cyclopium	Rhizopus species	Syncephalastrum racemosum	Trichoderma viride	Yeast spp.
Manure + Sulphate of ammonia	0	1	0	0	0	81	0	0	0	0	0	0	17	0	2	0
		2	0	0	0	84	0	0	0	0	0	0	18	0	18	0
		3	0	0	0	52	0	0	0	0	0	0	24	0	24	0
		c	0	0	0	55	0	0	0	0	0	0	26	0	18	0
	0.05	1	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		2	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		3	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		c	0	0	0	100	0	0	0	0	0	0	0	0	0	0
	0.10	1	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		2	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		3	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		c	0	0	0	100	0	0	0	0	0	0	0	0	0	0
Manure	0	1	0	0	0	7	0	0	0	0	0	0	16	0	77	0
		2	0	0	0	0	0	0	0	0	0	0	23	0	77	0
		3	0	0	0	0	0	0	0	0	0	0	23	0	77	0
		c	0	0	0	0	0	0	0	0	0	0	56	0	44	0
	0.05	1	0	0	0	100	0	0	0	0	0					
		2	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		3	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		c	0	0	0	100	0	0	0	0	0	0	0	0	0	0
												0	0	0	0	0
	0.10	1	0	0	0	100	0	0	0	0	0					
		2	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		3	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		c	0	0	0	100	0	0	0	0	0	0	0	0	0	0
												0	0	0	0	0

Table 50: Fungal flora at harvesting of onion bulbs of Red Creole variety plants grown in the rainy season (April, 1989 - June, 1989), cured after harvesting for 30 days and irradiated at 0.05 and 0.10 Gy.

Soil Treatment	Irradiation Dosage (Gy)	Part of bulb	% Frequency occurrence (to the nearest whole number) of species													
			Alternaria alternata	Aspergillus clavatus	Aspergillus flavus	Aspergillus niger	Cladosporium herbarum	Curvularia lunata	Fusarium oxysporum	Fusarium sp.	Penicillium chrysogenum	Penicillium cyclopium	Rhizopus species	Syncephalastrum racemosum	Trichoderma viride	Yeast spp.
Manure + Sulphate of ammonia	0	1	0	0	0	13	0	0	0	0	0	0	87	0	0	0
		2	0	0	0	11	0	0	0	0	0	0	89	0	0	0
		3	0	0	0	2	0	0	0	0	0	0	98	0	0	0
		c	0	0	0	49	0	0	0	0	0	0	51	0	0	0
	0.05	1	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		2	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		3	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		c	0	0	0	100	0	0	0	0	0	0	0	0	0	0
	0.10	1	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		2	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		3	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		c	0	0	0	80	0	0	20	0	0	0	0	0	0	0
Manure	0	1	0	0	0	3	0	0	0	0	0	0	53	0	44	0
		2	0	0	0	10	0	0	0	0	0	0	46	0	44	0
		3	0	0	0	24	0	0	0	0	0	0	44	0	32	0
		c	0	0	0	61	0	0	0	0	0	0	20	0	19	0
	0.05	1	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		2	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		3	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		c	0	0	0	100	0	0	0	0	0	0	0	0	0	0
	0.10	1	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		2	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		3	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		c	0	0	0	83	0	0	0	0	0	0	0	0	0	0

Table 51: Fungal flora at harvesting of onion bulbs of Red Creole variety plants grown in the rainy season (April, 1989 - June, 1989), cured after harvesting for 30 days and irradiated at 0.05 and 0.10 Gy.

Soil Treatment	Irradiation Dosage (Gy)	Part of bulb	% Frequency occurrence (to the nearest whole number) of species													
			Alternaria alternaria	Aspergillus clavatus	Aspergillus flavus	Aspergillus niger	Cladosporium herbarum	Curvularia lunata	Fusarium oxysporum	Fusarium sp.	Penicillium chrysogenum	Penicillium cyclopium	Rhizopus species	Syncephalastrum racemosum	Trichoderma viride	Yeast spp.
Manure + Sulphate of ammonia	0	1	0	0	1	93	0	0	0	0	0	6	0	0	0	0
		2	0	0	1	98	0	0	1	0	0	2	0	0	0	0
		3	0	0	0	96	0	0	0	0	0	0	0	0	0	0
		c	0	0	0	92	0	0	0	0	0	8	0	0	0	0
	0.05	1	0	0	8	69	0	0	15	0	0	8	0	0	0	0
		2	0	0	0	99	0	0	1	0	0	0	0	0	0	0
		3	0	0	0	97	0		3	0	0	0	0	0	0	0
		c	0	0	0	89	0	0	11	0	0	0	0	0	0	0
	0.10	1	0	0	0	88	0	0	0	0	0	12	0	0	0	0
		2	0	0	0	100	0	0	0	0	0	1	0	0	0	0
		3	0	0	0	95	0	0	0	0	0	0	0	0	0	0
		c	0	0	8	85	0	0	0	0	0	8	0	0	0	0
Manure	0	1	0	0	0	99	0	0	1	0	0	0	0	0	0	0
		2	0	0	1	98	0	0	1	0	0	1	0	0	0	0
		3	0	0	0	98	0	0	2	0	0	1	0	0	0	0
		c	0	0	0	92	0	0	0	0	0	8	0	0	0	0
	0.05	1	0	0	0	39	0	4	36	0	0	0	0	0	0	0
		2	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		3	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		c	0	0	10	64	0	0	12	0	0	12	0	0	0	0
	0.10	1	0	0	0	88	0	0	0	0	0	12	0	0	0	0
		2	0	0	0	100	0	0	0	0	0	1	0	0	0	0
		3	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		c	0	0	0	85	0	0	0	0	0	8	0	0	0	0

Table 52 Fungal flora at harvesting of onion bulbs of Red Creole variety plants grown in the rainy season (April, 1989 - June, 1989), cured after harvesting for 30 days and irradiated at 0.05 and 0.10 Gy

Soil Treatment	Irradiation Dosage (Gy)	Part of bulb	% Frequency occurrence (to the nearest whole number) of species													
			Alternaria alternata	Aspergillus clavatus	Aspergillus flavus	Aspergillus niger	Cladosporium herbarum	Curvularia lunata	Fusarium oxysporum	Fusarium sp.	Penicillium chrysogenum	Penicillium cyclopium	Rhizopus sp.	Syncephalastrum racemosum	Trichoderma viride	Yeast spp.
Manure + Sulphate of ammonia	0	1	0	0	0	87	0	0	0	0	0	11	0	0	0	0
		2	0	0	0	98	0	0	0	0	0	2	0	0	0	0
		3	0	0	0	98	0	0	0	0	0	2	0	0	0	0
		c	0	0	0	50	0	0	0	0	0	50	0	0	0	0
	0.05	1	0	0	0	70	0	0	18	0	0	10	0	0	0	2
		2	0	0	0	98	0	0	2	0	0	0	0	0	0	0
		3	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		c	0	0	0	100	0	0	0	0	0	0	0	0	0	0
	0.10	1	0	0	0	97	0	0	2	0	0	1	0	0	0	0
		2	0	0	0	99	0	0	1	0	0	0	0	0	0	0
		3	0	0	0	100	0	0	0	0	0	0	0	0	0	0
		c	0	0	0	100	0	0	0	0	0	0	0	0	0	0
Manure	0	1	0	0	0	89	0	0	0	0	0	11	0	0	0	0
		2	0	0	0	98	0	0	0	0	0	2	0	0	0	0
		3	0	0	0	98	0	0	0	0	0	2	0	0	0	0
		c	0	0	0	47	0	0	0	0	0	53	0	0	0	0
	0.05	1	0	0	0	70	0	0	28	0	0	10	0	0	0	2
		2	0	0	0	98	0	0	2	0	0	0	0	0	0	0
		3	0	0	0	94	0	0	5	0	0	1	0	0	0	0
		c	0	0	0	100	0	0	0	0	0	0	0	0	0	0
	0.10	1	0	0	0	93	0	0	4	0	0	3	0	0	0	1
		2	0	0	0	92	0	0	5	0	0	1	0	0	0	1
		3	0	0	0	95	0	0	3	0	0	1	0	0	0	1
		c	0	0	0	100	0	0	0	0	0	0	0	0	0	0

Table 53: Fungal flora at harvesting of onion bulbs of Red Creole variety plants grown in the rainy season (April, 1989 - June, 1989), cured after harvesting for 30 days and irradiated at 0.05 and 0.10 Gy.

Soil Treatment	Irradiation Dosage (Gy)	Part of bulb	% Frequency occurrence (to the nearest whole number) of species													
			Alternaria alternata	Aspergillus clavatus	Aspergillus flavus	Aspergillus niger	Cladosporium herbarum	Curvularia lunata	Fusarium oxysporum	Fusarium sp.	Penicillium chrysogenum	Penicillium cyclopium	Rhizopus sp.	Syncephalastrum racemosum	Trichoderma viride	Yeast spp.
Manure + Sulphate of ammonia	0	1	0	0	1	95	0	2	0	0	0	1	1	0	0	1
		2	0	5	0	95	0	0	1	0	0	1	1	2	0	1
		3	0	0	2	79	2	0	13	0	7	5	1	2	0	2
		c	0	0	15	37	0	0	37	0	0	2	1	6	1	0
	0.05	1	0	0	1	36	0	0	0	0	0	1	1	0	0	0
		2	0	0	9	72	4	0	0	0	0	6	1	0	7	0
		3	0	0	0	97	0	0	0	0	0	1	1	0	1	0
		c	0	0	3	87	2	0	3	0	0	1	2	0	2	0
	0.10	1	0	0	1	95	0	0	0	0	0	3	1	1	0	1
		2	0	0	2	97	1	0	0	0	0	1	1	0	1	1
		3	0	0	1	92	1	0	0	0	0	1	1	1	1	1
		c	0	2	1	90	0	0	0	0	0	1	2	4	0	0
Manure	0	1	0	0	12	50	0	0	3	0	0	2	2	10	0	0
		2	0	0	3	80	3	0	6	0	0	15	1	1	0	0
		3	0	0	0	69	1	0	25	0	0	1	1	0	0	0
		c	0	0	5	67	0	0	20	0	0	1	0	0	1	0
	0.05	1	0	0	1	95	0	0	3	0	0	0	1	0	0	0
		2	0	1	0	88	0	0	0	0	0	2	9	0	0	0
		3	0	0	28	69	0	0	0	0	0	1	1	1	0	0
		c	0	0	4	91	4	0	0	0	0	1	2	0	0	0
	0.10	1	0	5	0	56	0	0	0	0	0	0	3	3	0	0
		2	0	0	3	57	0	0	0	0	0	1	1	1	0	0
		3	0	0	0	59	2	0	0	0	0	4	1	6	0	0
		c	0	0	4	80	0	0	0	0	0	5	2	9	0	0

Table 54: Fungal flora at harvesting of onion bulbs of Red Creole variety plants grown in the rainy season (April, 1989 - June, 1989), cured after harvesting for 30 days and irradiated at 0.05 and 0.10 Gy.

Soil Treatment	Irradiation Dosage (Gy)	Part of bulb	% Frequency occurrence (to the nearest whole number) of species													
			Alternaria alternate	Aspergillus clavatus	Aspergillus flavus	Aspergillus niger	Cladosporium herbarum	Curvularia lunata	Fusarium oxysporum	Fusarium sp.	Penicillium chrysogenum	Penicillium cyclopium	Rhizopus sp.	Syncephalastrum racemosum	Trichoderma viride	Yeast spp.
Manure + Sulphate of ammonia	0	1	0	0	8	80	0	0	0	0	0	7	3	2	0	0
		2	0	0	9	65	0	0	22	0	0	0	2	0	2	0
		3	0	0	13	33	0	0	0	0	0	10	4	0	4	0
		c	0	0	11	66	0	0	0	0	0	7	3	8	0	0
	0.05	1	0	1	6	85	0	1	0	0	0	2	2	2	1	0
		2	0	0	5	87	0	0	5	0	0	0	2	0	1	0
		3	0	0	2	82	0	0	1	0	0	0	2	0	14	0
		c	0	1	2	92	0	0	0	0	0	0	1	0	4	0
	0.10	1	0	18	13	59	0	0	0	0	0	0	3	7	0	0
		2	0	5	3	33	0	14	2	0	0	38	2	3	0	0
		3	0	3	5	76	0	0	0	0	0	9	1	6	0	0
		c	0	6	6	53	0	9	0	0	0	9	6	11	0	0
Manure	0	1	0	15	0	73	0	0	0	0	0	4	3	3	3	0
		2	0	5	0	74	0	0	0	0	0	0	7	12	2	0
		3	0	6	0	72	0	0	3	0	0	0	6	6	21	0
		c	0	14	11	41	0	0	0	0	0	12	3	14	5	0
	0.05	1	0	0	6	81	0	0	0	0	0	0	32	0	1	0
		2	0	0	13	43	0	0	0	0	0	2	38	2	2	0
		3	0	0	2	83	0	2	0	0	0	7	33	0	0	0
		c	0	0	1	60	0	3	0	0	0	2	33	0	1	0
	0.10	1	0	8	2	80	0	2	0	0	0	3	3	3	0	0
		2	0	1	1	97	0	0	0	0	0	0	1	1	0	0
		3	0	1	0	85	0	0	0	0	0	4	1	9	0	0
		c	0	7	4	79	0	0	0	0	0	2	2	6	0	0

FIG. 29: DOMINANT FUNGAL SPECIES ISOLATED FROM BULBS OF RED CREOLE AND TEXAS GRANO ONIONS PLANTED IN SOIL WITH MANURE (—) OR MANURE AND SULPHATE OF AMMONIA (═) DURING THE RAINY (▨) AND DRY (□) SEASONS AFTER HARVESTING CURING IRRADIATION AND STORAGE FOR 90 DAYS