EFFECT OF MANAGETIZED WATER ON THREE FUNGI, *Rhizoconia solani, Macrophomina phaseolina* and *Fusarium axysporum* f-lycopersici INFECTING ECONOMICALLY IMPORTANT CROPS

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بسم الله الرحمن الرحيم

تأثير الماء الممغنط على ثلاثة فطريات هي:
Rhizoconia solani, Macrophomina phaseolina and *Fusarium axysporum* f-*lycopersici*
التي تصيب محاصيل ذات أهمية اقتصادية

أطروحة مقدمة من:

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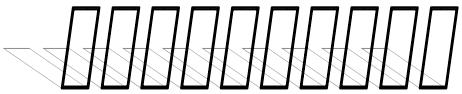
قال الله تعالى:

﴿ وجعلنا من الماء كل شيء حي أفلا يؤمنون ﴾

صدق الله العظيم



T*o the soul of my father..*

to my mother ***Omelhassan*** *, who fulfilled the precept of my father, to my great family .. to every one who helped me to successfully finish this study ..*

with

love..

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ABSTRACT

The present investigation was conducted to study the effect of application of magnetic technologies such as magnetized water and magnetized seeds on the three fungi *Macrophomina phaseolina, Rhizoctonia solani* and *Fusarium oxysporum* f-lycopersici on sorghum and tomato.

The studies included isolation of the pathogens from seeds and infected plants of the above mentioned crops.

The experimental examination included the effect of magnetized water on rate of linear growth of added magnetized water to PDA media in seven treatments, and also its effects on mycelial dry weight in liquid media + magnetized water in seven treatments.

The study included the effect of the combination of magnetized water, and magnetized seeds plated on blotter, magnetized seeds on agar medium in test tubes.

The most important results can be outlined as follows:

1- The linear growth rate showed highly significant difference at ($P < 0.05$) on the three fungi, M_7 medium revealed lowest growth among other media tested. However, the mycelial dry weight showed highly significant difference at ($P < 0.05$), among seven liquid media. M_7 proved to be the best for reduction of the mycelial growth.

2- The magnetized water inhibited the *in vitro* growth of *M. phaseolina, R. solany* and *F. oxysporum.*

3- Agricultural aspects:

a) Reduction of disease incidence and severity.

b) Activation of seed germination and seedling emergence.

c) The combination of magnetized seeds + magnetized water resulted in optimization of plant growth and plant disease resistance.

بسم الله الرحمن الرحيم

ملخص الأطروحة

أجري هذا البحث لدراسة تأثير الماء الممغنط على الأحياء الدقيقة وكـذلك علـى النباتات من حيث سرعة إنباتها ودرجة القابلية للإصـابة بـالأمراض أو القـدرة علـى مقاومتها.

تم اختيار الفطريات التالية وأجرينا عليها دراسة معملية وهي:
Macrophomina phaseolina, Rhizoctonia solani and *Fusarium oxysporum* f-lycopersici

1. *Fusarium oxysporum* f-lycopersici ويسبب الذبول الفيوزارمي في الطماطم.
2. *Macrophomina phaseolina* ويسبب العفن الفحمي في الذرة والذبول ولفحـة الساق.
3. *Rhizoctonia solani* ويسبب عفن الساق في الذرة ولفحة الريزوكتونيا.

وهذه الفطريات تعتبر من أهم الفطريات التي تصيب المحاصيل الحقلية والبستانية حيث انها تسبب أضرار بالغة الأثر علي هذه المحاصيل وينتج عن الإصابة بها:

1. فشل إنبات البذور.
2. تعفن طري للبادرات.
3. تعفن جذور النباتات.
4. تقرحات الساق.

وبالطبع هذا يقلل من إنتاج المحاصيل وأحياناً عند اشتداد الإصابة تؤدي لموت النباتات في مختلف مراحل عمرها.

تحديدا تم إجراء التجارب التالية:

1. عزل وتعريف الفطريات الثلاثة من أجزاء النباتات والبذور المصابة.
2. شملت هذه الدراسة التأثيرات الفسيولوجية على الفطريات في سـبعة بيئـات غذائية صلبة (PDA) مضافاً إليها الماء الممغنط بكميات مختلفة حيث تمـت مغنطة المياه بتوصيل جهاز المغنترون (Magnetron) مقيـاس (30-40 م)

واحد بوصة بمصدر المياه وذلك لدراسة التأثير المباشـر علـى الفطريـات وأظهرت النتائج ان البيئة أعلى درجة لنمو الفطريات حيث انها لـم تضـاف إليها ماء ممغنط ويتناقص النمو بزيادة كميات الماء الممغنطة المضافة حتـى يصل في البيئة السابعة أقل درجة نمو.

3. كذلك أعطت الفطريات نفس النتائج في البيئـات السـائلة مـن حيـث وزن الميسيليوم الجاف.
4. شملت هذه الدراسة أيضاً تأثير مغنطه البذور علي نسبه الإنبـات ومقاومـة النبات للإصابة بالمرض حيث تمت مغنطه البذور باستخدام جهاز المغنترون بمقياس (40-30م) واحد بوصة مع استخدام قمع في أعلاه بحيث تمر البذور من خلاله قبل زراعتها وتم توفير هذه الأجهزة بواسطة شركه عواد للتقنيات المغنطيسية. أظهرت النتائج فعالية البذور الممغنطة في سرعة إنبات البـذور وإكساب النبات مناعة ضد الأمراض مقارنه مع البذور الغير معامله بالمـاء الممغنط.
5. كذلك أثبتت الدراسة فعالية استخدام البذور الممغنطة +الماء الممغـنط حيـث أظهرت نتائج جيده وعالية الفعالية في التأثير علي الفطريات مما نـتج عنـه نباتات سليمة ذات مقاومة عالية للإصابة وخاليه من أعراض المرض .كذلك يلاحظ تأثير البكتيريا والفطريات المترممة بالماء الممغنط.ومن هذه الدراسـة نستخلص ان استخدام الماء الممغنط في المجالات الزراعية يظهـر النتـائج التالية:
    1. الزيادة في معدل الإنبات.
    2. الزيادة في معدل الاستطالة.
    3. تحسين خصائص الماء.
    4. هذه التقنية أثبتت كفاءه عالية في زيادة مناعة النباتـات ومقاومتهـا للإصابة بالمرض.ولذلك

تعتبر هذه الدراسة ذات أهمية كبيره لمقاومة الأمراض وبها نتخلص من الآثار السلبية لتطبيق المكافحة بالمبيدات لما لها من تأثير خطير علي البيئة والإنسان والحيوان.

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CHAPTER ONE
INTRODUCTION

Sorghum is a hardy plant able to grow and yield in a wide range of climatic conditions in the warmer zones of the world.

Sorghum is cultivated at varying extents in almost all tropical and subtropical areas of the world. In the central plain of the Sudan, Kordofan is considered the original home of sorghum, and all imported Sudanese sorghum seem to have their counterparts in this area (Evelyn, 1951).

Sorghum is the fifth most important cereal in the world and a major staple constituent in the diets of the people of the semi-arid tropics. It is the second most important cereal crop in Africa. Sorghum is cultivated largely in Asia and Africa particularly in areas, which are too hot, too dry or which have seasons too short for other cereals (Tarr, 1962).

In the Sudan, sorghum occupies about 67% of the total area cultivated by the main field crops.

A number of pathogenic fungi, bacteria and viruses are reported to cause diseases on sorghum. Also, there was considerable devastating damage caused by the flowering parasitic plant (*Striga hermonthica*).

Diseases of sorghum, which are caused by several fungi, are of great economic importance compared to those caused by other agents. Tarr (1962) categorized and described the different fungal diseases of

sorghum according to the stage and part of the crop. The seedling blight is caused by *Rhizoctonia solani*, and *Macrophomina phaseolina* as described by Uppal *et al*. (1936). Other fungal diseases are seedling blight, damping-off and root browning of sorghum and other grasses caused by *Pythium arrhenomanes* (Ezekiel, 1938; Sprague, 1950, Leukel, 1951.

In Western Savannah Development Corporation (WSDC, South Darfur State), it was reported that there was severe attack of sorghum head smut, leading to heavy grain losses and the pathogen was suspected to be transmitted through the seed (WSDC Annual Report, 1992).

The economic importance of tomato

In many countries, tomato (*Lycopersicon esculentum Mill*) is a very popular vegetable. This is because of its acceptable flavour, nutritive value, and ability to fruit in a wide range of environmental conditions. In temperate areas where the environmental conditions are conducive to tomato production and the technical information is available to growers the production of tomato is greater than in the tropical areas. The total acreage of tomato crop is the world is 2.2 million hectares and the total production of the tomato crop is 45.1 million tons (Villareal, 1980).

Tomato production in the Sudan

Tomato is gaining importance in the Sudan and the cropped areas increased from 19,000 to 28,000 feddans in the period from 1965 to 1977.

The crop is still grown mainly by small farmers and it represents one of the main cash crops. This increasing interest has also been motivated by the setting up of the paste processing factories in

Karema, Khartoum North and Juba. The increasing market demand for fresh and processed tomatoes is appreciated by farmers who took for a bright future by tomato cultivation (Mahmoud *et al*., 1984).

Tomato is one of the most important winter vegetable crops grown in the northern region of Sudan. Summer or out-of-season tomato production is limited by the prevailing high temperature and strong dry winds.

Many diseases, which are caused by pathogenic fungi, bacteria, virus and weeds are known to affect tomato cultivation. Those include:

Early blight, which is caused by *Alternaria solani*, damping-off caused by *Pythium* spp. and *Phytophthora* spp., leaf spot caused by *Septoria lycopersici*, powdery mildew caused by *Leveillula turica*. Fusarium wilt by *Fusariun oxysporum* f. sp. lycopersici and tomato mosaic virus disease (Centre for Overseas Pest Research, 1983). Other diseases caused by bacteria are bacterial wilt, which is caused by *Pseudomonas solanacearum*, bacterial canker caused by *Corynebacterium michiganense,* bacterial leaf spot caused by *Xanthomonas vesicatoria* (Asian Vegetable Research and Development Centre, 1979).

Diseases of tomato and sorghum caused by fungi are of great economic importance compared to those caused by other agents. Fungal diseases are the most prevalent and widespread problem limiting crop productivity.

The importance of water for growing crops and fungi, the future needs of new water resources necessary for soil-borne diseases are the most difficult problems to control prophylactic methods aiming for preventing the introduction of pathogens in healthy soils. It is almost

impossible to eradicate pathogens from an infested field soil. Even the drastic disinfestations techniques based on the application of biocide molecules such as methyl bromide failed to eliminate the pathogen and are also harmful to man and the environment.

Due to the importance of water for growing crops and microorganisms, there is a future need for new water resources necessary for attaining optimum crop production and preventing transformation of highly productive crops.

Very recently magnetic systems were used to magnetize water and started to gain spreading use in irrigation and agriculture.

Magnetic treatments of water reported to play a role in providing better soil water crop relations (Magnetic Technology (L.L.C), 1995).

According to the following concept from the book (Practical Magnetology) that dwells on application of magnetic technologies in agriculture, aspects pertaining to magnetized water were investigated:

1- The effect of magnetized water on the three fungi:

a) *Fusarium oxysporum* f-lycopersici.

b) *Rhizoctonia solani*.

c) *Macrophomina phaseolina*.

2- The effect of magnetized water and magnetized seeds on infected plants by the three fungi mentioned above.

CHAPTER TWO
LITERATURE REVIEW

2.1 Fungi

2.1.1 *Rhizoctonia solani*

The fungi of the form *Rhizoctonia* are among the most common and universally distributed group of pathogenic soil fungi, and have been studied by many investigators.

Dugger (1915) suggested that *Rhizoctonia* is composed of two main species *Rhizoctonia solani* kiihn (*Corticium vagum* B. and C) and *Rhizoctonia corcorum* pers. and DC. It has also been suggested that the fungus appear to have been the only form reported previously by Julius Kiihn in 1858 who described and named the fungus *Rhizoctonia solani* (Kotila, 1929).

Kotila (1929) added that in 1891 Prillieux and Delacoix described the sterile *Hypochus solani*, which became a synonymous of *C. vagum*. Moreover, Kotila (1929) mentioned that Rolf in 1903 found a species of *Corticium* definitely associated with *R. solani* who also suggested the sterile stage of *Rhizoctonia* from single basidiomycetes Houston (1945) reported that *C. solani* includes a group of heterogenous fungi in nature. The correct nomenclature of this fungus has been controversy.

The English and American mycologists have named the fungus as *C. vagum* Brekeley and Curit, while the continental Europeans have named the same fungus as *C. solani* Prillieux and Delacroix. Even though, the name of *R. solani* is still common in the literature.

Hawn and Vanterpool (1953) reported that *R. solani* is a complex of species and its perfect stage was not known until 1891 when Prillieux and Delacroix reported *R. solani*, while in 1904 Rolf proved the perfect stage was referring either to *C. vagum* var. *solain* Burt. or *C. solain* (Prill. and Del.) Bourd and Glaz. Furthermore, Hawn and Vanterpool (1953) have pointed that in 1943 Rogers recommended that the fungus with its synonyms to be included in the new combination of *Pellicularia filmentosa* Pat. Rogers.

Flentje (1956) reported that the sterile mycelium of *R. solani* was known in 1903 when Rolf established the connection between the vegetative and perfect stage. The vegetative mycelium of the organism parasites potato plants, while perfect stage was found occurring on potato stem. In a report of Whitney and Parmeter (1964), they stated that the genus *Rhizoctonia* was suggested by Decandolle in 1815 to include the genus of *R. solani* (pers) Dec. most of the strains of Rhizoctonia are multinucleate, while some strains are binucleate.

Saksena (1971) mentioned that the perfect stage of *R. solani* is known in literature under different names. The long synonymy of the perfect stage *Thanatephorus cucumeris* includes the familiar names like *Ceratobasidium filamentosa*, *Corticium microsclerotia* (*R. microsclerotia*), *C. solain, C. vagum, Hypochnus cucumeris*, *H. solani* and *Pellicularia filamentosa.*

Other possible synonyms are *C. aerolatum, C. sasakii* and *T. praticolus* (Kotila) Flentje syn. In a study of Singh *et al*. (1972) *R. solani* and *Pellicularia filamentosa* (Pat) Rogger were found as soil and seed borne pathogens.

2.1.1.1 Host range

Rhizoctonia species attack a wide range of host plants and it was reported to cause diseases of economic importance in Graminaceae, Leguminaceae and Malvaceae for instance Butler and Jones (1955) reported that *R. solani* attacks a wide range of host plants including ornamental plants, weeds as well as confer trees, Lettuce sugar beet, tomatoes, cucumber, cotton and sorghum. Saksena (1971) found that *Rhizoctonia* species were heterogeneous and have ability to produce diseases on crops as well as horticultural crops and forest trees. They occurred in aerial plant parts producing diseases like spot and blight, stem blight, stalk rot and fruit rot.

However, the effect of sowing depth and date of harvest on the incidence of *R. solani* Klapp *et al*. (1936) who mentioned that the tuber-borne sclerotia may be due to soil-borne sclerotia, the same results were obtained by Singh (1964).

2.1.1.2 The disease and its importance

Rhizoctonia disease is widely spread in the world and affects many species of plants. The fungus attacks the host at one or more stages in the development of the latter with the result that more than one distinct disease has become differentiated on a single host species (Walker, 1969).

Frank and Murphy (1977) reported that *Rhizoctonia* disease can affect the plant from the initiation of sprout emergence through the harvest.

In Germany, Richardes (1922) found that about 50% of potatoes were lost as a result of canker disease. The effect of black-scurf on the yield of potato was detected by reduction in tuber size and reduction of spouting plants (Newton, 1923). Martin (1931) mentioned that the reduction of yield from different states of Canada and USA might be as high as 18% due to the black scurf infection.

The stem lesion produced by this fungus on the young sprouts of potato tubers often girdle and kill them, and from superficial scabs on the tubers (Boughey, 1942).

2.1.1.3 Symptomatology

2.1.1.3.1 General

Early infection gives rise to seed decay and pre- and post-emergence damping-off. Later infection causes stem canker, wirestem, eye spot and other diseases, which result from the decay of the stem cortex and may be accompanied by stunting, yellowing and leaf roll symptoms.

Other diseases include rot of organs in contact with the soil, web, leaf and thread blights, fruit rot, root rot and storage rots and blemishes. Sites susceptible to infection are generally more restricted with increasing maturity of the host (Mordue, 1974).

Rhizoctonia disease symptoms may vary some what on the different crops and even on the same host plant depending on the stage of growth at which the plant becomes infected under the prevailing environmental conditions (Agrios, 1988).

2.1.1.3.2 *Rhizoctonia* stalk rot

Tarr (1962) stated that *Rhizoctonia solani* is a soil-inhabiting fungus occurring in many parts of the world. It has been recorded on several hundred host plants, including numerous grasses as listed by Sprague (1950) on which it is often associated with seedling blight, damping-off and rotting of roots, stalks, and leaf sheaths.

On sorghum it can cause a characteristic stalk rot in which the pith is first attacked and becomes reddish in colour, with vascular bundles remaining as light streaks. Brown sclerotia were later detected on the outside of the stalk under the leaf sheath (Leukel *et al*., 1951). In inoculation experiments, *R. solani* pathogenic to rice caused stem rot of sorghum (Palo, 1926 in the Philippines) and also seedling blight (Wei, 1934 in China). Robert (1979) reported a similar symptoms as mentioned above.

2.1.1.4 Disease control

Disease included by soil-borne plant pathogens cause extensive damage to many types of crops allover the world. To control soil-borne diseases, the use of resistant varieties may be available. Intensification of the chemical application is not sufficient to control satisfactorily the soil-borne pathogen and has detrimental effects on the soil fertility and the environment. During the two last decades there was a trend to adopt new control strategies, based on the integration of several practices including application of reduced dosage of pesticides, soil solarization and biological (Katan, 1996).

2.1.1.4.1 Chemical control

Available fungicides on *Rhizoctonia* disease control were chlorothalonil, thiophanate methyl, I prodine (Rovel) and some other chemicals are sometimes recommended as spray on the soil before planting and once or twice on the seeding soon after emergence. The use of the meruric chloride, chlorophenyl and other chemicals were also reported to be effective (Rushde, 1959).

2.1.2 *Fusorium oxysporum* f-lycopersici

Agrios (1997) stated that the mycelium is colorless, at first, but with age it becomes cream – colored, pale yellow, pale pink or somewhat purplish. The fungus produce three kinds of asexual spores. Microconidea, which have one or two cells, are the most frequently and abundantly produced spores under all conditions, even inside the vessels of infected host plants. Macroconidia are the typical "*Fusarium*" spores, they are three to five celled, have gradually pointed and curved ends, and appear in sporodochia-like groups on the surface of plants killed by the pathogen. Chlamydospores are one – or two celled, thic-walled, round spores produced intercallary or terminally on older mycelium or in macroconidia. All three types of spores are produced in cultures of the fungus and probably in the soil, although only chlamydospores can survive in the soil for long time.

2.1.2.1 Diseases

Agrios (1997) mentioned that, *Fusarium* wilts affect and cause severe losses on most vegetable and flowers, several filed crops such as cotton and tobacco, plantation crops such as banana, plantain,

coffee, and sugarcane, and a few shade threes. Fusarial wilts are most severe under warm soil conditions and in greenhouses.Most Fusarial wilts have disease cycles and develop symptoms similar to those of the *Fusarium* wilt of tomato.

2.1.2.2 *Fusarium* wilt of tomato

As mentioned above, *Fusarium* wilt is one of the most prevalent and damaging disease of tomato wherever tomatoes are grown intensively. The disease is most destructive in warm climates and warm, sandy soils of temperate regions.

2.1.2.3 Distribution

Wide spread in Africa, Asia, Australia, Central America, Europe and West India.

2.1.2.4 Economic importance

The disease causes great losses especially on susceptible varieties and under favourable weather conditions. Infected plants become stunted and soon wilt and finally die. Occasionally entire fields of tomatoes are killed or severely damaged before a crop can be harvested. Generally, however, the disease does not cause serious losses unless soil and air temperatures are rather high during much of the season (Agrios, 1997).

2.1.2.5 Symptoms of the disease

Centre for Overseas Pest Research (1983) reported that the infection takes place through the roots and the vascular tissue is attacked. The infected xylem shows a brown discoloration and this

progresses upwards rapidly. The water supply to the leaves is obstructed and as a result they droop and curl downwards, begin to yellow ad eventually wilt irreversibly. Lower leaves start yellowing first and often only one side of the plant shows the symptoms. The wilt moves rapidly upwards leading to wilting and death of the plant. Plants are usually stunted in growth and fruits ripen prematurely.

Description of the symptoms given by Agrios (1988) reported similar results for wilting of tomato caused by *Fusarium oxysporum* f. Lycopersici.

In cross sections of the stem near the base of the infected plant a brown ring is evident in the area of the vascular bundles. The upward extent of the discoloration depends on the severity of the disease.

2.1.2.6 Control of *Fusarium oxysprum* f. *Lycopersicis*

2.1.2.6.1 Chemical control

Allyas (1975) noted that significant reduction in seedling emergence and plant stand has been reported in plots treated with various systemic and non-systemic fungicides in case of soybean, so that the present method of fungicide application after emergence of plant gives an advantage of avoiding such loss.

On other hand, the Centre for Overseas Pest Research (1983) reported that the soil may be disinfected by the use of methyl bromide, chloropicrin or metham-sodium. This is only economical if the crop is of a sufficiently high value but it should increase yields.

2.1.2.6.2 Resistant varieties

Agrios (1997) mentioned that the use of tomato varieties resistant to the fungus is only practical measure for controlling the disease in the field, several such varieties are available today.

2.1.3 *Macrophomina phaseolina*

Tarr (1962) described the fungus *Macrophonia phaseolina* in culture as having young hyphal growth, which is colourless, about 8ml in diameter, and with characteristic branching.

2.1.3.1 Charcoal-rot disease

Maholay and Sohi (1983) stated that *M. phaseolina* affected seed from infected fruit of (cucurbit-squash) and muskmelon; the loss of the seed weight ranges between 14 and 55%. The fungus survived for 21 months in both hosts, while in sorghum survived for 27 to 30 months.

Dry root rot by *M. phaseolina* affected several hosts both leguminous and non-leguminous and caused damage as shedding, blight, damping-off, leaf spotting and stem rot of sorghum as cited by Tarr (1962).

2.1.3.1.1 Seasonal persistence and incidence of the disease

Under natural conditions *M. phaseolina* produces abundant sclerotia on the sorghum but is not known to form pycnidia or other production bodies on the host. The sclerotia occur within the infected

root and stem. When the plant die it is established in crop residues. The essentially resting bodies contain food material, and can remain dormant but viable in soil as reported by Tarr (1962).

Butler (1918) reported that the field infection retained the fungus in the soil for as such as three years, also he added that the incidence and severity of the seed blight and charcoal rot are ultimately associated with climatic and soil conditions. In India, winter sorghum often suffered severe attack during period of high temperature and heavy rain.

2.1.3.1.2 Distribution

Tarr (1962) cited that probably the fungus occurs in most warm areas of the world. It has been reported from almost all such countries where degenerated listing of plant diseases has been carried out, as causing specific disease (charcoal rot of stalk and seedling blight). It has been reported from United States, India, Uganda, France, Sudan, New Mexico, Pakistan, Romania, Morocco and Argentina that are associated with stalk rot of maize. It was also reported that *M. phaseolina* occurs mainly in tropical regions where high temperatures and humidities prevail simultaneously.

2.1.3.2 Economic importance

Charcoal rot incited by *M. phaseolina* occurs widely in many countries causing severe damage to crops of great economic

importance. The fungus is seed-borne and may destroy many germinating seeds before they emerge from the soil.

On sorghum Tarr (1962) mentioned that *M. phaseolina* can be responsible for a complex of symptoms including seedling blight and damping-off, root rot, and dry rot of stalks, in all leading to poor stands, stunted plants and loading with attendant decreased yields and inferior, shrunken gain.

2.1.3.3 Host range

Tarr (1962) mentioned that this is very wide and includes such diverse hosts as sorghum. Potatoes, beans and many other legumes, cotton, sesame, jute, tobacco, sweet potato, tomato. Young (1949) listed nearly three hundred susceptible species. There is evidence that some degree of host specialization occurs, such as grain, sorghum, sweet sorghum, Sudan grass, broomcorn, Johnson grass and Guinea grass.

Recently, it has been reported as causing foot rot, hollow stem and lodging of finger millet in India (Thirumalachar *et al*., 1953).

Moholay and Soli (1983) observed that charcoal rot of squash and melon was caused by *M. phaseolina*.

2.1.3.4 Symptoms of the disease

Descriptions of the symptoms on various crop plants are given by Young (1949) and Roger (1953) who reported that *M. phaseolina* can be associated with various symptoms including typical dry (charcoal rot) of root, stem, fruit and storage organs (ashy stem blight) of legume leaf, cotyledon spotting, damping-off and seedling blight.

The fungus enters the plant through feeding roots and to stem causing stalk rot. Root attack varies from scattered lesion at the first brown and water soaked but later darkening to wet, black rot of root center. The fungus advances primarily through the cortical tissues and extensive rotting may occur before the stele is invaded. Infected roots tend not to die until their inner tissues have been destroyed (Livingston, 1945).

In infected sorghum seedlings the cortical tissue of the young stem at and near soil becomes flaccid, rotted, and turns reddish brown in colour (Tarr, 1962).

Short *et al.* (1978) reported that the infected sorghum, seedlings charcoal rot expressed as seedling blight, damping-off and dry rot. Stalk lodging is the most apparent symptom of charcoal rot.

The stem of lodged plant should be split and examined internally for pith disintegration with separated fibrovascular bundles, profusely marked by small, dark, charcoal coloured sclerotia of the pathogen.

Gray *et al*. (1991) mentioned that the incidence of charcoal root in sorghum in India was positively correlated with soil populations of *Machrophomina phaseolina*.

2.1.3.5 Disease control

2.1.3.5.1 Chemical control

Rani and Srivastava (1977) demonstrated that the fungicides Topsin M., Benlate, Barassicol, Denosen and Difoliate were most promising fungicides for control of the disease. They also reported that no phytotoxicity was observed with any fungicide treatment. Added to that Benomyl at concentration as low as 0.3 g/pot could control root rot of sesame to a greater degree. Also, Doftori and Verma (1975) reported that the seed dressing with Vitavax is an effective control against root rot of sesame.

Rnltha *et al*. (1989) reported that there is ability of *M. phaseolina* to acquire tolerance to two systemic fungicides namely thiophosphate and tolcofosmethyl (Rizeolex) developing resistance to fungicide and become major problem in practical agriculture.

Livingstone (1945) reported that virtually known seedling blight occurred in natural soil or in inoculated soils treated with chloropicrin when Alliance sorghum or other host plants were planted.

In 1977, Sinha and Khare reported that out of nine systemic and non-systemic fungicides tested, Bavistin and Benomyl were excellent in controlling the seed-borne *M. phaseolina* associated with cowpea seeds in laboratory, pots and field experiment.

2.2 Brief history of magnetology

The history of magnetology began many centuries ago. Pythagoras (599 BC) was the first to state that all thoughts, words, emotions and deeds of a human being were reflected in the world magnetic lack-mirror, imprinted there forever. Ancient doctors of China and India paid a great attention to magnetism.

Mesmer the famous and popular doctor of the 18^{th}-19^{th} centuries discerned two constituents in the world magnetic ocean: space inanimate magnetic energy and animate magnetic energy emitted only by live organisms and specially people. Mesmer was the first ever-European scientist who has applied two methods of efficient medical for treating various diseases: (trace and biomagnetic). Mesmer magnetized almost everything: water, creams, wool, medicines, leather, clothes, wood, bread, …etc.

A number of contemporary doctors and magentologists still practice Mesmer's amazing method whose fame has lived throughout the ages up to the present.

A serious breakthrough of scientific and technical thoughts in 18^{th}-19^{th} centuries enabled world scientists to create multitude of technical solutions and make a number of discoveries, which were deemed important at the point in time.

It is noted worthy that Russian scientists have played a vital role in the evaluation of magnetic technologies and magnetology as a science. Back in Stalin's times when the national economy was on a military industry footing behind the Iron Curtain, Soviet secret institutions became the cockpit of extensive and versatile research centered round magnetic energies. The research was conducted in strict confidence and involved thousands of most gifted Russia's scholars.

These perseverant efforts bore fruit within a short period of time and encouraged the application of magnetic energies in the military industry. In early 70's for the first time ever some of the Soviet scientists seized upon a chance to immigrate to foreign countries.

The scientists leaving the Soviet Union possessed fragmentary information about magnetology, which would, ultimately, trickle into the United States, United Kingdom, France, Japan …etc. therefore, the original pieces of knowledge about fantastic magnetic technologies poped up in the countries where the Soviet scientists finally settled.

Against the backdrop of these developments, the Americans were the first to appear ruffled. They realized that once the knowledge

about magnetic technologies was brought within reach of the public, the existing technologies would be in great jeopardy. Such a run of events would have caused serious implications as the industrialized countries were vigorously implementing conventional technologies worldwide.

In 1973, Russia disclosed magnetic technologies to boost their wide application and introduction into the world market upon completion of major research work in the related domain.

In the 1980's Rossiikaya Korona company was set up to marshal the knowledge about magnetic technologies. As a result, the largest magnetology related data bank was created. For their part, Americans came to understand that further ridiculing of magnetic technologies was unthinkable and senseless. Positive feedback brought by the magnetic technologies and favourable applications was going from strength to strength to consolidate the magnetic phenomenon.

To further pursue this goal, Magnetic Technology L.L.C. a Russian-Emirates company, was set up to promote and implement magnetic technologies in the Persian Gulf region. The company got in touch with the National Research Centre in Cairo, Egypt to build public confidence in magnetic technologies joint efforts produced convincing results to endorse positive benefits of magnetic technologies (Magnetic Technologies (L.L.C.), 1997).

2.2.1 Ionic magnetization

As known, water has never been free; the one that is familiar to student generally is in impure condition. It means that the water has been polluted many times contaminated, mixed with certain other substance or other saturated element.

Because of the condition above, water becomes less or not good for all needs, such as for drinking, farming and so on. On the other words, it is hard to get water, which is really pure or alive and has the chance to bacterial total increase. Meanwhile, in the water, which is magnetized, all particles and saturated salt or colloids inside the water will be precipitated or coagulated quickly to get clean water. Biological activity and all pathogenic bacteria will be dead.

2.2.2 Magnetic system for water treatments

From water and wastewater treatment to agriculture, medical sciences and manufacturing industries, magnetic systems are slowly finding wide application the world over.

These systems use the principles of magnetology to restructure the molecules in any liquid to their original. Liquids passed through these systems get magnetized and the molecules regroup themselves into their original, thus enhancing their properties (Tkachenko, 1995).

2.2.3 Explaining magnetic theory

Prof. Tkachenko (1995) stated that Russian scientists had made discoveries that had led them to inventing magnetic system which were really prosthetic device for the earth’s destroyed magnetic field.

These allow us to correct some of the dire mistakes made by humans. While we cannot change the situation and restore the whole magnetic field, we can restore it locally in certain areas through implementing magnetic technologies.

The devices are very safe – they are manufactured according to the World Health Organization (WHO) specifications on the maximum limits of magnetic power that can be safely incorporated.

2.2.4 Application domains of magnetic technologies.

The following examples of economical benefits, which can be generated by magnetic applications in diversified economic spheres are:

2.2.4.1 Oil mining and oil refining industry

1- Reduction of expenses related to well drilling.
2- Pipeline dewaxing.
3- Preservation of productive stratum perviousness.
4- Better oil stratum output factor by 3-5%.
5- A considerable decrease in pipe corrosion (= 1.5 times) including costing and fountain pipes, in particular, at later stages of oil field development.
6- Extension of pipe lifetime by 40-50% due to slower formation of salt deposits.

2.2.4.2 Heat power engineering

1- Enhancement of cooling efficiency, at least, 384.

2- Reduction of incrustation growth all the way down the water loop by 3-4 times.
3- A significant minimum two-fold drop in the actives related to preventive maintenance of the cooling system.
4- Dramatic reduction of existing deposits to negligible soft formations that can be readily washed away by the water flow.
5- Reduction of recurrent expenses for the chemical involved in the softening process of water treatment.

2.2.4.3 Construction industry

1- Cement saving (up to 25%) with no loss in concrete durability.
2- Better concrete mix plasticity without application of costly and hazardous chemicals such as super plasticizers.
3- Enhanced concrete resistance to aggressive media, which is extremely important for the Gulf climate.
4- Positive changes in water absorption and water impermeability as well as dramatic reduction of metal corrosion in reinforced concrete structures.
5- Longer concrete lifetime (2-3 times). This produce a huge economical effect as construction investment. Life is directly based on this factor.

2.2.4.4 Cattle-breeding

1- An average daily additional weight of young animals goes up to 30%.
2- An average yield of milk increases by 10-20%.
3- Enhancement of milk fat and flavour.
4- A substantial drop in morbidity rate.

2.2.4.5 Poultry-farming

1- Improved egg-laying qualities.
2- Reduced time required for fowls to again desired weight.
3- A considerable drop in mortality and morbidity rate.

2.2.4.6 Medicine

Medically, the technique entails using magnetic devices to relieve and cure a varcety of health problems without resorting to medication or surgery.

Magnetology works by reviving, reforming and promoting the growth of cells rejuvenating tissues and increasing blood corpuscles, allowing the nervous system to gain full control over body functions to treat a variety of disorders including ENT, high blood pressure, migraine, insomnia, joint and muscular pains, and sexual impotency (Tkachenko, 1995).

2.3 Application of magnetic technology in agriculture

2.3.1 The effect of magnetic technologies in agriculture in Sudan

In a scientific experiment, the study was conducted to investigate the effect of magnetization of seeds and water on the productivity of *Sorghum valgare*.

A one inch magnetic device (Magnetic Technologies L.L.C. Dubai) was used in the current study. The following results were obtained.

1- 78% increase in germination rate (93% for magnetized and 53% for normal seeds-normal water).
2- 28% increase in elongation after 50% days.
3- 17% increase after 60 days and 21% after 70 days.
4- 24% increase in number of heads per feddan (126.117 heads for magnetized, 101.576 for normal).
5- 55% in plant density (163 magnetized and 105 for normal), (Badr, 2001).

2.3.2 The effect of magnetic technologies in agriculture in Egypt

A report compiled by Mustafa (1998):

1- Magnetizing seeds and/or irrigation water increase seed germination of wheat by 20%, tomato seeds germination increased by 65% pepper and cucumber the rate of increase was around 100%.
2- Magnetized irrigation water increased wheat yield by 12.7% to 33% depending on date of plant.
3- Increase in sesame production reached 24%.

4- Response of corn was also around 24%.

2.3.3 The effect of magnetic technologies in agriculture in United Emirates

Yasin (1995) stated that the installation of the magnetic system has been a great success and has achieved an excellent germination rate in both plant and grass.

2.3.4 The effect of magnetic technologies in agriculture in Uzbekistan

The water problem institute of the Republic of Uzbekistan allotted one of its testing grounds in 1998 for yield trials of a magnetic system. The said system was used for irrigation of cotton plants.

Analysis of the cotton yield provided the indication of 3.200 kg/hectare for the magnetic sub-plot and 2,000 kg/hectare for the usual one, respectively (Magnetic Technologies L.L.C., 2002).

2.3.5 Some results of application of magnetized water of soil desalination

Soil desalination is crucial problem nowadays. It was noted worthy that the possibility of using magnetized water to desalinate the soil accounts for its enhanced dissolving capacity, which has been registered repeatedly.

Tkachenko (1997) reported that the Soviet scientists staged myriad trials on the soil of experiment drainage grounds. They came to establish that the density of magnetized water, which had

penetrated the soil layer was 0.1 g/cm^3 more than that of unmagnetized water.

Table 1. The test implemented on the soil that contained the following indicators (%).

CO_{-3}^{-2}	0.019	Ca^{2+}	0.082
HCO_3	0.066	Mg^{+2}	0.006
CI^{-1}	0.572	$Na^+ + K^+$	1.072
SO_4^{-2}	1.663		

The dry sediments were 3.46 mg/l. Magnetic treatments was applied to the water, which contained (mg eqv./1).

$$HCO^-_3 - 1.4,\ CI - 0.79,\ Ca^{2+} - 1.16,\ Mg^{2+} - 0.76$$

The dry sediments were 372 mg/l it was found that with optimized mode of magnetic treatments the magnetized water will wash salts out by 5 times more efficiently than usual water. The second test indicated that the magnetized water can bring out the salts by 18-32% more than usual water including the use of hydrochloric acid as meliorant.

Table 2. Comparison between magnetized water, normal water and HCl in washing out the toxic salts.

Treatment	Type of flushing fluid	Toxic salts washed out	
		Total/hector	%
1	Normal water	54.5	100.0
2	HCl% solution	55.8	102.4
3	Magnetized water	65.7	120.5

In the third test as is seen from Table 3 the magnetized water can wash out salts twice as such as normal water.

Table 3. Effect of magnetized water in washing out salts.

Sample	Depth m	Salt reserves in the soil layer						Salt removed after wash out			
		Before flushing		After flushing by				Usual water		Magnetized water	
				Usual water		Magnetized water					
		%	T/hec	%	T/hec	%	T/hec	%	T/hec	%	T/hec
1	0-0.3	2.9	126	2.3	100	1.6	70	26	100	56	216
2	0.3-1.0	2.4	242	1.9	192	1.4	142	50	100	100	200
3	1.0-1.5	1.7	123	1.4	102	1.3	94	21	100	29	138
	Total depth										
4	0-1.0		268		292		212	76	100	156	205
5	0-1.5		451		394		306	97	100	185	192

Table 4. Removal of diverse anions from the soil by normal and magnetized water (%).

Treatment	Anion	Water	
		Normal	Magnetized
1	CI^-	30%	50-80%
2	SO_4^{2-}	15%	30%
3	HCO^-_3	0%	30%

2.3.6 Magnetic treatment of seeds prior to sowing

Seeds play a vital role in plant life and a plant greatly depends on the quality of this system, which for its part, decides on the chances that plant has for survival in the vegetative community of phytocynosis. Seeds posses different potential energy.

Magnetic treatment and growth activation of weakened seeds make it possible to preserve up to one third of the sowing seeds. Likewise, similar treatment of good quality seeds will cut down the number of sowing seeds by three times. It saves a valuable and high cost sowing material.

In this regard, the manner of magnetic field affects seeds is not just a method that stimulates and activities metabolism alone but rather a process, which brings the latter to conformity with its natural and historical background upset by present-day technologies. The plant wields a mighty genetic potential. In particular, this applies to the seeds in repose, which are adjusted to carrying and keeping the gene even under extreme circumstances. All relaxing seeds of cereals, fruits are fully differentiated whereas their skin and upper coating retard oxygen diffusion and block the water. At the same time the inhibitors will prevent seeds from sprouting. This problems may be straightened out by way of treatment of seeds by sodium alkali or phusicocin. Special magnetic systems can substitute for such expensive materials (Tkatchenko, 1997).

Certainly, there are hormones known to withdraw seeds from the state of repose. For instance, they include auxin and gibereline (for apple trees). These hormones will accelerate the seed germinating capacity by 30% days whereas the adequately picked magnetic field is likely to produce the same effect on apple seeds as early as on the 9^{th} day. Before being sown fruit seeds need as stratified in order to enlarge the embryo by cell division rather than stretching (Tkatchenko, 1997).

The magnetic field of magnetic system lessens the effect of germinating inhibitors due to an increase in pH of the cells juice. Magnetic field X^o of magnetic system from system outside affects the field X^1 inside the cell through energy membranes X and receives a back waves X^1 through X-membranes and X^{-o}. That brings about intensification, damping or absorption depending on the value of magnetic field is matched for each individual crop to increase the efficiency of seed magnetic treatment. Activating properties are manifested in the case of the right choice of magnetic field gradient and magnetic material, which will strengthen the RNA transcription. This will lead to the formation of portions, stimulate the growth of roots as well as activate the growth of weak seeds, which never germinate in normal condition. Once precipitated by the magnetic field at a low temperature, the germinating rate of some seeds, which require a certain period of time to sprout breaks down the growth rate on nodes (Tratchenko, 1997).

2.3.7 Municipal agriculture

In a nutshell the advantages of magnetic technology of irrigation could be enumerated as follows:

Magnetic technologies allow to:

1- Save 30% of water used for irrigation.

2- Reduce quantity of seeds required for sowing by 50%.

3- Decrease vegetative period, of plants by 15-20 day.

4- Magnetized water washes salts out of the soil with higher efficiency (2.5-3 times more efficiently).

5- Reduce the quantity of applied fertilizers minimum twice.

2.3.8 Economic prerequisites

In case magnetic technologies are applied, municipalities and governments will get the following benefits:

1- Investments required for achieving the final goal can be decreased 5 times minimum.

2- A very period of time is required for accomplishing. This task (minimum 30 times less than, which solving the same problem by other methods).

3- No additional space is required for constructing extra premises.

4- A range of ecological problems that can not be solved by other methods can be solved by magnetic technologies.

5- And the most important factor-purified water supplied to a customer will have a completely new, biologically active structure capable of conducting cardinal changes in the environment.

2.3.9 Changes in the environment

Such, water can flush and desalinate soil several times more actively. It exerts an exclusively favourable effect on all kinds of plants and animals. Such, water is extremely useful for human health (Tkatchenko, 1997).

2.3.10 Hydro-magnetic systems and their role in creation of microclimate

2.3.10.1 Ionization

Formation of ions (particles with electrical charge) that happens when electrically neutral atoms lose or join electrons. Thus, forming cations (positive ions) or anion (negative ions), respectively. While passing though a substance. Alpha- and Beta-particles ionize atoms usually forming cations. Particle energy is so high that one or several electrons “breaking out” from the atom. Gamma-rays can also ionize atoms.

2.3.11 Magnetic technology as a method for destroying bacteria and fungi

Bacteria, fungi initiated and stimulate process of corrosion and aging by products of their vital activity. When affecting directly and in combination with other factors to provoke a special type of destroying materials, covers and biological-surface damage, which is a techno-ecological problem. Loss from direct biological damages only exceeds 3% of the industrial output. Over 50% of all corrosion processes are connected with microorganisms influence. The following is an example:

1- Sulphate-restoring bacteria (*Desulfovibrio desulfuricans, D. vulgars, D. salexigenes, D. gigas, D. africants, D. thermofilus* and *Desulfotomaculum* of four types) affect pipelines, heat

exchanger, boring machines, reservoirs, oil and gas refining equipment, fuel systems, engines, …etc.

2- Ferro-bacteria (*Gallionella ferrugues*, …etc) destroy condensers heat exchangers, water pipelines of chemical and processing industries, water cooling systems of turbines at electrical stations, sewage system and water supply of industrial and domestic use.

3- Sea accumulations, sulfur-restoring bacteria, …etc. Affect under-water surfaces of ships, heat exchangers, and tankers.

4- Fungi (*Aspergillus flavus* and *Aspergillus niger*, *Alternaria tenus*), ferro-bacteria and sulfur-restoring bacteria destroy building, bridges, metal and ferro-concrete constructions of energetic and port objects, construction objects, agricultural machinery.

Unlike the larger organisms, which exhibit differentiation and specialization of cells into tissues, organs, and soon, the microorganisms have been single-celled and perform all their necessary life functions within their single cell. Microorganisms include bacteria, fungi, blue-green algae, green and brown algae, the protozoa, and virus (Chhatwal, 1993).

Thus, the problem of protecting metal constructions from biological damage and bio-corrosion is important for many branches of economy.

Modern methods of protection from disease and biological damage are far from being perfects. The most effective methods are mechanical vibrations of the liquid media of fungi and bacteria's existence and apparition of fungi and bacteria's vital activity by high frequency currents. However, these methods, unlike magnetic technologies, are very costly and power consuming (Tkatchenko, 1997).

2.3.12 Pesticide contamination of the environment

Ahmed *et al.* (1991) stated, while we need to control crop pests and disease for adequate production, the environment is often harmed by the use of synthetic pesticides. Board spectrum insecticides are sprayed for control of both vertebrate and invertebrate pests, control of aquatic weeds, seepage or leakage of chemicals or empty containers in an environment, all have effect on environment quality. Metcalf (1980) indicated that insecticides more than other pollutants, has been the subject of violent controversy because of their wide spread effects on environmental quality. All pesticides are biocides and there are no safe pesticides. Groulding (1989) added that there is no single set of rules for safe use pesticides, which caters for every eventuality.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Source of the three fungi

3.1.1 *Macrophomina phaseolina*

Dr. Waheeb of Hudeiba Research Station provided the isolate. The isolate was identified with the help of staff of Crop Protection Laboratory in the Faculty of Agriculture. The isolate was picked with sterilized needles and transferred aseptically to sterilized Petri dishes containing PDA medium. The isolate was incubated at 30^{o}C for 7 days and culture characteristics were recorded. A stock of 7 days old culture was maintained under drop of sterilized paraffin oil in MeCarteny bottles containing a slant of PDA medium. Then it was kept at 5^{o}C.

3.1.2 *Rhizoctonia solani*

Rhizoctonia solani (Kuhn) saprophytic activity was assessed following the method of Papavizas *et al*. (1975). The culture was kindly provided by Head Department of Horticulture, Faculty of Agriculture, University of Khartoum, mixed with 100 g soil sample in 9 cm diameter Petri dishes and after 2 days of incubation in soil, beet seeds were retrieved with sterilized forceps, washed for 20 min. in running tab water, and transferred to Petri dishes (8 seeds/dish) containing 15 ml water agar (2% agar). Three plates were used per replicate.

3.1.3 *Fusarium oxysporum* f-lycopersici

Roots and stems of infected tomato plants were taken from the infected field to the laboratory. They were washed under running water, cut into one inch segments, then they were surface sterilized with 1% chlorax ($NaOCL_3$) for 5 minute, washed 5 times in sterile

distilled water, dried on sterile filter paper and then plated onto potato dextrose-agar medium (PDA). The plates were incubated for 7 days at 25^{o}C. The fungus was isolated in a pure culture and preserved as a single spore culture in MeCarteny bottles

3.2 The analysis of normal and magnetized water

A sample of water was taken from normal water and similar volume was also taken from magnetized water. The water samples were analyzed for the following parameters.

1- pH

2- CND conductivity Ms/cm

3- T.D.S. total (T.D.S) mg/L

4- Total hardness mg/L Ca^{+2}/Mg^{+2}

5- Total alkalinity mg/L CO^{-}_{3}, HCO^{-}_{3}, OH^{-}

6- Permanent hardness mg/L

7- Excess alkalinity mg/L

8- Ca^{+2} mg/L

9- Mg^{+2} mg/L

10-Chloride Cl^{-} mg/L

11-Chromium mg/L Cr^{6+}

12- Iron $Fe^{2+.3+}$ mg/L

13- Nitrite NO_2 mg/L

14- Turbidity FAU

A one inch magnetic device (Magnetic technologies L.L.C., Dubai) was used to magnetize the water and magnetic funnel to magnetized seeds (Plate 1 and 2).

3.3. Effect of magnetized water on linear growth of *Macrophomina phaseolina, Rhizoctonia solani* and *Fusarium oxysproum* f-lycopersici

A Number of 100 ml conical flasks were prepared with PDA medium (Appendix I). The flasks were sterilized, six different volumes of magnetized water were added under sterile conditions. Seven treatments in 5 replicates were setup to cover the following:

a) 100 ml PDA – control
b) 95 ml PDA + 5 ml magnetized water
c) 90 ml PDA + 10 ml magnetized water
d) 80 ml PDA + 20 ml magnetized water
e) 70 ml PDA + 30 ml magnetized water
f) 60 ml PDA + 40 ml magnetized water
g) 50 ml PDA + 50 ml magnetized water

To each of the sterilized Petri dishes (35), the above 7 treatments were added. Two diameters were drawn on the back of each Petri dish for centering the inoculum. Then a 5 mm disc was cut from the edge of a 7 days old culture of isolate. Three sets of

experiments were prepared for three isolates of fungi (35 Petri dishes per fungus).

The Petri dishes were then incubated at optimum temperature for each fungus. The rate of fungal growth was estimated daily by measuring the colony size along the two diameters drawn previously and the mean colony diameter were calculated for each treatment.

3.4 Effect of magnetized seeds on growth plants inoculated with *Macrophomina phaseolina, Rhizoctonia solani* and *Fusarium oxysporum* f-lycopersici in test tubers

Magnetic mechanisms are available for treating seeds passing seeds through a magnetic funnel.

Adding 1% water agar (Appendix 1) for each test tubes, three treatments in three each replicates were setup to cover the following:

a) Magnetized seeds + inoculum
b) Normal seeds + inoculum
c) Normal seeds without inoculation – control

Then one seed was put on slant agar in test tube (10 ml.) and plugged with a loose cotton plug, and incubated for 4 – 5 days. The plug was removed and the tubes were incubated for 14 days under alternating cycles of 12 hrs light and 12 hrs darkness at 20^{o}C.

3.5 Effect of magnetized seeds and magnetized water on growth of plants *M. phaseolina, R. solani* and *F. oxysporum* f-lycopersici in blotter test

Three refrigerator boxes (10 x 20 cm, 6 cm high) used in the experiment as follows:

a) Magnetized seeds + magnetized water + inoculum

b) Normal seeds + normal water + inoculum

c) Normal seeds + normal water – control

Number of magnetized seed and normal seeds were soaked in a heavy suspension of the fungus in water for short period of time, then the seeds were placed on filter paper in two refrigerator boxes, the normal seeds and water without inoculum were placed in the third one and incubated on 12 hrs light and dark for about 14 days at the optimum temperature and moistened everyday.

3.6 Effect of magnetized water on the dry mycelial weight of *M. phaseolina, R. solani* and *F. oxysporum* f-lycopersici in liquid media

21 of 250 ml conical flasks were prepared with PDB medium (Appendix 1). The flasks were sterilized. Six different volumes of water were added. Seven treatments in 3 replicates were setup to cover the following:

a) 100 ml PDB – control

b) 95 ml PDB + 5 ml magnetized water

c) 90 ml PDB + 10 ml magnetized water

d) 80 ml PDB + 20 ml magnetized water

e) 70 ml PDB + 30 ml magnetized water

f) 60 ml PDB + 40 ml magnetized water

g) 50 ml PDB + 50 ml magnetized water

After they were cooled they were inoculated with a 5 mm disc, of the inoculum was cut from the edge of a 7 days old culture of the isolate, and the inoculum was carefully removed and introduced into each flask. The flasks were incubated at the optimum temperature for each fungi for 10 days. The mycelial mat was filtered with cheese-cloth and the dry weights were obtained.

Three sets of experiments were prepared for each isolate of the three fungi.

3.7 Effect of magnetized water and normal water on growth of *M. phaseolina, R. solani* and *F. oxysporum* f-lycopersici *in vitro*

The three flasks each containing 100 ml sterile potato-dextrose agar, were cooled to 40^{o}C. And both seeded with 5 ml of a spore suspension of *Macrophomina phaseolina, Rhizoctonia solani* and *Fusarium oxysporum* f-lycopersici (18 spore/ml) prepared from a 7 day-old culture. After mixing, each flask of medium was distributed amongst 15 sterile Petri dishes (5 Petri dishes per fungus). Then magnetized water and normal water were pipette under sterile conditions into four cavities cut with a 6 mm. sterile cork borer in PDA plates seeded with fungi. The plates were then incubated at the optimum temperature.

CHAPTER FOUR
EXPERIMENTAL RESULTS

4.1 Experiment (1): Isolates of the causal agent

4.1.1 *Macrophomina phaseolina*

The vegetative mycelia of the isolate in pure culture was grey to black, the hyphae were sepatated and branched (Plate 3). Sclerotia of isolate were scatted on surface of the media and black in colour.

4.1.2 *Rhizoctonia solani*

The vegetative mycelia of the isolate in pure culture was white, the hyphae are septated, hyaline and branching at right angle with the main hyphae (Plate 3). The scleraotia of the isolate was surface-borne and brown to dark brown in colour after 7 days.

4.1.3 *Fusarium oxysporum* f-lycopersici

The mycelium is colourless at first, but with age it becomes cream-coloured, pale yellow, pale pink or somewhat purplish.

The fungus produces three kinds of sexual spores (Plate 3) Microconidia, which have one or two cells. Macroconidia are the typical *Fusarium* spores, they are three to five celled, have gradually pointed and curved ends.

Chlamydospores are one or two celled, thick walled, round. Spores are produced intercallary terminally on older mycelium or in macroconidia.

Plate 3

4.2 Experiment (2): Characteristics of normal and magnetized water

The results of analysis of magnetized and normal water showed the differences between them in all parameters. The results are summarized in Table 5.

Table 5. Characteristics of normal and magnetized water.

Parameters	Normal water	Magnetized water
pH	6.68	7.17
CND conductivity ms/cm	332.00	200.00
T.DS total (T.DS) mg/L	166.50	140.00
Total hardness mg/L Ca^{+2} Ma^{+2}	112.00	92.00
Total alkalinity mg/LO_3^-, HCO_3^-, OH^-	172.00	112.00
Excess alkalinity mg/L	60.00	20.00
Ca^{+2} mg/L	30.40	27.25
Mg^{+2} mg/L	8.15	5.83
Chloride Cl^- mg/L	113.76	71.10
Iron Fe^{2+m2+} mg/L	0.26	0.13
Turbidity FAU	2.00	0.00

Where:

CND: electrical conductivity

T.D.S: total dissolved solid

FAU: formazin attenuation unit

FTU: formazin turbidity unit

4.3 Experiment (3): Effect of magnetized water on linear growth of *Macrophomina phaseolina, Rhizoctonia solani* and *Fusarium oxyporum* f-lycopersici

4.3.1 *Macrophomina phaseolina*

The results showed highly significant ($P < 0.05$) differences among the seven media used on the linear growth of *Macrophomina phaseolina* (Plate 4). The highest linear growth was obtained on M_1 (4.3 cm), which was significantly different from all other treatments. However, the smallest linear growth occurred on M_7 (0.01 cm) (Fig 1 and Table 6).

In the 2nd day there was no significant difference between M_1, M_2, M_3, and M_4. They have the same effect on the linear growth of *M. phaseolina*. They produced a mean linear growth of 6.2 and 5.9 cm. There was highly significant

difference between M_5 and M_7, which means it, has reduced the linear growth and the fungus.

On the other hand, there was no significant difference between M_5 and M_6 in their effects on the linear growth of the fungal growth. M_7 was highly significantly different from all the other media. It has produced the highest effect on the linear growth of the fungus.

In the 3rd day, there were no significant differences between M_1, M_2, M_3, and M_4. These media were highly significantly different from M_5, M_6 and M_7. Also, M_5 revealed high significant difference from M_6 and M_7. M_6 manifested high significant difference from M_7.

Fig. 1

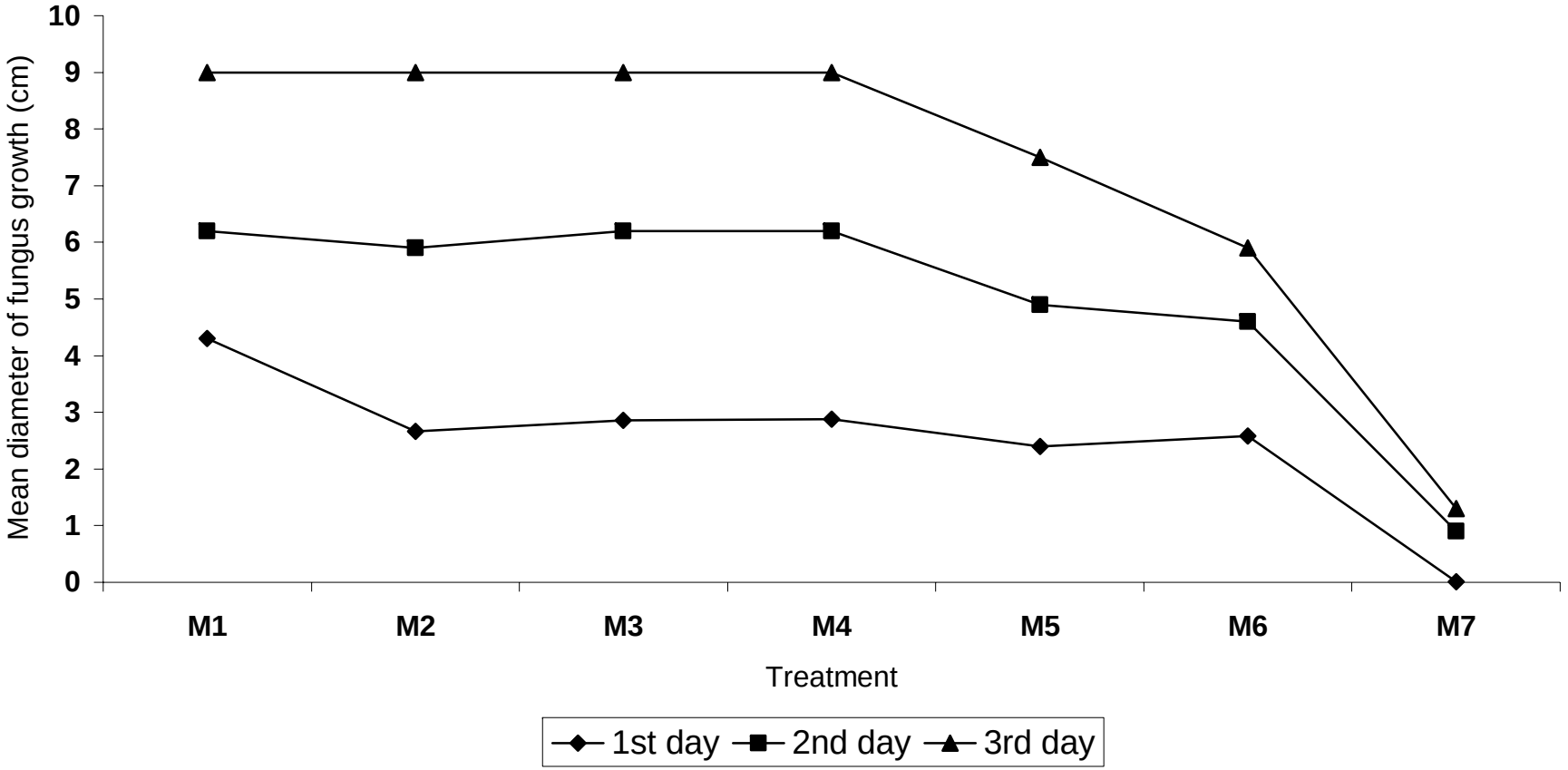

Fig.1 Effect of magentized water on linear growth of *M. phaseolina*

Table 6. Effect of magnetized water on linear growth of *M. phaseolina.*

Media	Linear growth (cm)		
	1st day	2nd day	3rd day
M_1	4.30	6.20	9.00
M_2	2.66	5.90	9.00
M_3	2.86	6.20	9.00
M_4	2.88	6.20	9.00
M_5	2.40	4.90	7.50
M_6	2.58	3.60	5.90
M_7	0.01	0.90	1.30
5% LSD	0.16	0.37	0.88
1% LSD	0.22	0.49	1.19

Mean linear growth of *Macrophpomina phaseolina* on seven growth media.

4.3.2 *Rhizoctonia solani*

These results were presented and summarized in Table 7 show that in the 1st day:

1- Highly significant (P < o.o5) differences among the seven media used on the linear growth of *Rhizoctonia solani* (Plate 5).

2- There was significant difference among M_1 and M_4 .

3- M_1 was not significant different from M_4 but was significantly different from the other media.

4- There were no significant differences between M_2, M_3 M_4 and M_5. These media were significantly different from M_6 and M_7.

5- There was no significant difference between M_6 and M_7 in their effects on the linear growth of *Rhizoctonia solani*.

In the 2nd day, differences among M_1, M_2, M_3, M_4 and M_5 were non-significant. These 4 media were significantly different from M_6 and M_7.

In 3rd day, was non-significantly different from M_2 and M_3 whereas, it was significantly different from the other media. M_2 was non-significant different from M_3 and M_4 but significantly different from M_5, M_6 and M_7.

M_3 was significantly different from M_6 and M_7. Similarly, M_4 and M_5 were significantly different from M_6 and M_7.

In the 4th day M_1, M_2, M_3, M_4, and M_5 were similarly in their effect. On the other hand, these media were significantly different from M_6 and M_7. Also, M_6 was significantly different from M_7 (Fig.2).

Table 7. Effect of magnetized water on linear growth of *R. solani*.

Media	Linear growth (cm)			
	1st day	2nd day	3rd day	4th day
M_1	1.70	3.80	3.80	9.00
M_2	1.20	3.70	7.30	9.00
M_3	1.10	3.80	7.20	9.00
M_4	1.30	3.90	7.10	9.00
M_5	1.10	3.90	7.00	9.00
M_6	0.20	2.80	5.30	8.10
M_7	0.10	2.80	5.30	6.10
Mean	**0.96**	**3.53**	**6.64**	**8.46**
5% LSD	**0.43**	**0.18**	**0.29**	**0.23**
1% LSD	**0.58**	**0.25**	**0.39**	**0.31**

Mean linear growth of *Rhizoctonia solani* on seven growth media.

Fig. 2

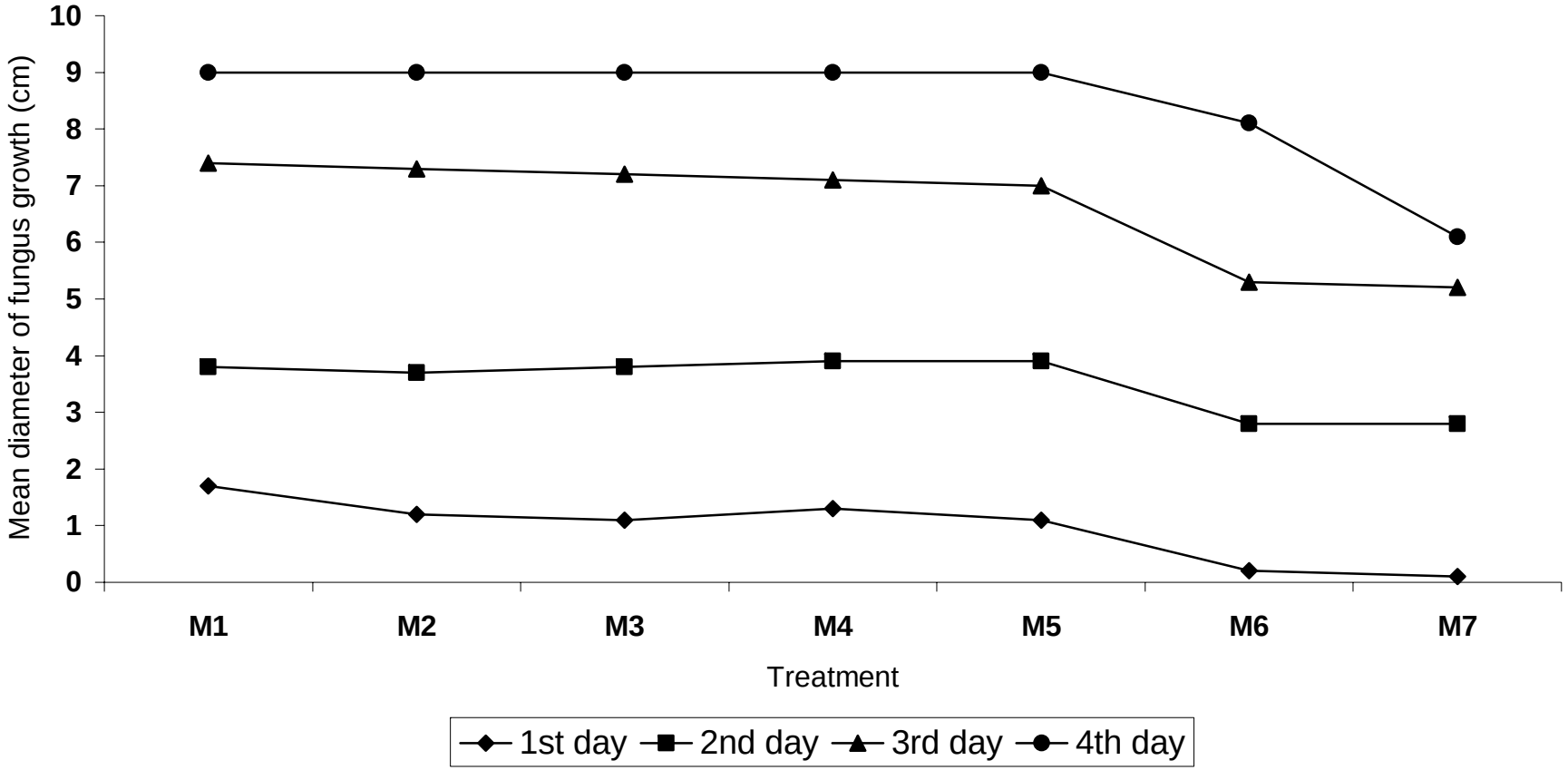

Fig.2 Effect of magentized water on linear growth of *Rhizoctonia solani*

4.3.3 *Fusarium oxyporum* f-lycopersici

In the 1st day after inoculation, the result showed highly significant ($P < 0.05$) difference among the seven media used for linear growth of *Fusanium oxysporum* f-lycopersici (Plate 6). Media, M_1, M_2, M_3 and M_4 were similar in their effect (Table 8).

M_5, M_6, and M_7 were similar in their effect but were highly significantly different from the other treatment.

In 2nd day, M_1 was significantly different from all other treatments. M_2, M_3 and M_4 were similar in their effect but were significantly different from M_5, M_6 and M_7. M_5 and M_6 were similar but were significantly different from M_7.

In 3rd day, M_1, M_2, M_3, M_4 and M_5 were non-significantly different from each other were similar but were significantly different from M_7. M_7 was highly significantly different from M_6.

In 4th day M_1, M_2, M_3 and M_4 were non-significantly different from each other, but were significantly different from M_5, M_6 and M_7.

M_5 was highly significantly different from M_6 and M_7. Also, M_6 was highly significantly different from M_7.

In 5^{th} day M_1, M_2, M_3, and M_4 were similar in their effect. Also, M_5, M_6 and M_7 were similar in their effect, but were highly significantly different from the other treatment.

In 6^{th} day, there were no significant differences between M_1, M_2, M_3, and M. These media were highly significantly different from M_5, M_6 and M_7. Also, M_5 was highly significantly different from M_6 and M_7. M_6 was highly different from M_7

(Fig. 3).

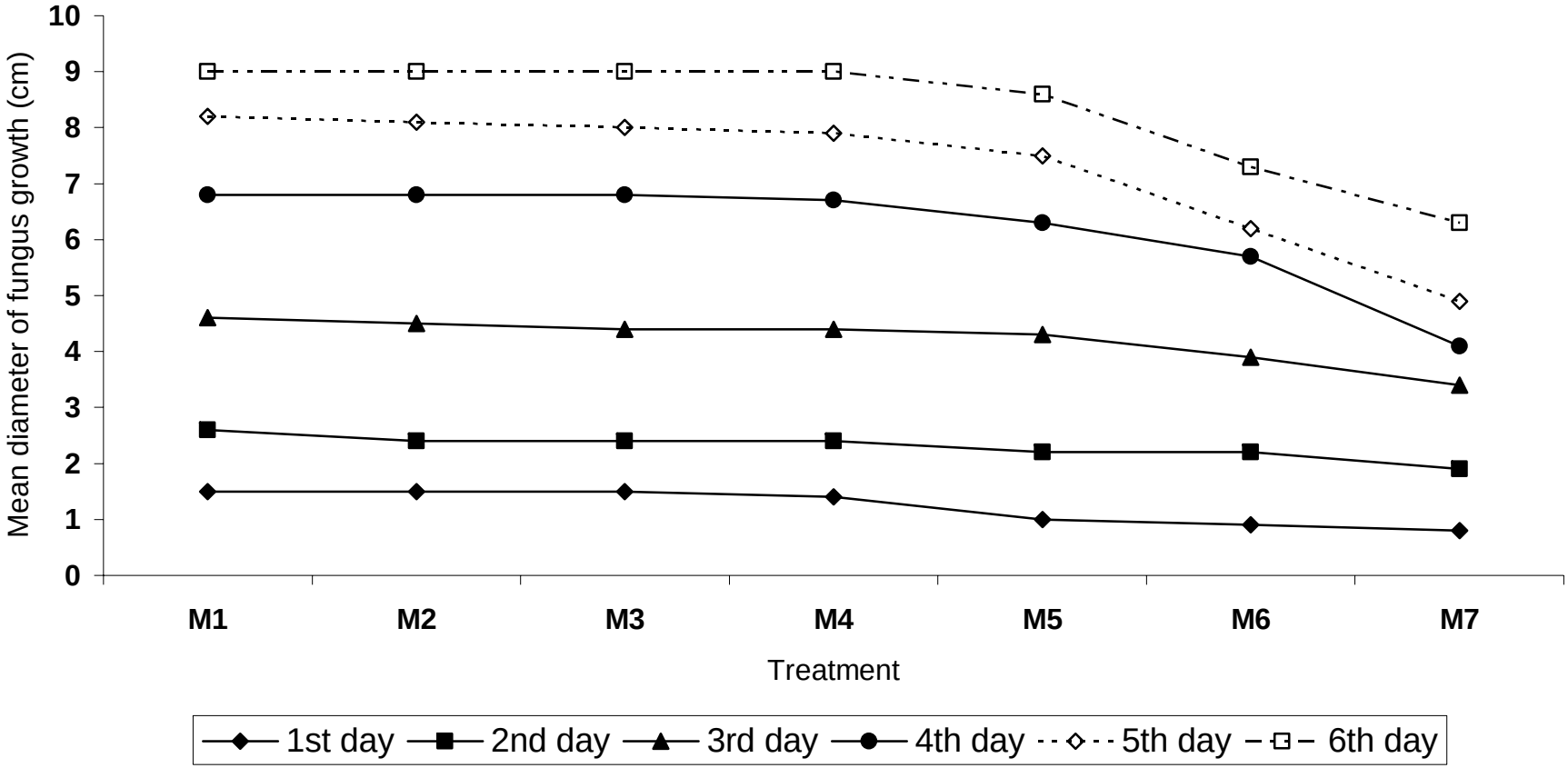

Fig.3 Effect of magentized water on linear growth of *F. oxysporum f. lycopersici*

Plate 4, 5 & 6

Fig. 3

Table 8. Effect of magnetized water on linear growth of *Fusarium oxyporum* f-lycopersici.

Media	Linear growth (cm)					
	1st day	2nd day	3rd day	4th day	5th day	6th day
M_1	1.50	2.60	4.60	6.80	8.20	9.00
M_2	1.50	2.40	4.50	6.80	8.10	9.00
M_3	1.50	1.30	4.40	6.80	8.00	9.00
M_4	1.40	2.40	4.40	6.70	7.90	9.00
M_5	1.00	2.20	4.30	6.30	7.50	8.60
M_6	0.90	2.20	3.90	5.70	6.20	7.30
M_7	0.80	1.90	3.40	3.10	7.90	6.30
Mean	**1.24**	**2.30**	**4.21**	**6.17**	**7.26**	**8.31**
5% LSD	**0.22**	**0.19**	**0.32**	**0.21**	**0.21**	**0.18**
1% LSD	**0.29**	**0.25**	**0.43**	**0.28**	**0.29**	**0.24**

Mean linear growth of *Fusanium oxysporum* f-lycopersici. on seven growth media.

4.4 Experiment (4): Effect of magnetized seeds on growth of plants inoculated with *Macrophomina phaseolina, Rhizoctonia solani* and *Fusarium oxyporum* f-lycopersici in test tubes

4.4.1 *Fusarium oxysprum* f-lycopersici

The results these experiments after inoculation showed that:

a) The inoculated magnetized seeds, tomato plants remained green and disease free.

b) The inoculated normal seeds, symptoms were observed in plants, the first leaves, showed yellowing on their margins and tips, then followed by other leaves. Sum of stems turned brown before plants died, roots were rotted and turned black, all inoculated plants looked stunt.

c) The control remained green (Plate 7).

4.4.2 *Macrophomina phaseolina*

a) In inoculated normal seeds:

After two weeks the results showed that the disease symptoms appeared, the plant (sorghum) were bright brown on the stem near the agar level. The leaves became yellow coloured and dropped plants got dry and fell dead.

d) In inoculated magnetized seeds, the plants looked healthy and green.

e) In control the plants remained green (Plate 8).

4.4.3 *Rhizoctonia solani*

The results showed that:

a) In inoculated magnetized seeds all plants green and disease free.

b) In inoculated normal seeds, the plants were examined, the symptoms have been recognized as browning and dry rot.

c) The control, the plants remained green (Plat 9).

4.5 Experiment (5): Effect of magnetized seed and magnetized water on growth of plants inoculated by *M. phaseolina* *F. oxysporum* f-lycopersici and *R. solani* in blotter methods

4.5.1 *Macrophomina phaseolina*

After the incubation, the inoculated seeds were examined for disease symptoms and it was noticed that:

a) In inoculated magnetized seeds and magnetized water, the plants remained green and healthy more than the control.

Plate 7, 8 & 9

b) In inoculated normal seeds and normal water, the infection after 9 days was heavy in the form of dead brown area, in seedlings and dry rot of roots and seeds were observed (Plate 10).

c) Control remained green.

4.5.2 *Rhizoctonia solani*

The inoculated seeds were examined for disease incidence and symptoms, the results shown that:

a) The inoculated magnetized seed and magnetized water revealed that plants looked healthy and green and seedlings were disease free.

b) In inoculated normal seeds and normal water, it was noticed that the fungal hyphea were seen grow over the seed surface into epidermis cells. The infected cells turned brown and later extend to whole seedling. These symptoms on the stem spourts give rise to stalks, which have lesions (Plate 11).

c) The control remained green.

4.5.3 *Fusarium oxysporum* f-lycopersici

The results after incubation showed that:

a) The inoculated magnetized seed and magnetized water was examined for disease symptoms, it was noticed that all the plants looked healthy and disease free seedlings more than the control.

b) In inoculated normal seeds and normal water, the fungal hyphea were observed growing over the seed surface. The infected cells turned brown and the infection after 10 days caused brown colour in roots and the seedlings were stunted (Plate 12).

c) The control remained green.

Plate 10, 11, 12

4.6 Experiment (6): Effect of magnetized water on dry mycelial weight of *Macrophomina phaseolina, Fusarium oxysporum* f-lycopersici and *Rhizoctonia solani*

The results indicate highly significant ($P < 0.05$) differences among the seven liquids media on the dry mycelial weight of *M. phaseolina F. oxysporum* f-lycopersici and *Rhizoctonia solani*. However, the analysis indicated that there was no significant difference among the media used on the dry mycelial weight of *F. oxysporum* f-lycopersici (Table 9).

4.6.1 *Macrophomina phaseolina*

For *Macrophomina phaseolina,* the highest dry mycelial weight was (1.6 g) given by M_1 followed by M_2 (1.4 g). On the other hand, the lowest dry mycelial weight given by M_7 was (0.2 g).

4.6.2 *Rhizoctonia solani*

For *Rhizoctonia solani,* the highest dry mycelial weight was (1.5 g) given by M_1 followed by M_2 (1.3 g). The lowest dry mycelial weight given by M_7 was (0.22 g).

The media M_3, M_4 and M_5 were intermediate in their effects on the two fungi mentioned above.

4.6.3 *Fusarium oxysporum* f-lycopersici

In case of *Fusarium oxysporum* f-lycopersici, the overall mean dry mycelial weight was 0.34 g.

Table 9. Effect of magnetized water on the dry mycellial weight of the *F. oxysporum* f-lycopesici, *R. solani* and *M. phaseolina*

Media	Linear growth (cm)		
	F. oxysporum f-lycopersici	*Macrophomina phaseolina*	*Rhizoctonia solani*
M_1	0.66	1.60	1.51
M_2	0.53	1.40	1.30
M_3	0.35	1.20	0.93
M_4	0.37	1.30	0.61
M_5	0.26	1.30	0.91
M_6	0.14	0.50	0.40
M_7	0.10	0.20	0.22
Mean	**0.34**	**1.07**	**0.84**
5% LSD	**0.31**	**0.16**	**0.43**
1% LSD	**0.43**	**0.22**	**0.59**

Mean dry mycelium growth of *R. solani F. oxysporum* f-lycopersici and *M. Phaseolina* treated by magnetized water.

4.7 Experiment (7) Effect of magnetized and normal water on growth of *Macrophomina phaseolina,*

Rhizoctonia solani **and** ***Fusarium oxysporum*** **f-lycopesici** ***in vitro***

The results of experiment showed that there are differences between the effect of magnetized water and normal (Table 10). There is evidence, here, that magnetized water inhibits the growth of the three fungi *in vitro* (Plate 13).

Table 10. Effect of magnetized and normal water on growth of ***Macrophomina phaseolina, Rhizoctonia solani*** **and** ***Fusarium oxysporum*** **f-lycopesici**

The fungus	No. plate	Treated water magnetized		Untreated water normal	
		Replicates		Replicates	
		1	2	3	4
Macrophomina phaseolina		1 +	+	-	-
		2 +	+	-	-
		3 +	+	-	-
Rhizoctonia solani		1 +	+	-	-
		2 +	+	-	-
		3 ±	±	-	-
Fusarium oxysporum f-lycopersici		1 ±	±	-	-
		2 ±	±	-	-
		3 ±	±	-	-
				+	

+ = Inhibition

± = Inhibition (not clear)

- = No inhibition

plate 13

CHAPTER FIVE
DISCUSSION

5.1 General

The present investigation was conducted to assess the efficacy on magnetized water and magnetized seeds in the presence of *Macrophomina phaseolina, Rhizoctonia solani* and *Fusarium oxysporum* f-lycopersici on sorghum and tomato.

The agents of charcoal rot, *Rhizoctonia* stalk rot and *Fusarium* wilt were isolated and their pathogenicity together with other physiological studies were investigated

The pathogenic nature of the three isolates of fungi were demonstrated at different stages of growth of the two crops tested. The symptoms induced by the fungi on the two hosts were similar to those described previously by Tarr (1962), Walker (1969) and Agrios (1997).

Very recently, Magnetic Technology (L.L.C) (1995) has provided effective units to magnetize water and seeds. A magnetic unit for water treatment (Magnitron) and for seeds two magnetic mechanisms are available:

1- Passing seeds through a magnetic funnel.

2- Irrigating normal seeds with magnetized water allover the seedling stage.

Available literature of magnet is very limited.

5.2 The analysis of normal water and magnetized water

The results of using a one inch magnetic device (Magnetic Technologies L.L.D, Dubai) to magnetize the water showed the differences between normal water and magnetized water in all parameters.

These findings explain the positive effect of magnetic field on water. Tkatchenko (1997) reported similar result.

5.3 Effect of magnetized water on linear growth of *Macrophomina phaseolina, Rhizoctonia solina* and *Fusarium oxysporum* f-*lycopersici*

The results of addition of magnetized water to potato dextrose agar media showed highly significant differences among the seven media used on linear growth of the three fungi. The variation in the degree of inhibition in the different treatments suggests that it is dependent on the amount of the magnetized water.

Due to these results, the highest linear growth was obtained on M_1 and the lowest on M_7. Tkatchenko (1997) found that the magnetic technologies were most effective methods on microorganisms control and oppression of vital activity. So, we can say there is a correlation between the two rending.

5.4 Effect of magnetized seeds on growth of plant inoculated by *Macrophomina phaseolina, Rhizoctonia solina* and *Fusarium oxysporum* f-lycopersici in test tubes

The results of seeds treatment against *Macrophomina phaseolina, Rhizoctonia solina* and *Fusarium oxysporum f.*lycopersici

revealed that the plants remained green, disease-free and looked healthy compared to the untreated inoculated seeds.

In case of inoculated seeds symptoms induced by the three fungi on the two hosts were similar to those described previously.

Generally, it could be stated that, the using of magnetized seeds produces favourable conditions for healthy plants growth and consequently plants may have a better chance to resist plant pathogens. This is justified by the findings of Mohamed (1999), who reported magnetizing seeds had been very efficient to increase the number of germinating seeds and hastened the germination process.

5.5 Effect of magnetized water and magnetized seeds on growth of plant inoculated by *M. phaseolina, F. oxysporum* f-lycopersici and *R. solina* on blotter method

The findings in this investigation indicated that combination of magnetized water and seeds in presence of the fungi improved plant growth and the plants (tomato and sorghum) remained healthy, green and they reduced both disease incidence and severity compared with control.

The results also revealed the typical symptoms of the three diseases, in case of inoculated normal seeds + normal water. Even

seeds, which escape from infection and germinated were later infected in the seedling stage.

All these findings may explain the positive effect of magnetic technology application on the reduction of disease incidence and severity. Similar, results have also been reported previously by Mustafa (2002).

5.6 Effect of magnetized water on the dry mycelial weight of *M. phaseolina, R. solina* and *F. oxysporum* f-lycopersici

The results of the addition of magnetized water to liquid media (PDB) indicated highly significant differences among the seven liquid media on the dry mycelial weight of *M. phaseolina, F. oxysporum* f-lycopersici and *R solina.* The highest dry mycelial weight was obtained on M_1 and the lowest one given by M_7 (50 ml PDA + 50 ml magnetized water). However, for *F. oxysporum* f-lycopersici the results indicated no significant difference. The overall mean dry mycelial weight was 0.34 g.

Generally, the results obtained indicate the effect of magnetized water on growth of fungi in liquid media. These agreed with Tkatchenko (1997) who reported that the magnetic technologies were most effective methods for the liquid media of bacteria.

5.7 Effect of magnetized water on the growth of *M. phaseolina, R. solina* and *F. oxysporum* f-lycopersici *in vitro*

The findings in this investigation indicated the differences between the effect of magnetized and normal water. The three fungi indicated very closed similarly in their response.

The inhibition zone shown in the first two days after incubation due to the effect of magnetized water, were followed by over growth on the three fungi colonies. The fact that magnetized was remarkably inhibiting *M. phaseolina R. solina* and *F. oxysporum* f-lycopersici

in vitro could also be supported by the success in the use of magnetized water, which have consequently produced healthy plants resistant to fungal infection.

CONCLUSION

1- Application of magnetized water highly significantly ($P < 0.05$) reduced the harmful effects of *Fusarium* wilt on tomato, *Rhizoctonia* stalk rot and charcoal rot of sorghum.

2- The combination of magnetized water and seeds produced healthy plants, which could be the reason for reduction of disease incidence severity.

3- Application of magnetic technologies in these particular investigations may be a basis for solution of the most complicated ecological problems and formation for forecast of climatic conditions in a certain region. And the most important factor, purified water is extremely useful for human health.

4- The study aims to improve productivity with least possible cost by using magnetic technologies.

5- Application of magnetic technology induced changes in the microbial balance, reducing the population density of the pathogens and stimulating the activity of the plant cells.

6- The study represents the first original attempts for plant disease allover the world. Some other aspects of the study have been suggested for further research.

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* Original copy is not found.

APPENDIX 1

Culture media

a) Potato Dextrose Agar (PDA) was prepared from the foloowing constitutes:

Distilled water	**1000 ml**
Sliced potatoes	200 g
Dextrose	20 g
Agar	20 g

b) Water agar (WA) was prepared from the following constitutes:

Distilled water	**100 ml**
Agar	1 g

c) Potato Dextrose Agar (PDA) was prepared from the foloowing constitutes:

Distilled water	**1000 ml**
Sliced potatoes	200 g

APPENDIX 2

Statistical Analysis of Variance

df = Degree of freedom

SS = Sum of squares

MS = Mean squares

NS = Not significant

*** = Significant (P = 0.05)**

**** = Highly significant (P = 0.01)**

SV = Source of variance

Appendix 2a. Effect of magnetized water on linear growth of *M. phaseolina*.

ANOVA Table 1

SV	df	Mean squares		
		1st day	2nd day	3rd day
Media	6	8.12**		41.31**
Error	28	0.02	0.08	0.46

Appendix 2b. Effect of magnetized water on linear growth of *R. solani*.

ANOVA Table 2

SV	df	Mean squares			
		1st day	2nd day	3rd day	4th day
Media	26	1.77**	1.29**	4.28**	5.98
Error	28	0.11	0.02	0.05	0.03

Appendix 2c. Effect of magnetized water on linear growth of *Fusarium oxyporum* f-lycopersici

ANOVA Table 3

SV	df	Mean squares					
		1st day	2nd day	3rd day	4th day	5th day	6th day
Media	6	0.48**	0.23*	0.88*	4.79*	7.69*	5.73*
Error	28	0.03	0.02	0.06	0.03	0.03	0.02

Appendix 2d. Effect of magnetized water on the dry mycellial weight of the *M. phaseolina, R. solani* and *F. oxysporum* f-lycopersici

ANOVA Table 4.

SV	df	Mean square

		F. oxysporum f-lycopersici	*Macrophomina phaseolina*	*Rhizoctonia solani*
Media	6	$0.12^{n.s}$	0.65**	0.75**
Error	14	0.05	0.09	0.01

Plate 1 : Magnetron (one inch)

Plate 2 : Magnetic funnel

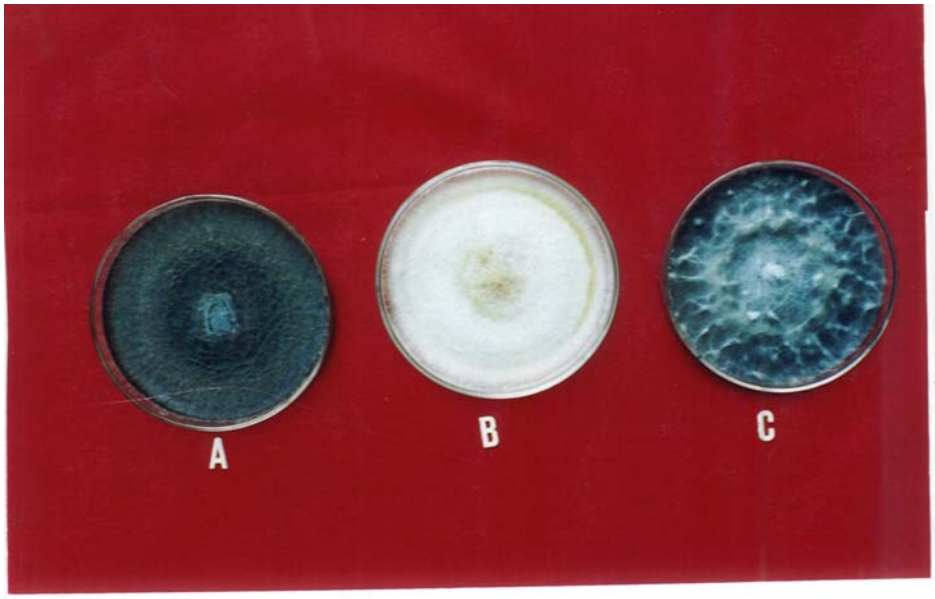


Plate3 : mycelia and formation of sclerotic

Rhizoctonia solani A:
Fusarium oxysporum f-lcopersici B:
Macrophomina phaseolina C:

Effect of magnetized water of seven media on liner growth of :-

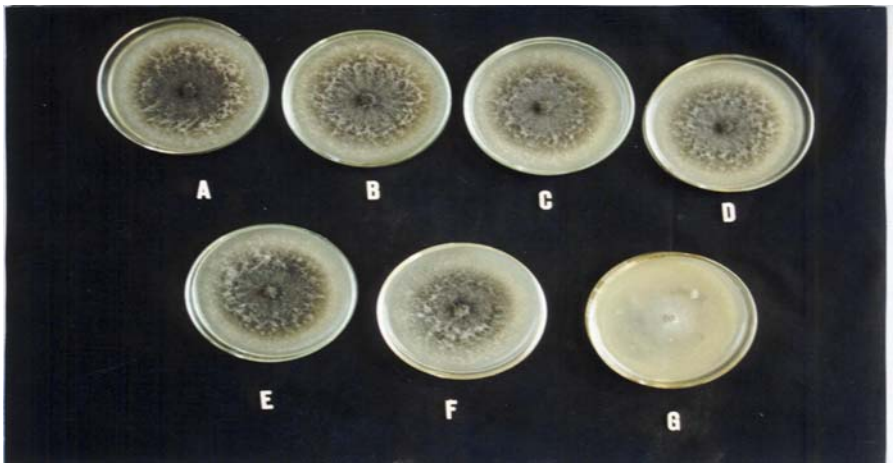


Plate 4 : *Macrophomin phaseolina*

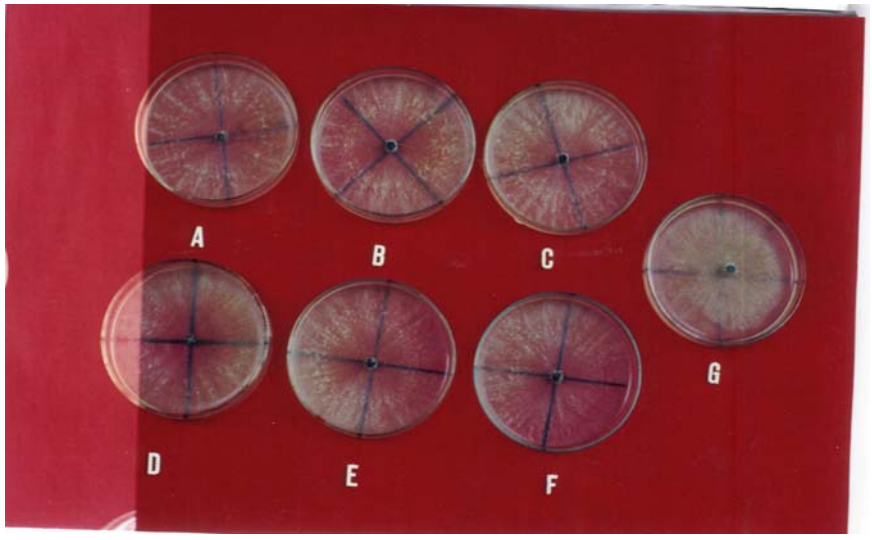


Plate 5 : *Rhizoctonia solani*

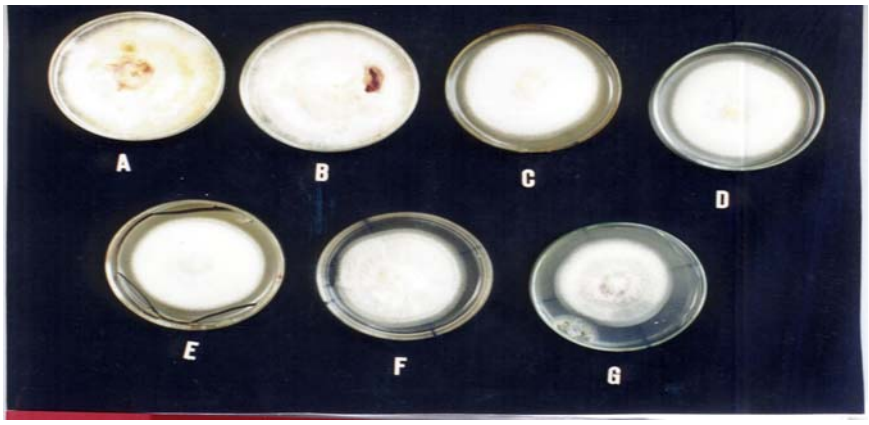


Plate 6 : *Fusarium oxysporum* f. Lycopersici
A:M_1 , B:M_2 , C:M_3 , D:M_4 , E:M_5 , F:M_6 , G:M_7 ,

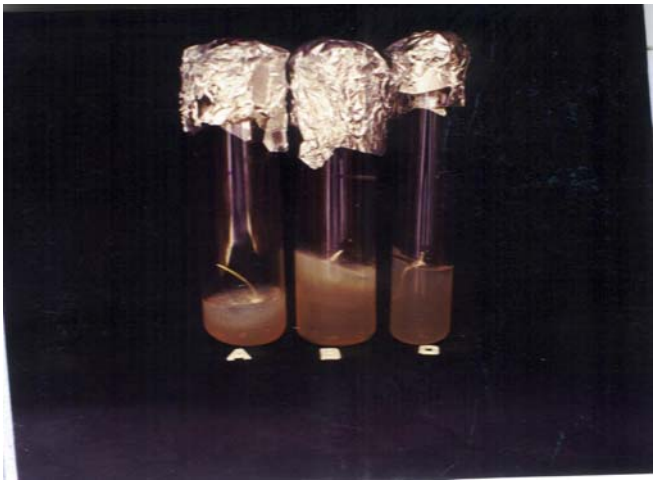


Plate 7: effect of magnetized seed (sorghum) on plant growth inoculated by *Macrophomina phaseolina*

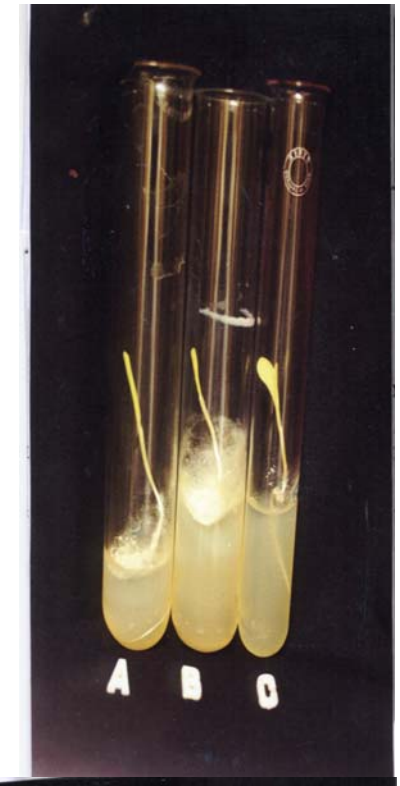


Plate 8: Effect of magnetized seed (sorghum) On plant growth inoculated by *Rhizoctonia solani*

Plate 9: Effect of magnetized seed(Tomato) on plant growth inoculated by *Fusarium oxysporum* f. lycopersici

A: Magnetized seed (disease – free)
B: normal seed (infected plant)
C: control

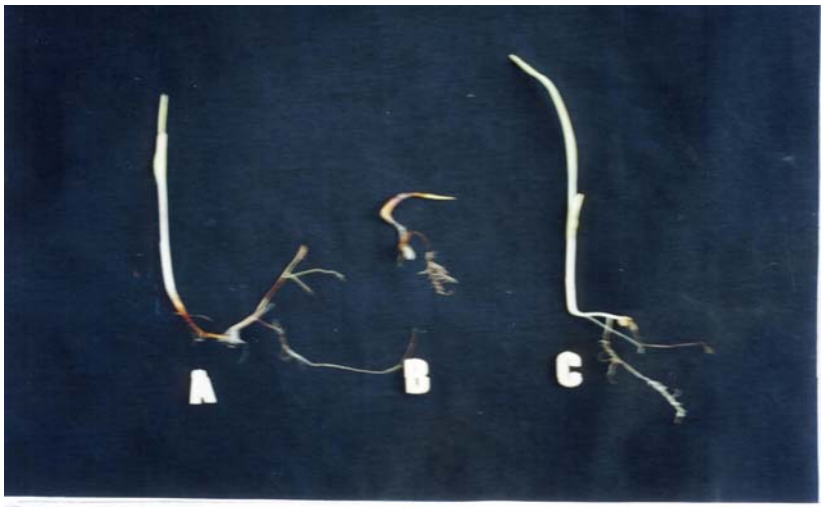


Plate 10: Effect of magnetized water + magnetized seed on plant growth (sorghum) inoculated by *Macroophomin phaseolina*

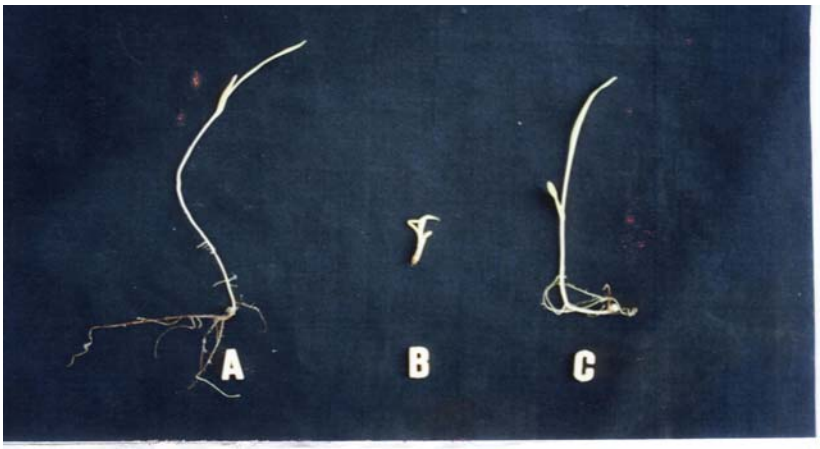
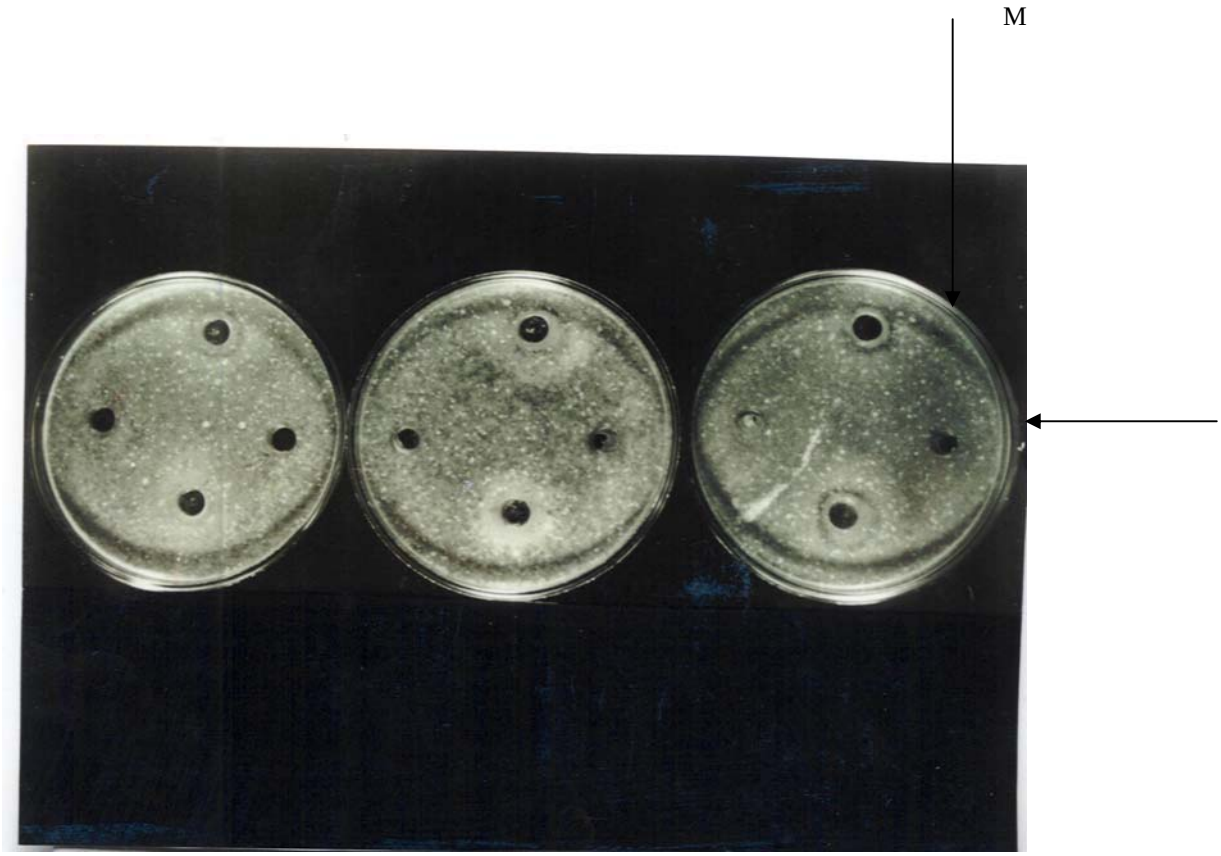


Plate 11: Effect of magnetized water +magnetized seed on plant growth (sorghum) inoculated by *Rhizoctonia solani*

Plate 12: Effect of magnetized water +magnetized seed on plant

growth (Tomato) inoculated by *Fusarium oxysporum f.lycopersici*

A: Magnetized water + Magnetized seed (disease – free seedling)
B: Infected plant
C: Control.



A B C

Plate 13: Effect of Magnetized water in vitro on growth of :

A: *Macrophomina phaseolina*
B: *Fusarium oxysporum* f.Lycopersici
C: *Rhizoctonia*

M. Magnetized water showing zone of inhibition
N. Normal water showing non-inhibition