A Study on the Efficacy of Melody Duo and Antracol 70 Fungicides On Early Blight Disease (*Alternaria solani)* on Potato and Tomato Crops

By

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Dedication

To my beloved Parents, Precious Brother and

Lovely Sisters.

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ABSTRACT

The present study was conducted during the seasons 2001 /0002 and 2002 /0003 to determine the efficacy of two fungicides for the control of early blight disease on potato (*Solanum tuberosum*) cv. Alpha and tomato (*Lycopersicon esculantum*) variety i.e., Peto 86 and Strain B, assessed in terms of disease incidence, disease severity and yield (quantitatively and qualitatively).

The fungicides tested in this study were Antracol 70 and Melody Duo. Each fungicide was tested in three concentrations. Fungicides application resulted in variable decrease in the disease incidence and disease severity and, increase in yield.

For potato crop, the highest dose of Antracol (0.6 Kg /fed.) proved to be efficient in combating disease incidence and disease severity, while the proposed dose of Melody Duo (1 Kg /fed.) proved to be the most efficient in increasing yield in season 2001 /0002. For the second season (2002 /0003), Melody Duo in the proposed dose (1 Kg /fed.) proved to be efficient in combating disease incidence and disease severity.

For tomato crop, cv. Peto 86, in season 2001 /0002, the highest dose of Melody Duo (1.25 Kg /fed.) proved to be efficient in combating disease severity and percentage of discarded fruits. On the other hand, the least dose of Melody Duo (0.75 Kg /fed.) resulted in the highest yield. In the second season (2002 /0003), the proposed dose of Melody Duo 1 Kg /fed. proved to be the most efficient in combating disease incidence and disease severity. Antracol in the

proposed dose (0.5 Kg /fed.) proved to be efficient in increasing the yield, while the highest dose of Antracol showed the highest percentage of healthy fruits.

For tomato cv. Strain B (Season 2002 /0003), the proposed dose for Melody Duo (1 Kg /fed.) proved to be efficient in combating disease incidence, while the least dose of Melody Duo proved to be efficient in increasing the yield (quantitatively and qualitaitively). The highest dose of Antracol proved to be efficient in combating the disease severity.

خلاصة الأطروحة

دراسة حول فعالية مبيدين فطريين لمكافحة مرض الندوة المبكرة

في محصولي البطاطس و الطماطم.

أجريت هذه التجارب خلال موسمي (2001 – 2002 / 2002 – 2003) لتحديد فعالية مبيدين فطريين لمقاومة ومكافحة مرض الندوة المبكرة في الطماطم (عينة strain B وعينة PETO86) والبطاطس (عينة Alpha) وفعالية المبيد تحدد بنسبة حدوث المرض ، شدة المرض والإنتاجية كماً ونوعاً.

تم اختبار مبيد الانتراكول و مبيد الميلودى ديو و ذلك بتحضير ثلاثة تركيزات مختلفة من كل مبيد و قياس فعالية هذة التركيزات على تقليل نسبة المرض ، شدة المرض و زيادة الانتاجية (الكم و النوع) بالنسبة لمحصولى البطاطس و الطماطم.

بالنسبة لمحصول البطاطس ، اثبت اعلى تركيزلمبيد الانتراكول(0.6 كجم /فدان) فعاليتة فى تقليل نسبة المرض ، شدة المرض(موسم 2001 /2002)، بينما اثبتت الجرعة الموصى بها لمبيد الميلودي ديو(1 كجم /فدان) فعاليتها فى زيادة الانتاجية (موسم 2001 /2002).فى موسم 2002 /2003 اثبت مبيد الميلودى ديو(الجرعة الموصى بها، 1 كجم /فدان) فعاليتة فى تقليل نسبة المرض و شدة المرض.

اما بالنسبة لمحصول الطماطم ، صنف peto 86 موسم 2001 /2002 ، اثبت مبيد الميلودى ديو(اعلى تركيز ، 125 كجم /فدان) فعاليتة فى تقليل شدة المرض و خفض نسبة

الثمار المصابة، اما اقل تركيز من نفس المبيد(75 كجم /فدان) اثبت فعاليتة فى زيادة الانتاجية.فى موسم 2002 /2003 اثبت مبيد الميلودى ديو (الجرعة الموصى بها ،1 كجم /فدان) فعاليتة فى خفض نسبة المرض و شدة المرض. بينما اثبت مبيد الانتراكول (الجرعة الموصى بها ،5 كجم /فدان) فعاليتة فى زيادة الانتاجية،واعلى تركيز من المبيد(6 كجم /فدان) اثبت فعاليتة فى تقليل نسبة الثمار المصابة.

بالنسبة لصنف Strain B ،موسم 2002 /2003 اثبت مبيد الميلودى ديو (الجرعة الموصى بها ،1 كجم/فدان) فعاليتة فى تقليل نسبة المرض. اما اقل تركيز (75 كجم /فدان) فقد اثبت فعاليتة فى زيادة الانتاج (الكم و النوع).

اما اعلى تركيز من مبيد الانتراكول (6 كجم /فدان) فقد اثبت فعاليتة فى تقليل نسبة المرض.

CHAPTER ONE

INTRODUCTION

1.1 The Economic Importance Of Potato

Potatoes *(Solanum tuberosum* L.*)* belong to the family solanaceae. It is the fourth- ranked food crop used to support a growing world population because of cultivars versatility and high complex carbohydrate content (Secor and Gudmestad, 1999). It originated in the Andes mountains of South America. The Inca Indians were the first who cultivated the potatoes in 200 B.C. They introduced it into Spain from where it spread into Italy and then, into central Europe. Gradually, it became a staple food crop in Europe, especially in Germany, Russia, and Ireland (Rich, 1983).

China is currently the world's largest producer of potatoes, with a market share of over 20% of total world production. In 2001, the world's production amounted to 307.9 million metric tons (MMT) of potatoes (Skorburg, 2002)**.

1.2 Potatoes Production In Sudan

The potatoes were introduced into the Sudan by the British in the early 20th century. Initially, it was grown as a home-garden vegetable for the expatriates. Expansion of production occurred around army posts during the first and second world wars in an effort to augment British army rations. This expansion was accompanied by agricultural research in both the northern and southern parts of the country, although these efforts were somewhat disjointed. The first recorded importation of seed was in 1939 from India. Subsequent importation was from Kenya. Systemic research started from the early 1960$^{'s}$. Although potato is not a major food crop in Sudan, demand has increased steadily since independence (Information on Potato Production in Sudan)**.

The main producing areas of potatoes are, north of Khartoum, Jebal Marra and Kassala. In Khartoum and Kassala, potatoes are primarily a winter crop.

Planting takes place between the beginning of November and the first week of December. The harvest is 3 to 4 months later. Late planting may cause substantial decrease in yield due to high temperatures in March and April and infestation by Aphids.

Two potato crops per year are grown around Jebal Marra. The winter crop, under irrigation, coincides with the Khartoum crop. A second planting is made during the rainy season in June or July, depending on the rains, and harvested about 3 months later (Information on Potato Production in Sudan)**.

Certified seed potatoes, mainly Alpha [predominant cultivar around Khartoum], are imported from the Netherlands each year. But, because of the limited volume and high prices they are only available to a relatively small proportion of farmers. Moreover, the imported seed usually arrives late in the season due to congestion at Port Sudan (sea port) and lack of reliable transport, and consequently yields are often depressed.

Most farmers due to high cost of imported tubers store some of their yield and use it as planting material. Usually each tuber is cut into 2-4 pieces. The failure to take the necessary sanitary precautions during the cutting of tubers lead to contamination by various viruses and other pathogens. This is especially true in Jebal Marra where little or no certified seed is used e.g., PVY and PLRV (Information on Potato Production in Sudan)**

1.3 The Economic Importance Of Tomatoes

Tomatoes, (*Lycopersicon esculentum* Mill.), belong to the family solanaceae. It is a major vegetable crop that has achieved tremendous popularity over the last century. It is grown almost in every country of the world in outdoor fields, green houses and nethouses. The tomato plant is very versatile and the crop can be divided into two categories; fresh market tomatoes and processing tomatoes. In both cases, world production and consumption has grown quite rapidly over the past 25 years (Wener, 2000)**.

Tomatoes are good source of vitamins A and C, a fact that is becoming more important in modern diets (Wenar, 2000)**. Originally, tomatoes are cultivated by the Aztecs and Incas as early as 700A.D. The tomato is a native of the Americas. The Europeans were the first who were aware of tomato as a nutritive crop, when explorers brought back to Europe seeds from Mexico and Central America in the 16th century. Tomatoes were in use across America; and today the tomato is generally considered to be the favourite vegetable of the world public (Davenport, 2003)**.

World production of tomatoes for processing is expected to reach 22.3 Million tons in 0002/0003, up 9 percent from the previous year. The United States produces approximately 46 percent of all the tomatoes for processing produced worldwide (World Horticultural Trade & U.S Export Opportunities)**.

1.4 Tomato Production In Sudan

In Sudan, tomato is gaining importance and its consumption has increased tremendously. The fruits are consumed fresh, as paste, dried, or cooked. The crop is still grown mainly by small farmers and it represents one of their main crops. The area cultivated with tomatoes has increased from 16330 hectare in 1989 to 96100 hectare in the year 1996 with corresponding production of 144020 Mt to 1169380 Mt, respectively (Anon., 1997).

1.5 The Economic Importance Of The Disease

The occurrence of early blight disease *Alternaria solani* (Ell. And Mart.) is considerably observed mainly on three crops. These were: potato, tomato, eggplants and perennial plant species namely, *Datura sp*. and *Ipomea sp*. (ELTayeb, 1989).

The incidence of early blight disease on potato plants raised from uncertified seeds was two folds the incidence of disease recorded on potato plants raised from certified seeds at Shambat and WadRamli (ELTayeb, 1989).

A yield reduction of 40-60% was attributed to the disease. Major insect pests include termites, cutworms, boll worms, aphids, white flies and tuber moth. In addition, locally multiplied planting material degenerates rapidly. In the Khartoum region the periodic introduction of imported seed potatoes alleviates these problems slightly.

The present study was undertaken with the following objectives: -

1. To study the efficacy of Melody Duo and Antracol fungicides on Early Blight Disease.
2. To determine the appropriate lethal dose.
3. To study the efficacy of both fungicides on the yield quantitatively and qualitatively.

CHAPTER TWO
LITERATURE REVIEW

Rich (1983) reported that the potato crop is susceptible to many diseases, some of which are wide spread, and others are localized. The causal agents of these diseases include bacteria, fungi, viruses, mycoplasmas, viroids, and nematodes. Another group of disorders, called non-infectious diseases, include those due to unfavorable environment, faulty nutrition, or other abiotic factors. Late blight disease caused by the fungus *Phytophthora infestans*, is an example of a disease which can ruin the crop (Rich, 1983).

2.1 Economic Importance of the Disease

Early blight is a very common disease of both potatoes and tomatoes. Ellis and Martin first described the early blight pathogen in 1882 from dying leaves of potatoes collected in New Jersey. The most critical early work was that of Jones at Vermont during the period from about 1891 to 1903. Tubers rot due to early blight disease was overlooked until 1925 (Walker, 1952). It causes leaf spots and tubers blight on potatoes, and leaf spot, fruit rot or stem lesions on tomatoes. The disease can occur over a wide range of climatic conditions [Africa, Asia, Australia, Europe, and America] (Miller and Pollard, 1976). Probably it occurs almost everywhere when potatoes are grown. Developement of the disease is favored by mild temperature (24-29 ºC) although it can develope at higher temperature and rainy weather. The disease progresses most rapidly when alternating periods of dry and wet weather prevail. It is also more severe on plants under stress and significantly milder on plants grown under conditions of high soil fertility (Early blight of potato)**. The disease can be destructive if left uncontrolled, often resulting in complete defoliation of plant. In contrast to the name, it rarely developes early, but appears on mature foliage (Randall, *et al*)**.

The disease has been under-rated in contrast to the more spectacular late blight disease. However, in many areas the average annual loss from this disease exceeds the losses from late blight. Severe epidemics of early blight may reduce potato and tomato yields by as much as 20 – 30% (Blackinski, *et al* 1996). Stevenson, (1994) reported 18 –39 % increase in yield in well –sprayed areas.

2.2 Symptoms

On leaves of both crops (potatoes and tomatoes), the first symptoms usually appear on older leaves and consist of small, irregular, dark brown to black spots. As the spots enlarge, concentric rings may form as a result of irregular growth patterns of the pathogen. This gives the lesion a characteristic " target-spot" or " bull's eye" appearance. There is often a narrow, yellow halo around each spot. Lesions are usually boarded by veins. When spots are numerous, they may grow together, causing infected leaves to turn yellow and die. Usually the oldest leaves become infected first and they dry up and drop from the plant as the disease progresses up the main stem (Randall *et.al*)

On tomato, stem infections can occur at any age resulting in small, dark, slightly sunken areas that enlarge to form circular or elongated spots with lighter-colored centers. Concentric marking similar to those on leaves often developes on stem lesions. If infected seeds are used to start tomato transplants, seedlings may damp off soon after emergence. When large lesions develope at the ground line on stem of transplants or seedlings, the plants may become girdled, a condition known as " collar rot". Such plants may die when set in the field, or if stems are weakened, may break early in the season (Randall *et.al*).

Some plants may survive with reduced root systems if portions of stems above the canker develope root where they contact the soil. Such diseased plants; however; usually produce few or no fruits. Stems lesions are much less common and destructive on potato. Blossom drop and spotting of fruit may

occur, along with loss of young fruits, when early blight attacks tomatoes at the flowering stage. On older fruits, early blight causes dark leathery sunken spots, usually at the point of stem attachment. These spots may enlarge to involve the entire upper portion of the fruit, often showing concentric markings like those on leaves. Affected areas may be covered with velvety black masses of spores. Fruits can also be infected in the green or ripe stage through growth cracks and other wounds. Infected fruits often drop before reaching maturity.

On potato tubers, early blight results in surface lesions that appear little darker, and vary in size. There is usually a well defined and sometimes slightly raised margin between healthy and diseased tissue. Internally, the tissue shows brown to black corky, and dry rot. Deep cracks may form in older lesions (Randall *et.al*).

2.3 Etiology

Alternaria solani (Ell. and Mart.) Jones and Grout overwinters or over-summers as chlamydospores on crop debris in or on soil and on tubers and seeds. In warmer climates it can also survive on volunteer plants as well as weed host plants. Spores are formed when temperature of 34-50 ºC (42- 48 ºC is optimum) prevail during wet weather. Wind and rain dislodge spores. Conidia serve as primary inoculum and infect plant material directly through the cuticle. Then, these conidia serve as secondary inoculum and are disseminated by wind, running water, insects, field workers and implements (Kucharek)**.

2.4 The Fungus

Alternaria solani (Ell. and Mart.) Jones and Grout belongs to the class: Deuteromycetes; order: Moniliales and the family: dematiaceae. characterized by darkly pigmented, short, simple conidiospores single or branched chains of spores (conidia), which are formed at the apex of conidiophores. Conidia are distinctive; darkly pigmented, oval with horizontal and vertical internal septa. Conidia having elongated terminal cells (“ beaks” or “tails”) are generally

pathogenic (Walker, 1952); it germinated within 1 or 2 hr. in water at temperature from 6 to 34º C, and in 35 to 45 min. at the optimum temperature of 28-30 ºC. The cardinal temperature for growth in pure culture are: Minimum 1-2º C; optimum 26-28 º C; maximum 37 - 45º C.

The fungus penetrates leaf and stem directly through the cuticle. Spots become visible under favorable conditions within 2 or 3 days. Spore production usually begins when the leaf spot is about 3 mm. diameter. Heavy dews with frequent rains seem to be essential for abundant sporulation (Walker, 1952).

2.5 Control Measures

Control of early blight is best achieved by using several measures together i.e. cultural controls with the least amount of fungicides. Although genetic resistance to *Alternaria solani* has been reported, the disease is mainly controlled by chemical sprays (Kucharek)**.

A) Chemical Control

Chlorothalonil applied at the rate of 3 litre/ ha *via* irrigation and 2 and 3 litre/ha by conventional spraying method proved efficient in combating early blight disease (Brandao, *et al* 1996).

Difenoconazole and Mancozeb at the rate of 125g/ha at the intervals of 14 days proved efficienty in controlling early blight disease (Follas *et al,* 1992)**.

B) Biological Control

Sowing of coated tomato seeds with spore of three bacteria Streptomyces spp. As antagonist before sowing, proved efficient in controlling early blight disease (El-Abyad *et al,* 1993).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Potato Crop

3.1.1 Field Experiment I

This experiment was conducted during the season 2001/0002 (November –March) at River Nile state in El Sheikhab district (115 km north of Khartoum North). It is one of the oldest and traditional potato producing regions. Its soil being clay loamy suits potato production. During winter, day and night temperatures are conducive for potato production.

3.1.2 Field Experiment II

This experiment was conducted during the season 2002/0003 (November –March) in El Seilet Scheme, east of Khartoum state. The prevailing environmental conditions are similar to those of El Sheikhab district. The soil is heavy clay; with low fertility soil and characterized by a pH over 7.

Potato cv.Alpha was used. The seeds were raised from certified seeds in the previous season and stored for seven (7) months in a cold store at temperature of 2-4 ºC.

Seven treatments were chosen for this experiment. Two chemicals were tested each was used in three concentrations in addition to the untreated control (Table 1). Knap-sack sprayer, with a capacity of 5 liters and 15 lb./ inch pressure was used. Urea fertilizer (46% N) was applied in two doses.

Table (1): The Treatments

Treatments	Designation	Dose Kg/fed.	Symbol
Antracol	Proposed Dose*	0.5	A
	25% more the proposed dose	0.6	B
	25% less than the proposed dose	0.4	C
Melody Duo	Proposed Dose. *	1	D
	25% more than the proposed dose.	1.25	E
	25% less than the proposed dose.	0.75	F
Control		################	G

* Dose which is recommended by the manufacturing company "Bayer"

Table (2): Proposed Scale of Disease Severity

Proposed dose	Designation of disease severity
0	Healthy plants
1	1 – 25% of the leaves affected*
2	26 – 50% of the leaves affected
3	51 – 75% of the leaves affected
4	76 – 100% of the leaves affected

*Affected: Displaying typical Early Blight Disease Symptoms.

Table (3) Potato Grading According To Size

Tuber size	**Length**
Large	Over 6 cm
Medium	3 – 6 cm
Small	3 cm

3.1.3 Cultural Practices

The experimental field was prepared by ploughing, harrowing, leveling by a leveler throughout the field and redging. Blocks were accomplished by assigning every 14 ridges together.

The ridge length was four (4) meters, the space between ridges was 70 cm and the inter-row spacing was 20 cm. The sowing was in mid-November. Medium size tubers were chosen for the experiment. Each tuber was cut longitudinally into two halves, and was sown one piece per hole and immediately irrigated. Irrigation schedule was as follows:

Plant age	Intervals
1 – 40 days	Every 7 days
41 –50 days	Every 3 days (light watering)
51 – 90 days	Every 7 days
91 – 100 days	No watering (drying up)

The first dose of Urea (46% N) was applied at the second watering at the rate of 80 kg/ fed. equally broadcasted manually. The second dose of urea was applied just before earth lifting (6 weeks after sowing) at the rate of 80 kg/ fed. equally broadcasted manually . Hand weeding was done every two weeks.

3.1.4 The Treatments

The first spray was performed 10 weeks after sowing for each fungicide in the three concentrations. The second was two weeks afterwards. For each treatment, the plants in two (2) meter length of each ridge were harvested manually 100 days after sowing.

3.1.5 Statistical Analysis

The experimental design adopted was Complete Randomized Block Design (C.R.B.D) with four (4) replicates.

3.1.6 Observations

3.1.6.1 Disease Incidence

Disease incidence was recorded twice during the season, before the first spray (pre-spray I) and before the second spray (pre- spray II) by counting the number of diseased plants (displaying the characteristic symptoms of early blight disease). In each replicates (i.e. one ridge) the plants in holes 2 to 11 were chosen for these observations.

$$\text{percentage of disease incidence} = \frac{\text{No. of diseased plants} \times 100}{\text{Total No. of the plants}}$$

3.1.6.2 Disease Severity

Disease severity was assessed from the leaves of a whole plant. Arbitrary scale (1-4) was proposed (Table 2).

Ten plants were used for this observation. Each plant has an individual scale. Then, the disease severity was calculated using the following formula:

$$\text{Disease severity} = \frac{\text{Sum of scales of observed plants}}{\text{Total number of plants}}$$

3.1.6.3 Total Yield

Total yield was calculated by weighing the tubers of each treatment in each replicate. Ordinary balance was used (fresh weight). Before weighing, tubers were cleaned to remove the adhering soil.

3.1.6.4 Grading

The potato tubers were categorized into three sizes according to length of the tubers (Table 3).

3.2 Tomato Crop

3.2.1 Field Experiment

Two experiments were conducted at Shambat Demonstration Farm during the winter seasons 2001/0002 and 2002/0003 (November- April).

The climate of the locality has been described by Oliver (1965) as semi-arid and tropical. The mean maximum temperature is more than 40ºC. The mean minimum is 20ºC and the mean is 30ºC.Two tomato cultivars were used. These were strain B and Peto 86.

Knapsack sprayer with a capacity of 5 liters and pressure of 15 lb/inch was used. Urea fertilizer (46% N) was used in single dose.

3.2.2 Cultural Practices

The experimental field was prepared by ploughing, harrowing, and leveling. The field was divided into 56 plots. The plot size was 4X3 meters. Each plot comprised two mastabas, at 50 cm, 25cm (in the inter-row) running east west. The sowing was performed in the first week of December, on the northern side, by direct seeding, at the rate of 6-8 seeds per hole. Then, after seven (7) weeks thinning and resowing were executed. Four (4) plants were left in each hole. Two weeks after the first thinning the second thinning and resowing was performed leaving two (2) plants per hole. Irrigation was performed immediately after sowing and after each thinning at a frequency of 7-10 days then after.

Urea fertilizer was applied 8 weeks after sowing at the rate of 80 kg/ fed., which was equally broadcasted manually in a single dose. Weeding was carried out manually every two - three weeks.

3.2.3 The Treatments

In the field experiment the efficacy of two fungicides claimed by Bayer Company (Germany) as effective against Early Blight Disease was assessed. These were Melody Duo and Antracol (Table1). The fungicides were applied as shown in Table 1.

The first spray of the chemicals was after 9 weeks from sowing for both fungicides in the three concentrations chosen. The second spray was as the previous one and two weeks after.

Each treatment was tested in four mastabas (4 replicates), each mastaba comprises 24-26 plants.

Harvesting of tomato crop commenced 90-100 days after sowing and continued for 4-6 weeks. Picking of tomato fruits at the ripening stage was performed every 3-7 days.

The experimental design adopted was Complete Randomized Block Design (C.R.B.D).

3.2.4 Observations

3.2.4.1 Disease Incidence

Disease incidence was assessed twice during the season, before the first spray (pre-spray I) and before the second spray (pre-spray II), by counting the number of diseased plants in each treatment (ten plant in each treatment). Then, the disease incidence was calculated as follows: -

$$\text{Percentage of disease incidence} = \frac{\text{No. of diseased plants} \times 100}{\text{Total No. of the plants}}$$

3.2.4.2 Disease Severity

Disease severity was assessed from the leaves of the whole infected plants. For this assessment, proposed scale for the disease severity in the range of 1-4 was used (Table 2). Ten plants were used for the observations. Each plant had an individual scale, and then the disease severity was calculated as follows:

$$\textbf{Disease Severity} = \frac{\text{Sum of scales of the observed plants} \times 100}{\text{Total No. of plants}}$$

3.2.4.3 Yield

Total yield was calculated by weighing the fruits of each treatment in each replicate, using ordinary balance. Then total yield was calculated as follows:

$$\text{Yield (unit area)}^{-1}\ \text{Kg} = \frac{\text{Total Yield}}{\text{Area of Mastaba}} \quad \frac{\times 10000}{1000}$$

3.2.4.4 Number of discarded fruits

The discarded fruits were calculated by counting the number of unmarketable fruits (rottened and small fruits) by using the following formula:

$$\text{Percentage of discarded fruits} = \frac{\text{Total No. of discarded fruits} \times 100}{\text{Total No. of fruits}}$$

CHAPTER FOUR

RESULTS

4.1 Early Blight Symptoms

Symptoms progressed from lower to upper leaves. Leaf spots began as small brown areas. These areas enlarged and were surrounded by a border of yellow host tissue. As the spots matured, concentric rings of raised and depressed brown tissue were evident (Plates 1 and 2). Heavily infected plants often become defoliated. On tomato, this often results in sun scald fruit. Tomato fruit, both green and ripe, may also become infected with the fungus (Plates 3 and 4). Infection generally begins at the calyx end. Brown leathery areas were formed at infection sites. They contained the same concentric rings found in leaf spots. A mass of black spores may be evident on fruit lesions when ideal weather conditions exist. Tuber lesions were characterized by dark sunken lesions that were circular or irregular in shape. Lesions are bordered by raised area of tissue that has a blue-black to purplish discoloration. The flesh below the lesion was brown and had a corky or leathery texture. Lesions may continue to develope in storage and tubers may become shriveled. In less common instances, young plants, primarily tomatoes, may be affected. Stem infections on these plants may girdle the stem, causing premature death.

4.2 Potato Crop

4.2.1 Early Blight Disease Incidence

I. Pre-spray I

The results in Figure 1 and 2, and Appendix Table 1 and 2, revealed the disease incidence recorded just before spray I in season 2001/2002 and 2002/2003, respectively. Mean disease incidence in the range of 63.39%-45% and 22.50%-10% were recorded from the seasons 2001/2002 and 2002/2003, respectively.

Plate (1a): Tomato leaf showing typical early blight disease symptoms

Plate (1b): Healthy tomato leaf

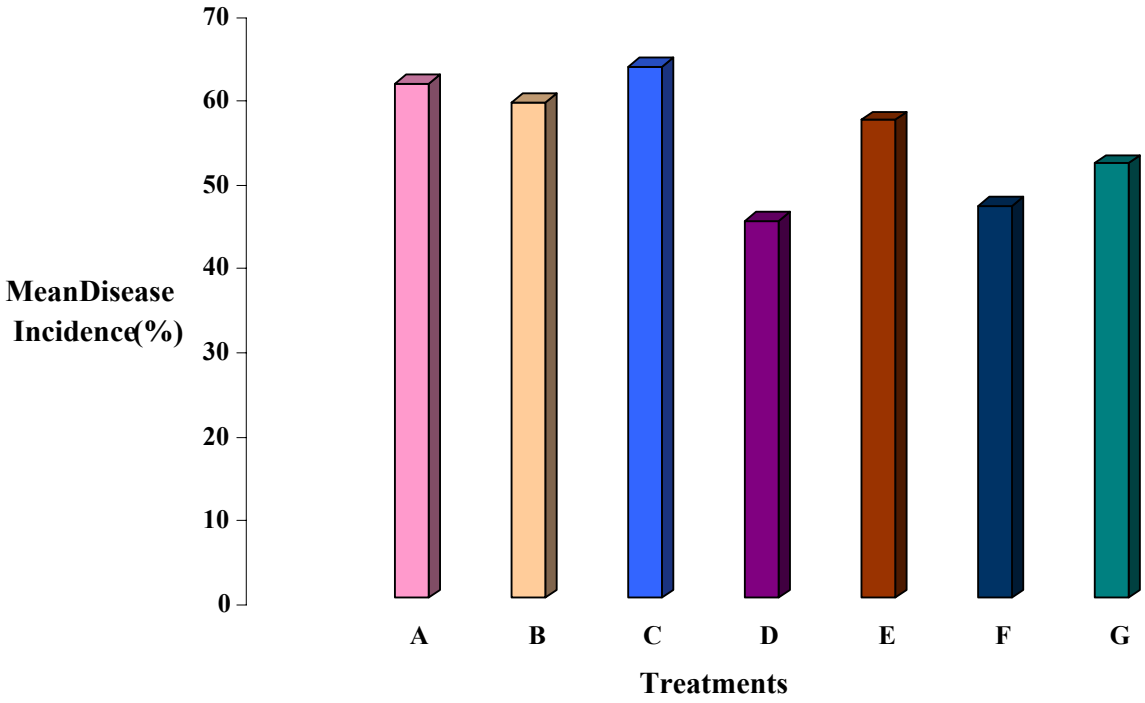
Plate (2a): Tomato branch with early blight infected leaves

Plate (2b): Tomato branch, healthy leaves

Plate (3) Healthy (above) Tomato Fruits and Rottened (bottom) Tomato Fruits

Plate (4 a): Rottened tomato fruits infected with early blight Disease

Plate (4.b): Infected Tomato Fruit (on the Left) and Healthy Tomato Fruit (on the Right)



Figure(1): Mean Disease Incidence (%) in potato cv. Alpha (Season 2001/0002) pre-spray I

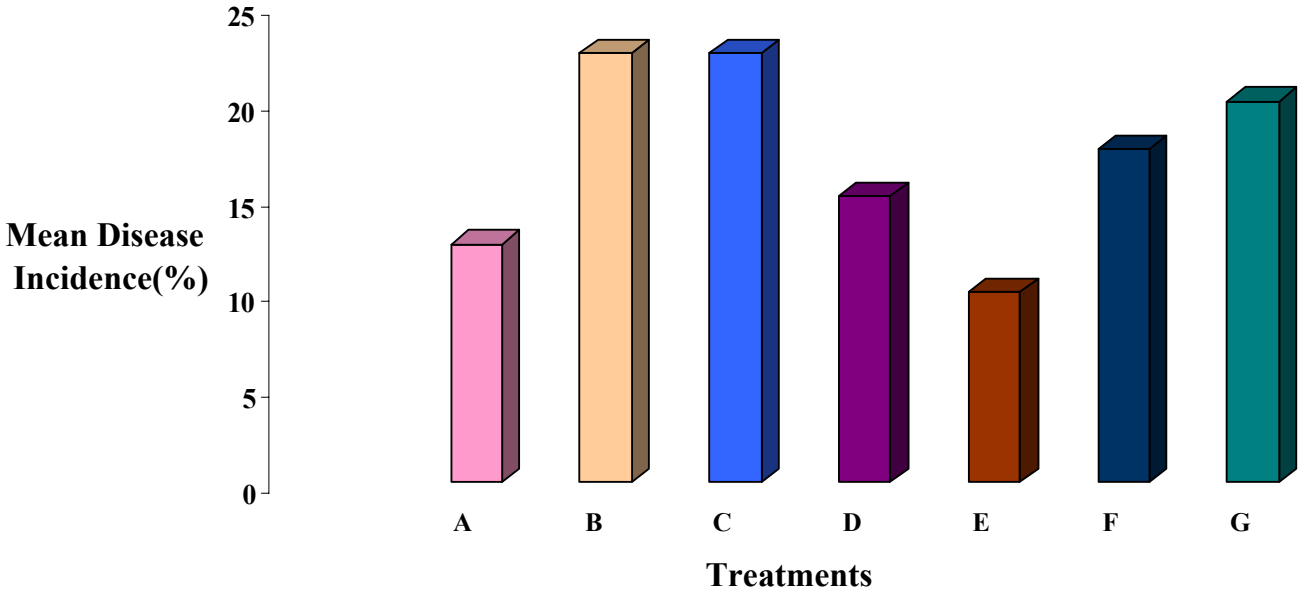


Figure (2): Mean Disease Incidence (%) in Potato cv. Alpha (Season 2002/0003) Pre-spray I

II. Pre-spray II

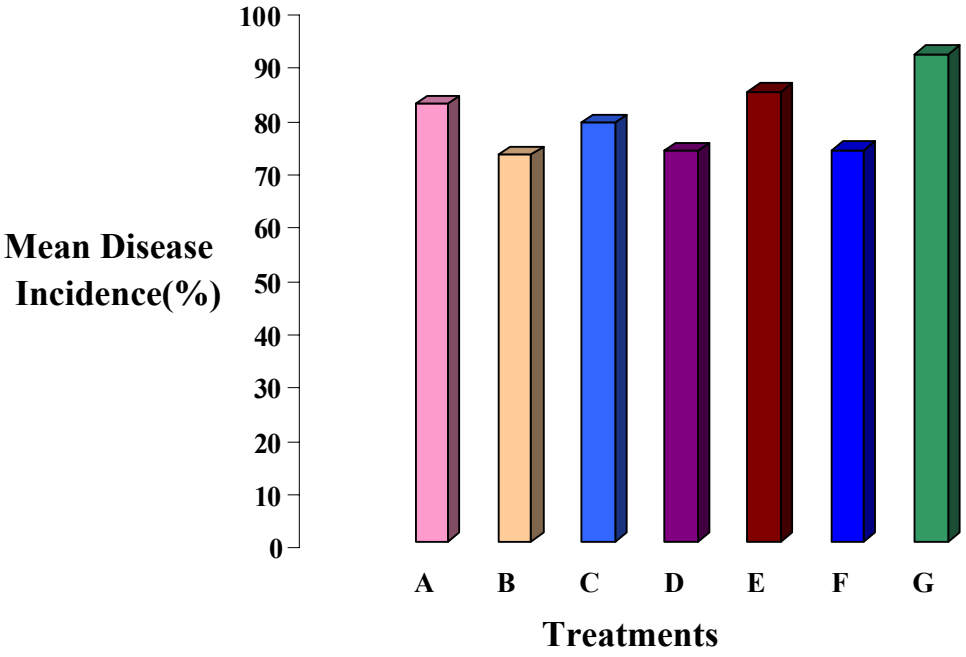
Two weeks after application of the fungicides *viz*. Antracol and Melody Duo at the different concentrations, the disease incidence in the seven (7) treatments were shown in Figures 3 and 4 and Appendix Tables 3 and 4 for seasons 2001/0002 and 2002/2003. The results showed that the use of both fungicides at the three concentrations chosen reduced the disease incidence in comparison with the control. The highest disease incidences of 91.43% and 77.50% were recorded in the control treatments in season 2001/0002 and 2002/2003 respectively. By contrast, the least disease incidence of 72.62% and 27.50% were recorded when Antracol at concentration of 0.06 kg/fed. and when Melody Duo at concentration of 1 kg/fed. were used. Within the Antracol treatments, the least percentage of disease incidence increase of 22.98%-33.93% and 155.56%-260% were recorded in comparison with the control treatments.

Within the Melody treatments the least percentage of disease incidence increase of 48.27%-62.96% and 83.33%-250% in season 2001/2002 and 2002/2003 respectively, were recorded in comparison with the control treatment.

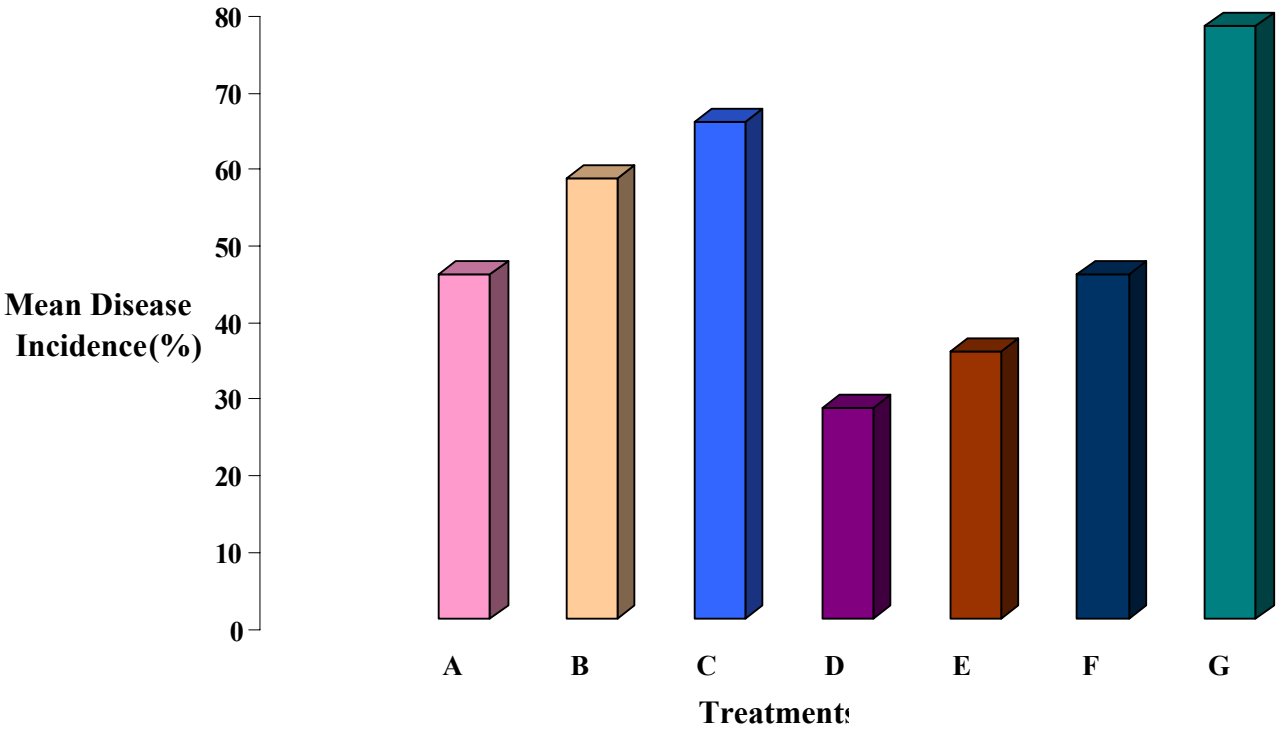
The statistical analysis revealed no significant difference between the different concentrations used of each treatment in season 2001/2002. In season 2002/2003 the statistical analysis showed that the use of both fungicides significantly reduced the disease incidence.

4.2.2 Disease Severity

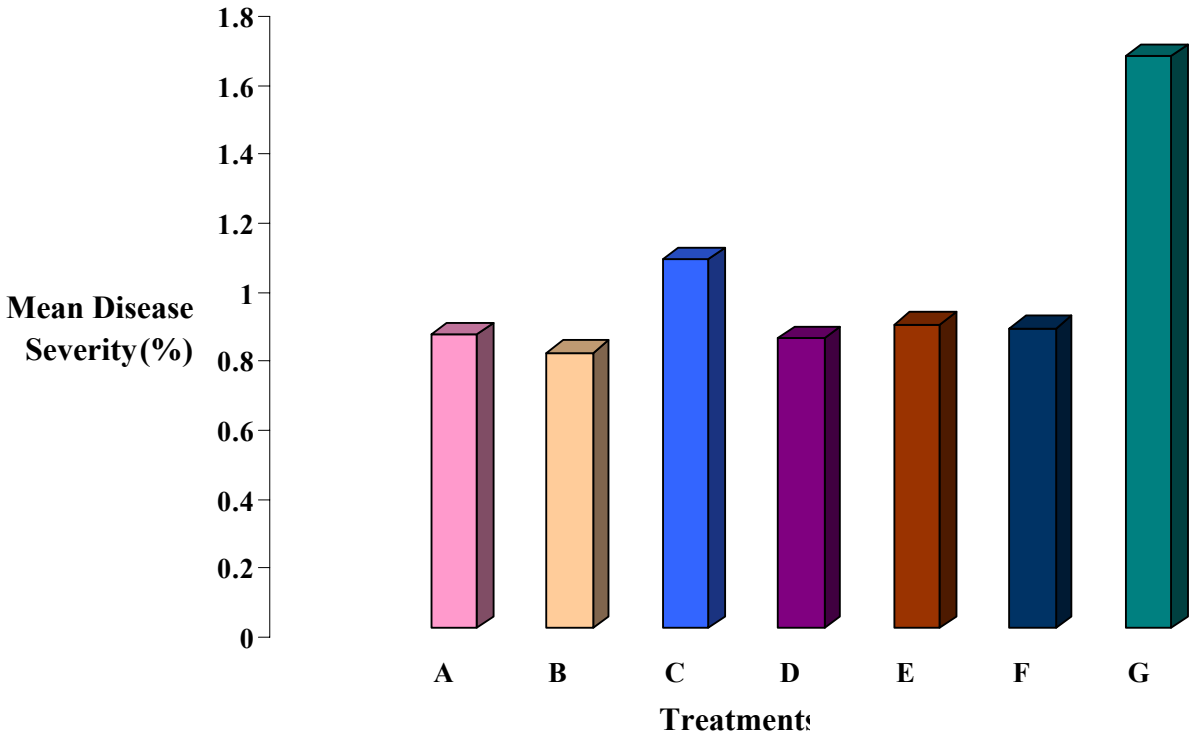
The results in Figures 5 and 6, and Appendix Tables 5 and 6 showed the severity of the disease, two weeks after spray II. The highest disease severity of 1.70% and 1.80% were recorded in the control treatments in seasons 2001/0002 and 2002/003, respectively. By contrast, the least disease severity of 0.8 and 1.33% were recorded when Antracol at the concentration of 0.6 kg/ Fed. and Melody at the concentration of 1 kg/fed. were used in the season 2001/0002 and 2002/2003 respectively.



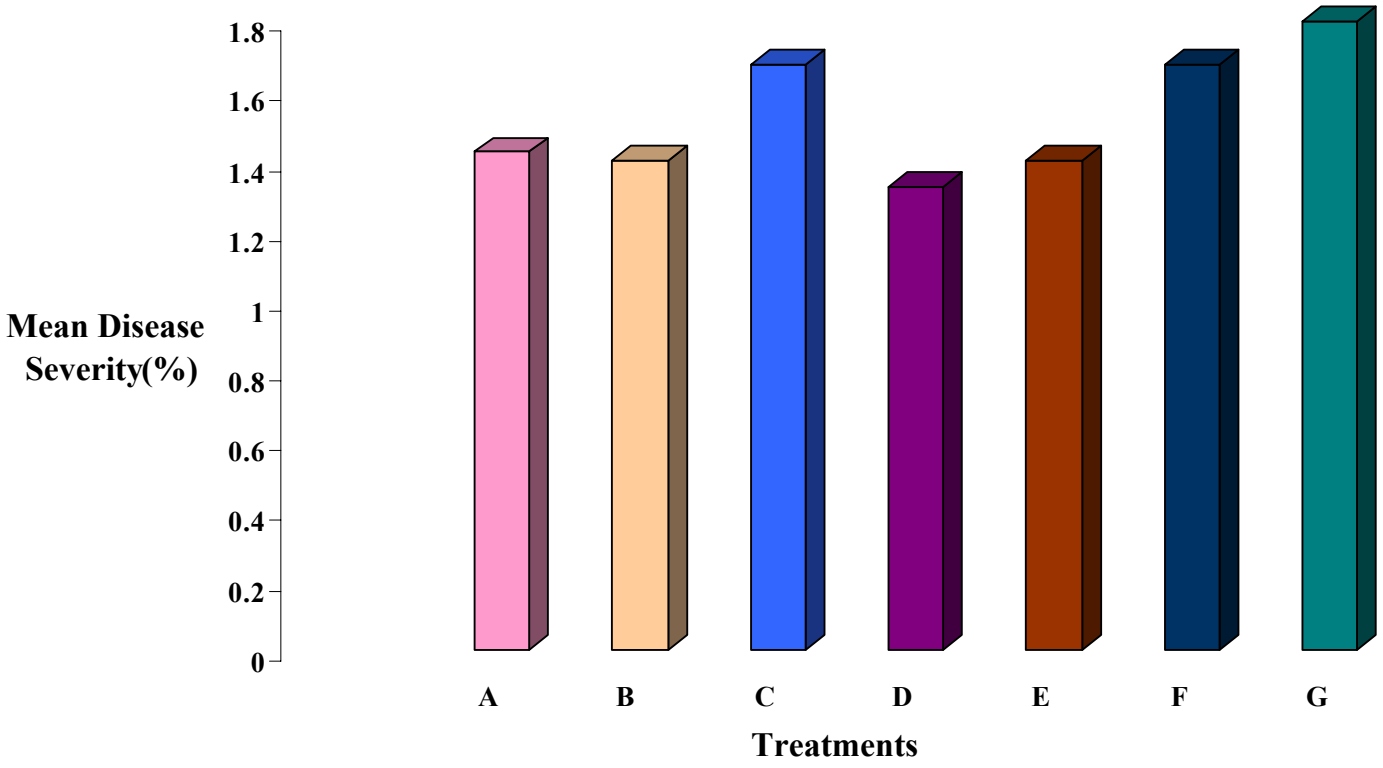
Figure(3): Mean Disease Incidence (%) in potato crop cv. Alpha (Season 2001/0002) pre-spray II



Figure(4): Mean Disease Incidence (%) in Potato cv. Alpha (Season 2002/0003) Pre-spray II



Figure(5): Mean Disease Severity (%) in Potato cv. Alpha (Season 2001/0002)



Figure(6): Mean Severity(%) in Potato cv. Alpha (Season 2002/0003)

The statistical analysis showed no significant difference between the different concentrations used from each fungicide in both seasons.

4.2.3 Yield

4.2.3.1 Total Yield

The results in Figure 7 and Appendix 7 revealed that the use of both fungicides at different concentrations (i.e. Antracol and Melody Duo) increased the yield in five (5) treatments out of six (6) treatments in comparison with the control. Variable percentages of increase ranging from 3.07 to 17.14% were detected. In Antracol treatments, the use of proposed dose resulted in the least increase in yield of 3.07%. In the treatment whereby the highest percentage of increase of 10.23 was recorded when the highest dose of Antracol was used(0.6 kg/fed.) Furthermore, the use of the least does of 0.4 kg/fed. of Antracol resulted in 7.16% increase.

Within Melody Duo treatments, similar yield was recorded for treatment of 1.25 kg/fed. and the control treatment. The use of the proposed dose resulted in the highest percentage of increase of (+17.14%). The least percentage of increase of (+ 4.60%) was recorded when Melody Duo in the least dose of 0.75 kg /fed. was used. Although noticeable increases due to the use of both fungicides were recorded no significant differences in yield was detected between the treatments.

4.2.3.2 Grading

The results in Appendix Table 8 showed the effect of the different treatments on the size of the tubers. The results revealed that the use of both fungicides at different concentrations increased the marketable portion 3.20% - 16.6% in five (5) treatments out of six (6) treatments in comparison with the control.

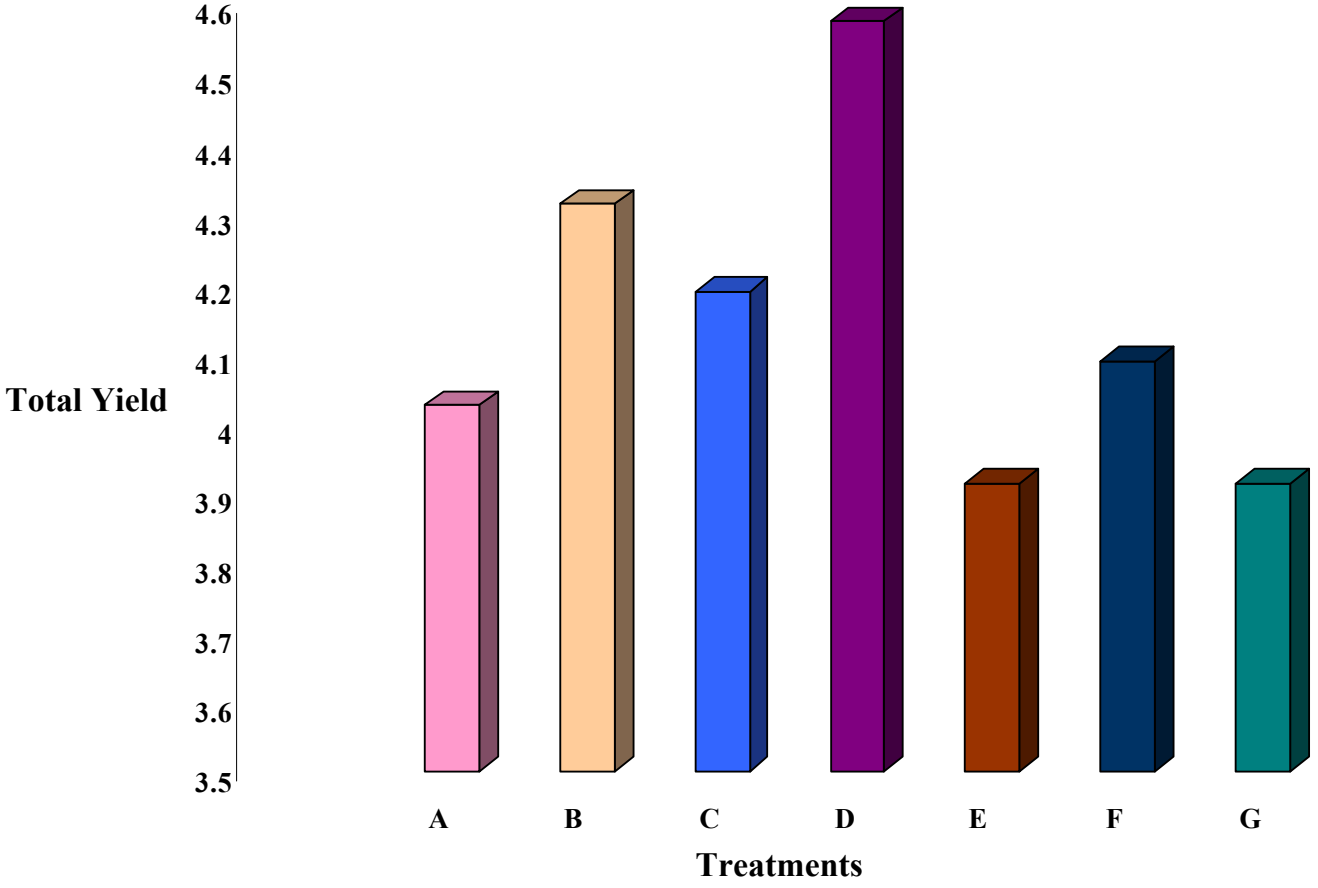


Figure (7): Total Yield in Potato cv. Alpha (Season 2001/0002)

The highest increase of marketable portion of 16.60% was recorded when Antracol at the concentration of 0.5 kg/fed. was used. By contrast, the least increase of marketable portion of 3.20% was recorded when Antracol at the concentration of 0.38 kg/fed. was used.

4.3 Tomato Experiments

4.3.1 Tomato Variety Peto 86

4.3.1.1 Early Blight Disease Incidence

I. Pre-spray I

The results in Figures 8 and 9. and Appendix Tables 9 and 10 revealed the disease incidences recorded just before spray I in season 2001 / 0002 and 0002 /0003 respectively. Mean disease incidences in the range of 92.50 % - 77.50% and 57.50 % - 50% were recorded for the seasons 2001 / 0002 and
2002 /0003 respectively.

II. Pre –spray II

Two weeks after application of the fungicides *Viz.*Antracol and Melody Duo at the different concentrations, the disease incidence in the seven (7) treatments were recorded in figure 10 and Appendix Table 11 for the seasons 2001 /0002 and 2002 /0003.

The results in the season 2001 /0002 showed 100% Disease incidence for all treatments.

The results in the season 2002 /0003 showed that the use of both fungicides at the three concentrations chosen reduced the disease incidences in comparison with the control. The highest disease incidence of 100% was recorded in the control treatment. By contrast, the least disease incidence of 62.50 was recorded when Melody Duo at concentration of 1 Kg/ fed. was used.

Within the Antracol treatments, the least percentage increase of 33.33% - 17.65% was recorded in comparison with the control treatment.

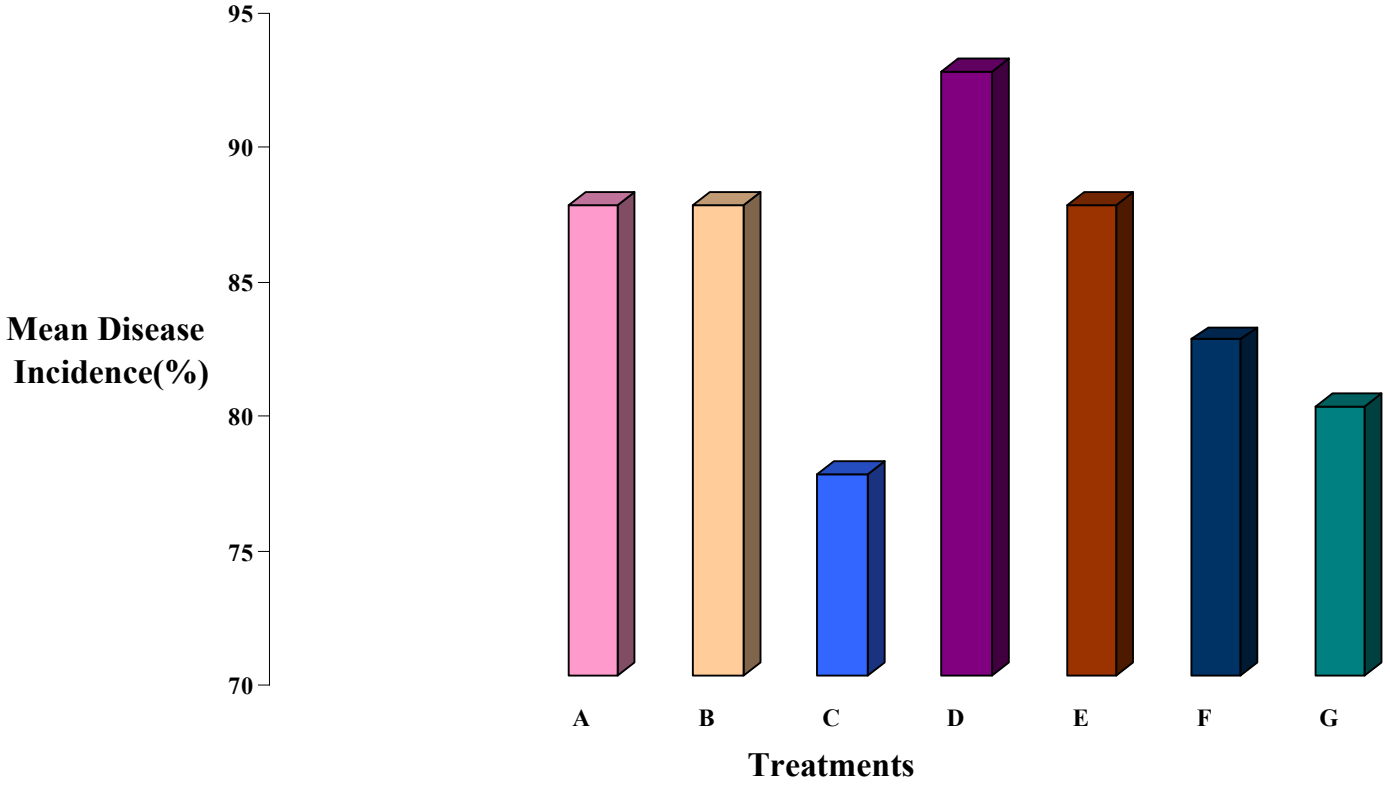


Figure (8): Mean Disease Incidence (%) in Tomato cv. Peto 86 (Season 2001/0002) Pre-spray I

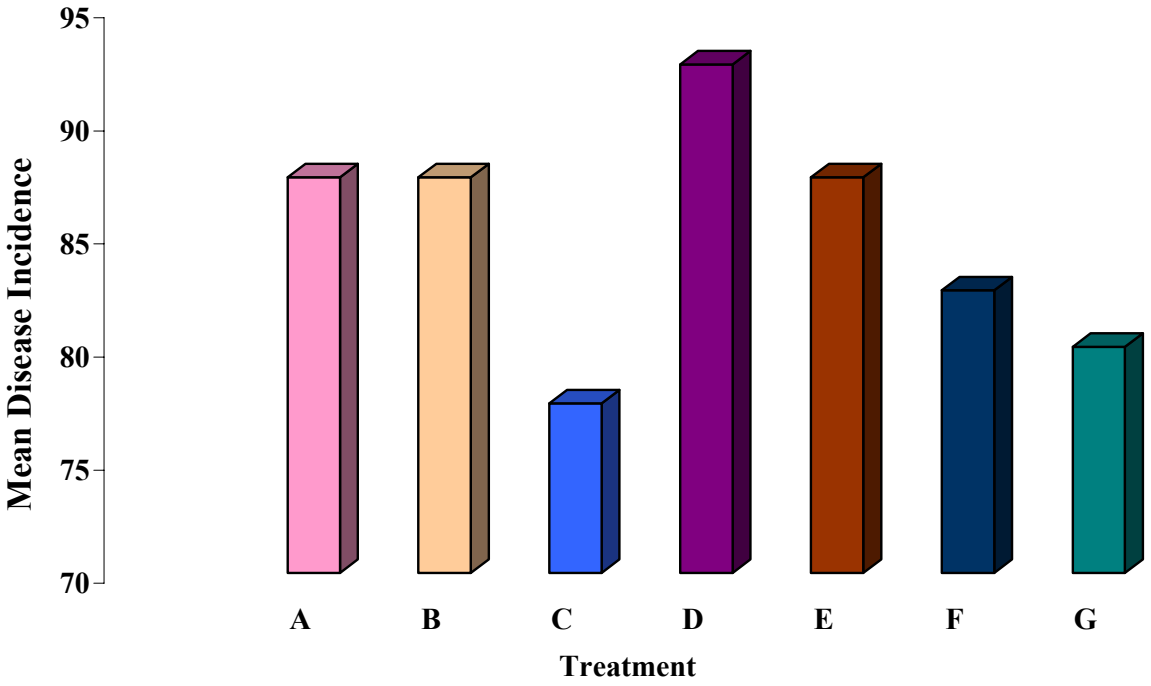
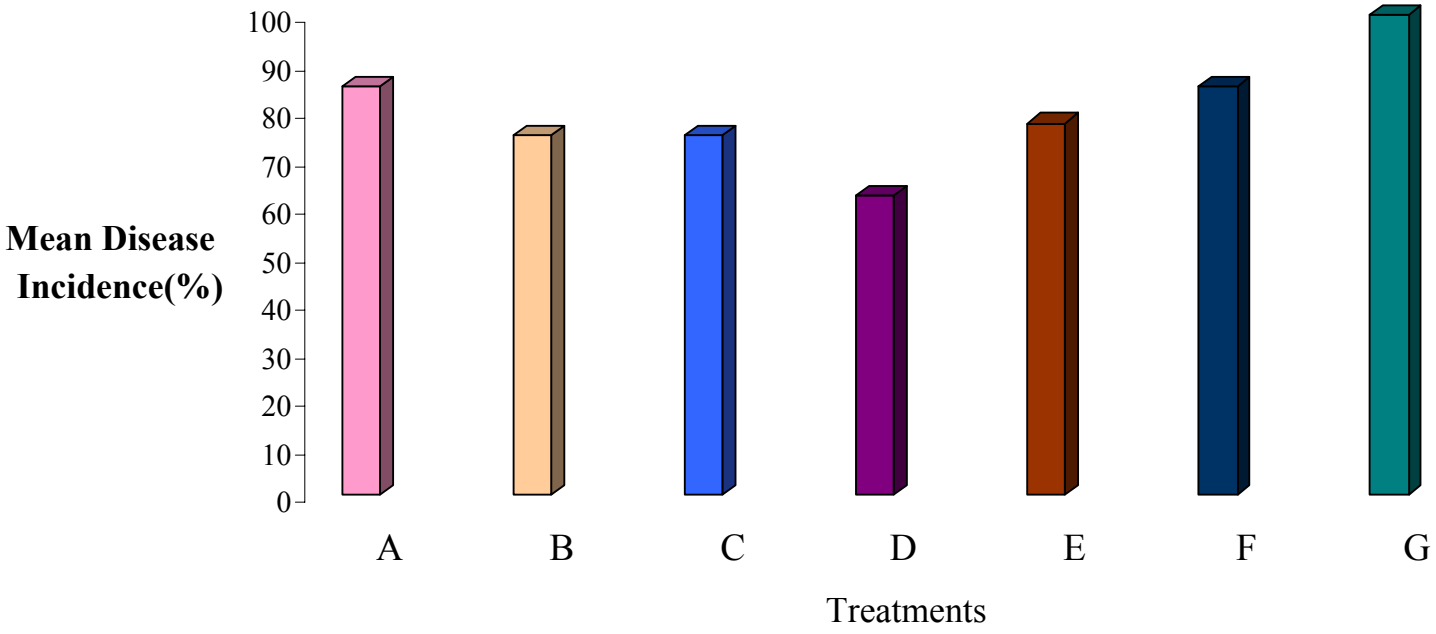


Figure (9): Mean Disease Incidence (%) in Tomato cv. Peto 86 (Season 2002 / 0003) Pre-spray I



Figure(10): Mean Disease Incidence (%) in Tomato cv. Peto 86 (Season 2002/0003) Pre-spray II

Within the Melody Duo treatments, the least percentage increase of 17.65% - 60% was recorded in comparison with the control treatment.

The statistical analysis revealed no significant difference between the different concentrations used of each treatment.

4.3.1.2 Early Blight Disease Severity

The results in Figures 11 and 12 and Appendix Tables 13 and 14, showed the severity of the disease, two weeks after the second spray. The highest disease severity of 3.13% and 1.9% were recorded when Antracol at the concentration of 0.5 Kg/fed. and at control treatment respectively for the seasons 2001 /0002 and 0002 / 0003. By contrast, the least disease severity of 2.45% and 1.20% were recorded when Melody Duo at the concentration of 1.25 Kg/fed. and 1 Kg/fed. were used for the season 2001 / 0002 and 0002 /0003 respectively.

The statistical analysis showed no significant difference between the different concentrations used of each fungicide for the (season 2001 / 0002). Furthermore, a significant difference between the treatments was detected for season 2002/0003

4.3.1.3 Yield

4.3.1.3.1 Total Yield

The results in Figures 13 and 14 and Appendix Tables 14 and 15 showed the use of both fungicides in different concentrations (i.e. Antracol and Melody Duo) increase the yield in four (4) treatments out of six (6) treatments in season (2001/0002); and in five (5) treatments out of six (6) treatments in season (2002/0003).

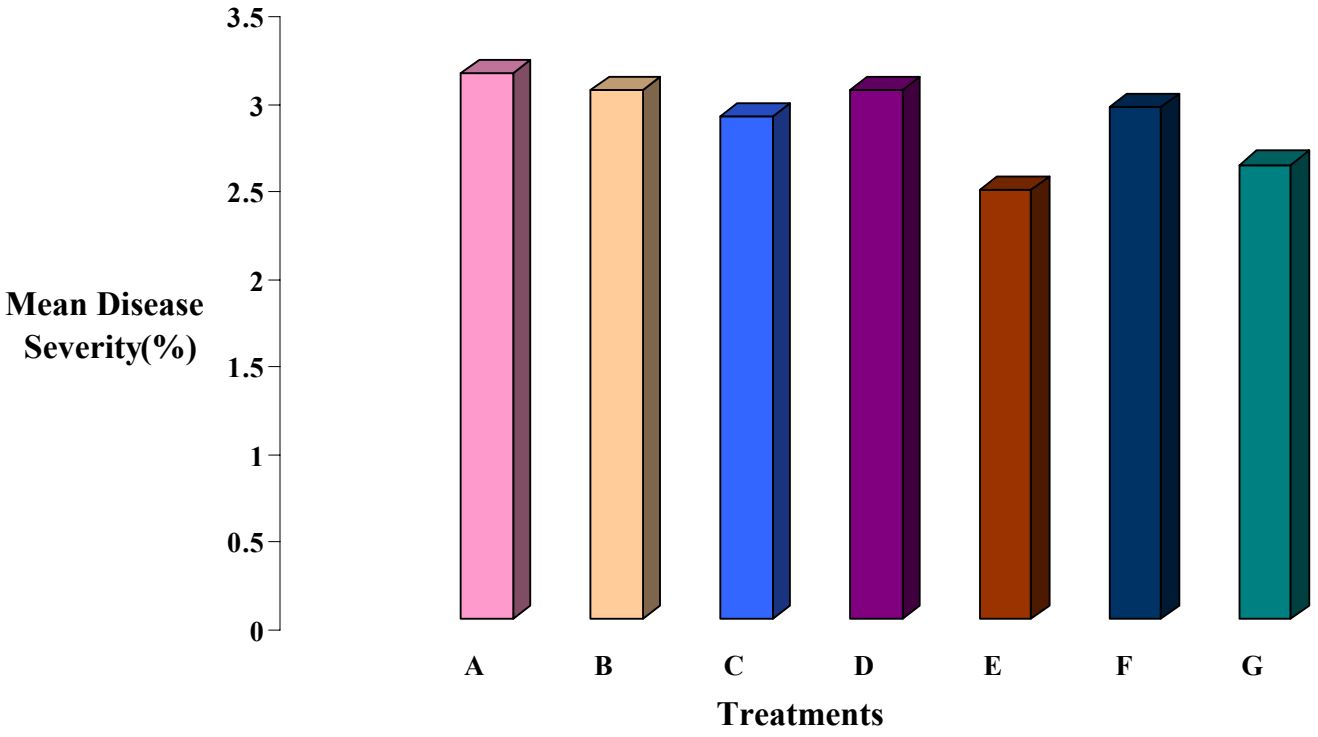


Figure (11): Mean Disease Severity (%) in Tomato cv. Peto 86 (Season2001/0002)

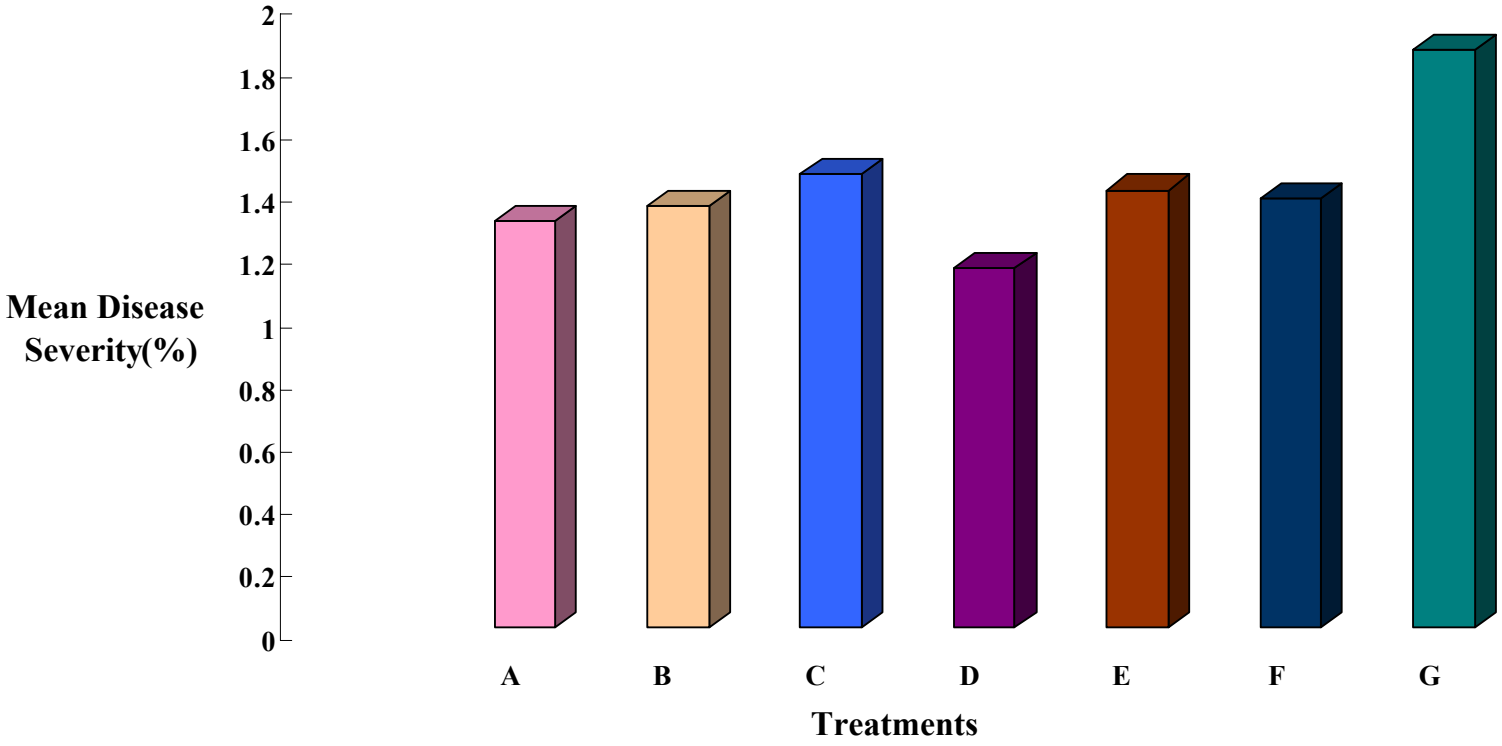


Figure (12): Mean Disease Severity (%) in Tomato cv. Peto 86 (Season 2002/0003)

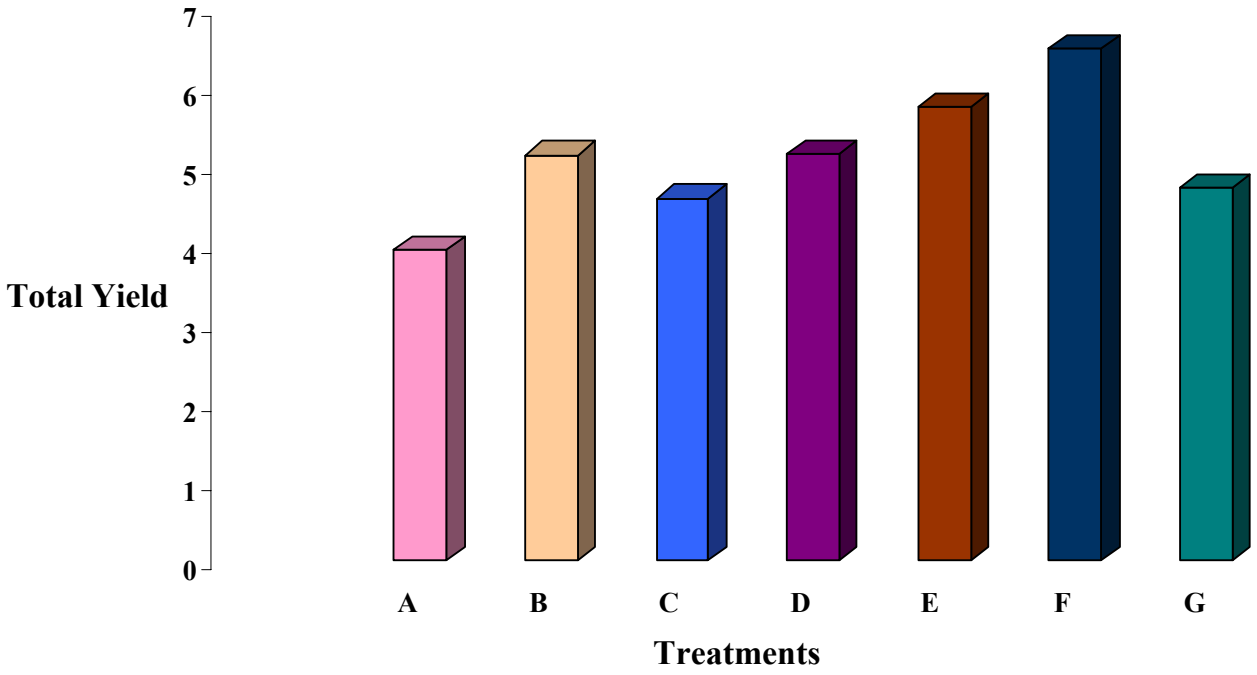


Figure (13): Yield / Area In Tomato cv. Peto 86 (Season 2001/0002)

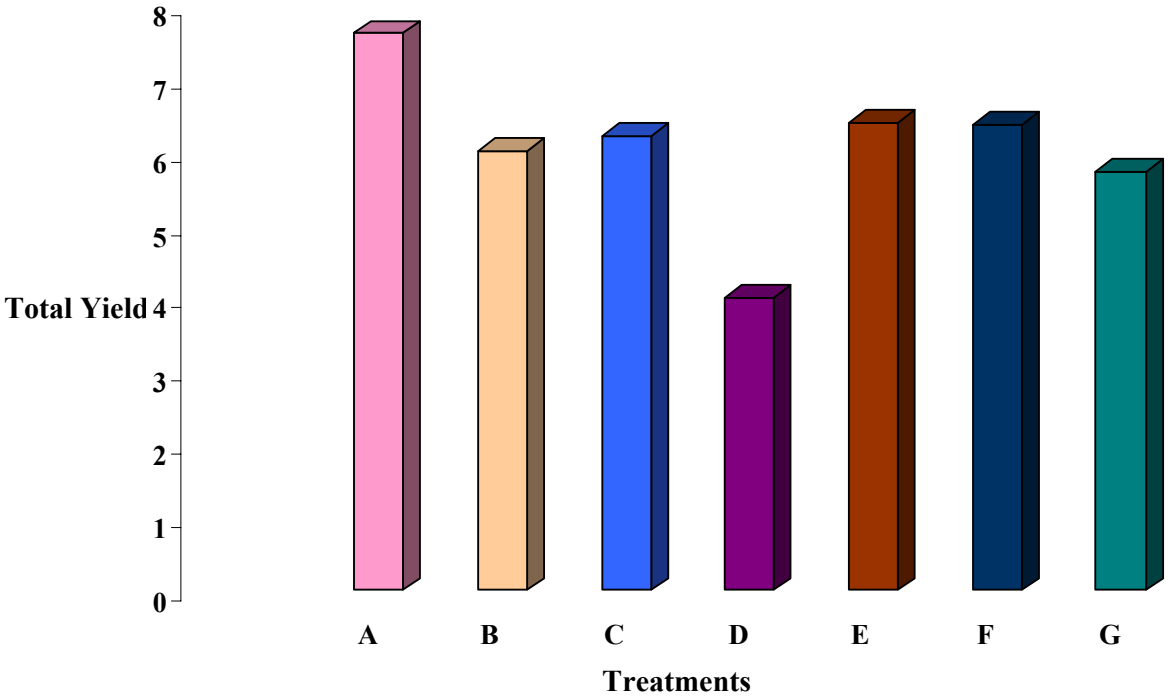


Figure (14):Yield / Area in Tomato cv. Peto 86 (Season 2002/0003)

In season (2001/0002) variable percentages of increase ranging from +9.22% to +37.53% were detected. In Antracol treatments the use of the highest dose of 0.6 Kg / fed. only increased the yield by 11.89 % in comparison with the control treatment.

Within Melody Duo treatments the use of the proposed dose of 1Kg/fed. resulted in the least increase in yield 9.22 %, whereby the least dose of 0.75 Kg /fed. resulted in the highest increase in yield 37.53%.

In season (2002/2003), variable percentage, of increase ranging from 4.87% -32.87% Within Antracol treatments. The use of the proposed dose of 1 Kg / fed. Resulted in the highest percentage of increase 32.87%, whereby the use of the highest dose of 0.6 Kg /fed. resulted in the least percentage of increase 4.87%.

The statistical analysis revealed no significant differences between different concentrations used of each fungicide and for both treatments.

4.3.1.3.2 Percentage of Discarded Fruits

The results in Appendix Tables 16 and 17, showed a noticeable decrease in discarded fruits percentage in five (5) treatments out of six (6) treatments in season (2001/0002), and in all treatments in season (2002/0003) in comparison with the control treatments.

The highest percentages of discarded fruits of 26.16% and 44.25% were recorded when Antracol was applied at the proposed dose and the control treatment in seasons (2001/0002) and (2002/0003) respectively. By contrast, the least percentages of discarded fruits of 14.56% and 29.63% were recorded when Antracol treatment at the concentration of 0.6kg/fed. was used and when Melody Duo at the concentration of 1.25kg/fed. was used for the seasons (2001/0002) and (2002/0003) respectively.

Within Antracol treatments, the least percentages of discarded fruits of discarded fruits of 21.63% -29.63% and 29.63% -33.33% were recorded in

comparison with the control treatment, for the seasons (2001/0002) and (2002/0003) respectively.

Within Melody Duo treatments, the least percentages of discarded of 14.56% - 21.17% and 34.99% - 36.33% were recorded in comparison with the control treatment for the seasons (2001/0002) and (2002/0003) respectively.

4.3.2 Tomato cultivar Strain B

4.3.2.1 Early Blight Disease Incidence

I) Pre- spray I

The results in Figure 15 and Appendix Table 18 Showed the disease incidence recorded just before spray I in season 2002/0003. Mean disease incidence in the range of 50.00% - 80.00% was recorded.

II) Pre-spray II

Two weeks after application of the fungicides *viz.* Antracol and Melody Duo at the different concentrations, the disease incidences in the seven (7) treatments were recorded in Figure 16 and Appendix Table 19 for the season 2002/0003.

The results revealed that the use of both fungicides in different concentrations reduced the disease incidence in two (2) treatments out of six (6) in comparison with the control.

The highest disease incidence of 90% was recorded when Antracol at concentration of 0.5 Kg/fed. was used. By contrast, the least percentage of disease incidence of 67.50% was recorded when Melody Duo at the concentration of 1Kg/fed. was used.

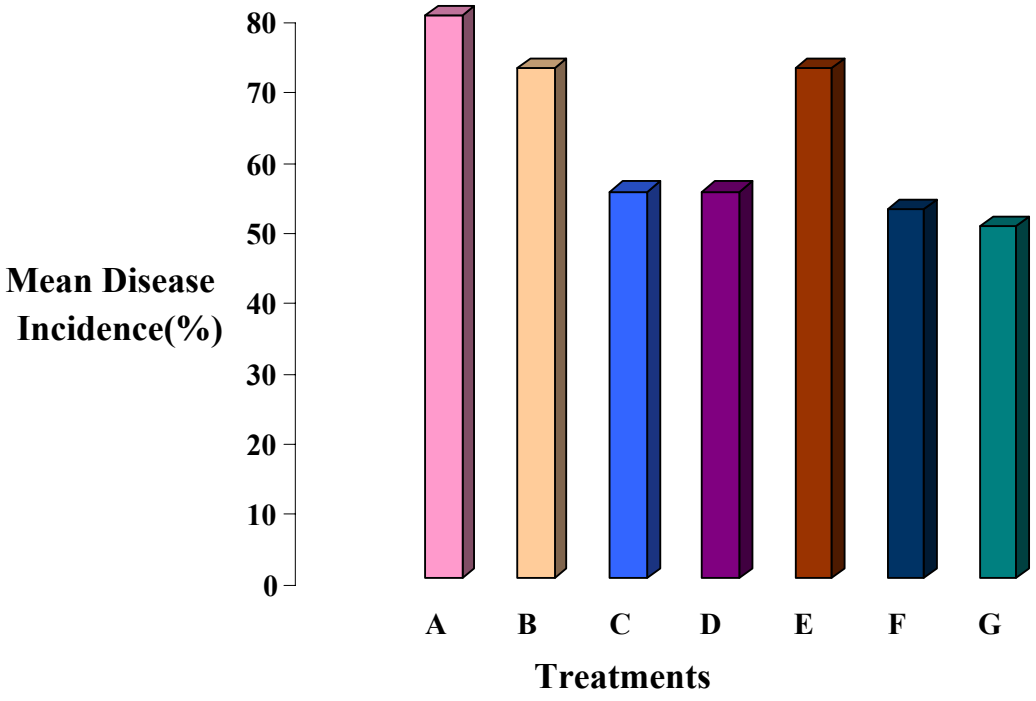


Figure (15): Mean Disease Incidence of Tomato cv. Strain B (Season 2002/0003) Pre-spray I

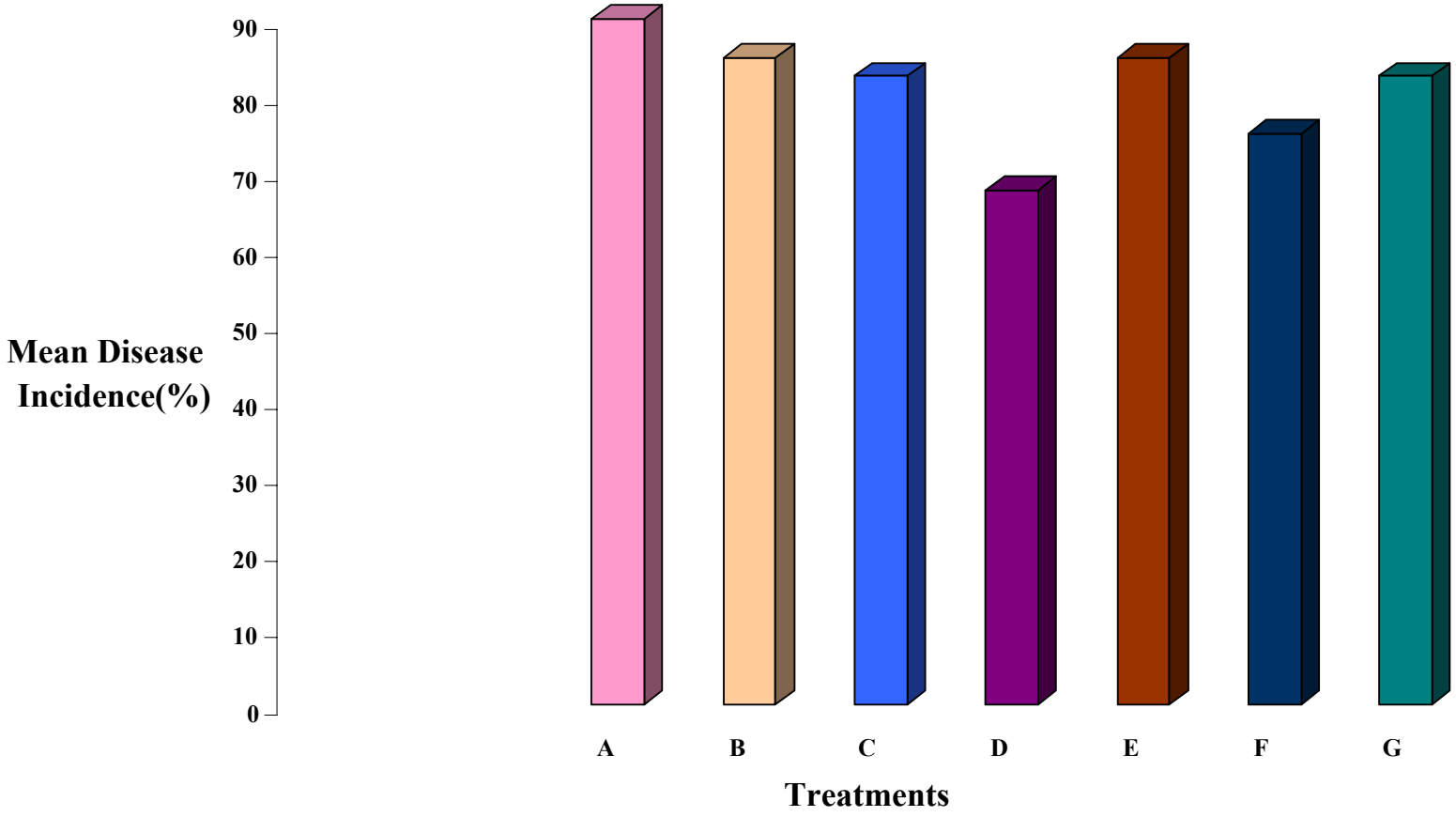


Figure (16): Mean Disease Incidence in Tomato(%) cv. Strain B (Season 2002/0003) Pre-spray II

Within the Antracol treatments, the least percentage increase of 50%- 9.09% was recorded in comparison with the control treatment.

Within Melody Duo treatments, the least percentage increase of 42.85% - 17.24% was recorded in comparison with the control treatment.

The statistical analysis revealed no significant differences between the different concentrations used of each treatment.

4.3.2.2 Disease Severity

The result in Figure (17) and Appendix Table (20) showed the severity of the disease, two weeks after the second spray. The highest disease severity of 1.78% was recorded when Melody Duo in the concentration of 1Kg/fed. was used, for the season 2002/0003. By contrast, the least disease severity of 1.03% was recorded when Antracol at the concentration of 0.6Kg/fed. was used.

The statistical analysis revealed no significant differences between the different concentrations of each treatment.

4.3.2.3 Yield

The results in Figure (18) and Appendix Table (21) showed that the use of both fungicides at different concentrations increased the yield in three (3) treatments out of six (6) treatments in comparison with the control.

4.3.2.4 Percentage of Discarded Fruits

The result in Appendix Table (22) showed that the use of both fungicides at different concentrations decreased the percentage of discarded fruits in all treatments for season (2002/0003). The least percentage of discarded fruits of 35.30% was recorded when Melody Duo at the concentration of 0.75Kg/fed. was used. By contrast, the highest percentage of discarded of 56.99% was recorded to the control treatment.

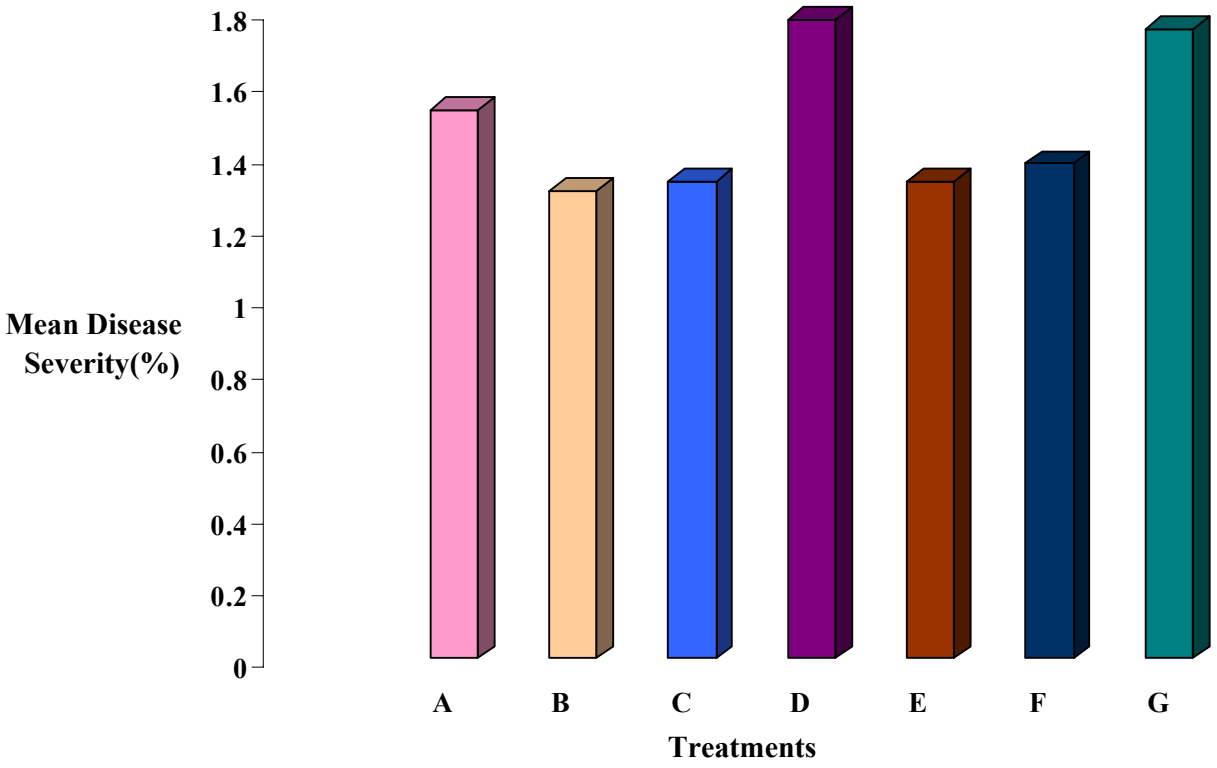


Figure (17): Mean Disease Severity (%) in Tomato cv. Strain B (Season 2002/0003)

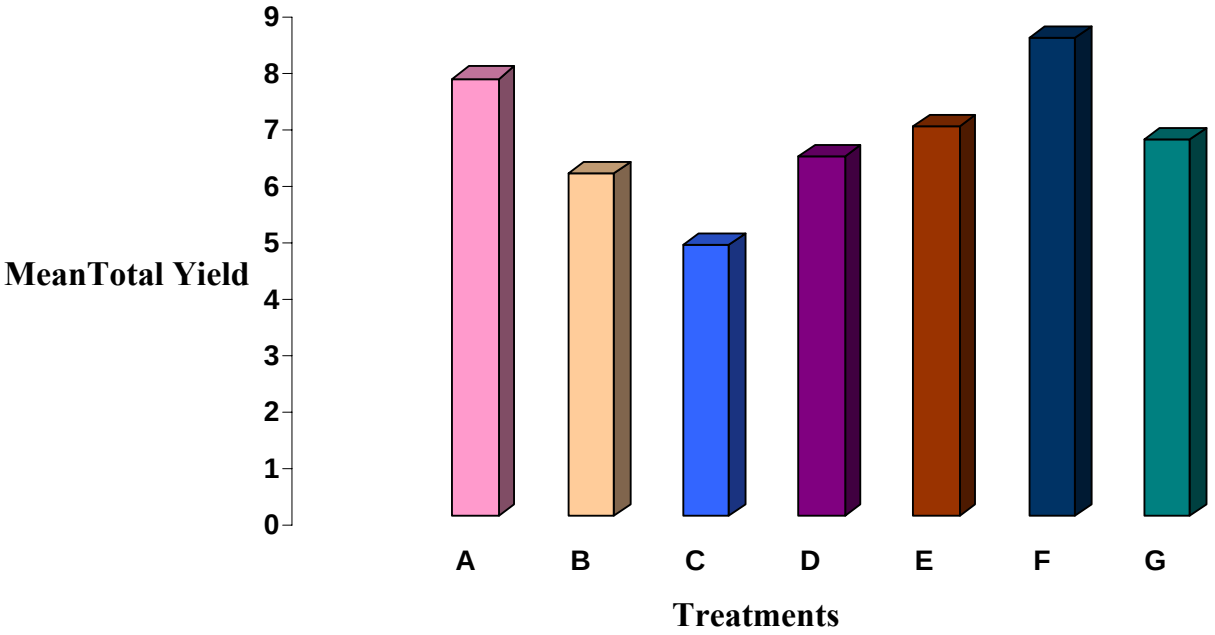


Figure (18): Total Yield in Tomato cv. Strain B (Season 2002/0003)

Within the Antracol treatments, the least percentage of discarded fruits of 39.98% - 40.17% was recoded in comparison with the control treatment for the season (2002/0003).

Within Melody Duo treatments, the least percentages of discarded of 35.3% - 40.61% were recorded in comparison with the control treatment for the season (2002/0003).

CHAPTER FIVE

DISCUSSION AND CONCULUSION

In the present study the efficacy of two fungicides *viz.* Antracol and Melody Duo was tested in an attempt to control Early Blight Disease incited by *Alternaria solani*.

The two chemicals were tested at three different concentrations i.e.0.4 Kg /fed., 0.5 Kg /fed., 0.6 Kg /fed. ; and 0.75 Kg/fed. , 1Kg /fed. and 1.25 Kg /fed. for Antracol and Melody Duo, respectively.

The two crops chosen for this study were potato cv. Alpha and tomato cv. Peto 86 and cv. Strain B.

The results concerning the disease incidence displayed on potato crop showed that the use of both fungicides at the different concentrations reduced the disease incidence. Variable reductions were recorded (Figures 3 and 4, and Appendix Tables 3and 4).

In season 2001/0002, the least disease incidence percentage of 72.62% was recorded when Antracol at the concentration of 0.6Kg /fed. was used. In the second season (2002 /0003) the least disease incidence of 27.50 % was recorded when Melody Duo at the concentration of 1 Kg /fed. was used. From these results it may be concluded that the dose of Antracol and the proposed dose by manufacturer for Melody Duo proved to be the most effective in combating the disease. Worldwide, different fungicides applied at different concentrations were recommended by different authors. Of these, Brandao *et al*, (1996) recorded that chlorothalonail applied at the rate of 3 liter /ha. *via* irrigation and 2 and 3 liter/ha. by conventional spraying method proved efficient in combating early blight disease. Similar results were recorded by Follas *et al*, (1992). They reported that Difenoconazole and Mancozeb at the rate of 125 g /ha. at the intervals of 14 days proved efficient in controlling early blight disease.

The results concerning disease severity displayed on potato crop showed that the use of both fungicides at the three concentrations reduced the disease severity. Variable reductions were recorded (Figures 5 and 6, and Appendix 5and 6).

In season (2001 /0002) the least percentage of disease severity of 0.80 % was recorded when Antracol at the concentration of 0.6 Kg /fed. was used. In the second season (2002 /0003) the least percentage of 1.33 % was recorded when Melody Duo at the concentration of 1 Kg /fed. was used. From the results it may be concluded that the highest dose of Antracol and the proposed dose by the manufacturer for the Melody Duo proved to be the most effective in combating the disease. Similar results were recorded by Platt *et al* 1993. They found that foliar application of chlorothalonail significantly reduced early blight disease.

For potato yield, the results showed that the use of both fungicides increased the yield except the concentration of 1.25 Kg /fed. of Melody Duo which resulted in similar yield to the control. Variable increases were recorded (Figure 7 and Appendix Table 7).

The highest percentage of increase of +17.14% was recorded when Melody Duo at the concentration of 1 Kg /fed. was used. From the results it may be concluded that the proposed dose by the manufacturer for Melody Duo proved to be the most effective in increasing the yield. Worldwide fungicides applied at different concentrations were recommended by different authors. Of these, Brignani – Neto – F *et al*, (1990). Who tested 11 fungicides against *Alternaria solani* on potatoes. All fungicide treatments improved the yield compared with untreated plots.

The results on the disease incidence in tomato crop cv. Peto 86 showed that the use of both fungicides at the three concentrations reduced the disease incidence in season (2002 /0003). Furthermore contradictive results were

recorded for the season (2001 /0002). Variable reductions were recorded (Figure 10 and Appendix Table 11).

The least percentage of disease incidence of 62.50 % was recorded when Melody Duo at the concentration of 1 kg / fed. was used. From the results, it may be concluded that the use of the proposed dose by the manufacturer of Melody Duo proved to be effective in controlling the disease.

The results concerning the disease severity on tomato cv. Peto 86 showed that the use of both fungicides at the three concentrations reduced the disease severity for the season 2002 /0003. Variable reductions were recorded (Figure 12 and Appendix Table 13).

The least percentage of disease incidence of (1.15%) was recorded when Melody Duo at the concentration of 1 Kg / fed. was used. From the results it may be concluded that the proposed dose by manufacturer for Melody Duo proved to be the most effective in reducing the disease severity.

In season 2001 /0002 the only reduction of disease incidence percentage 2.45 % was recorded when Melody Duo at the concentration of 1.25 Kg /fed. was used. From the results it may be concluded that the highest dose of Melody Duo proved to be the most effective in reducing the disease severity.

For tomato cv. Peto 86 yield, the results of the use of both fungicides at the three concentrations were different; some of them increased the yield, while others decreased the yield. Variable increase and decrease were recorded (Figures 13and 14, and Appendix Tables 14 and 15).

In season 2001 /0002, the highest increase of +37.53 % was recorded when Melody Duo at the concentration of 0.75 Kg /fed. was used. In season 2002 /0003 the highest increase of +32.87 % was recorded when Antracol at the concentration of 0.5 Kg /fed. was used. From the results it may be concluded that the lowest concentration for Melody Duo and the Proposed dose by the

manufacturer for Antracol proved to be the most effective in increasing the yield.

The results concerning the discarded fruits of tomato cv. Peto 86 showed that the use of both fungicides at the three concentrations decreased the percentage of discarded fruits except one concentration (the proposed dose of Antracol for the season 2001 /0002). Variable decreases of discarded fruits were recorded (Appendix Tables16 and 17).

In season 2001 /0002, the least percentage of discarded fruits of 14.56 % was recorded when Melody Duo at the concentration of 1.25 Kg /fed. was used. In the second season 2002 /0003, the least percentage of 29.63 % was recorded when Antracol at the concentration of 0.6 Kg /fed. was used. From the results it may be concluded that the highest dose of Melody Duo and the proposed dose by the manufacturer of Antracol proved to be the most efficient in decreasing the percentage of discarded fruits.

The results concerning the disease incidence displayed on tomato cv. Strain B in season 2002 /0003 showed that the use of both fungicides at the three concentrations reduced the disease incidence. Variable reductions were recorded (Figure 16 and Appendix Table 19).

The least percentage of disease incidence of 67.50 % was recorded when Melody Duo at the concentration of 1 Kg /fed. was used. From the results it may be concluded that the proposed dose by the manufacturer of Melody Duo proved to be the most effective in combating the disease incidence.

The results concerning the disease severity displayed on tomato cv. Strain B showed that the use of both fungicides at the three concentrations reduced the disease severity except one concentration of 1 Kg /fed. for Melody Duo. Variable reductions were recorded (Figure 17 and Appendix Table 20).

The least disease incidence percentage of 1.30 % was recorded when Antracol at the concentration of 0.6 Kg /fed. was used. From the results it may

be concluded that the highest dose for Antracol proved to be efficient in reducing the disease severity.

The results concerning the yield of tomato cv. Strain B showed that three concentrations of both fungicides increased the yield and three concentrations decreased the yield. Variable increases were recorded (Figure 18 and Appendix Table 21).

The highest increase of +26.95 % was recorded when Melody Duo at the concentration of 0.75 Kg /fed. was used. From the results it may be concluded that the lowest dose for Melody Duo proved to be efficient in increasing yield.

The results concerning the discarded fruits on tomato cv. Strain B showed that the use of both fungicides at the three concentrations decreased the percentage of discarded fruits. Variable decreases were recorded (Appendix Table 22).

The least percentage of discarded fruits of 35.30 % was recorded when Melody Duo at the concentration of 0.75 Kg /fed. was used. From the results it may be concluded that the lowest dose of Melody Duo proved to be efficient in decreasing the percentage of discarded fruits. Worldwide different fungicides applied at different concentrations were recommended by different Authors. Of these, Follas *et al*, (1992) recorded that Difenoconazole and Mancozeb at the rate of 125 g /ha. applied at the intervals of 14 days proved to be efficient in combating early blight disease incidence for tomato crop.

A similar result was recorded for severity and yield by Choulwar and Dater (1994). They recorded that Mancozeb was the most effective in reducing disease intensity and increasing the yield. Satter and Kassem (1991) recorded that Iprodine and Metalaxyal proved to be efficient in increasing yield.

Suggestions For Further Studies

1. Identification of the isolates; if any; of *A.solani* inciting Early Blight on Potato and Tomato.

2. Evaluation of efficacy of more fungicides in controlling Early Blight.
3. Determination of the appropriate dose of Antracol and Melody Duo.
4. Determination of the optimum time and frequency of application of fungicides.
5. Detailed study on the epidemiology of early blight.
6. Computerized system of prediction and application (Expert system).
7. Safety.

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Appendix Table (1): Mean Percentage of Disease Incidence in Potato cv. Alpha (Season 2001/0002) Pre-spray I

Treatments	No. of Plants	% Diseased Plants				Total	Mean Disease Incidence (%)
		RI	RII	RIII	RIV		
A	39	80.00	70.00	55.56	40.00	245.56	61.39
B	33	50.00	60.00	83.33	42.86	236.19	59.05
C	35	60.00	28.57	90.00	75.00	253.57	63.39
D	36	50.00	20.00	60.00	50.00	180.00	45.00
E	34	50.00	77.78	60.00	40.00	227.78	56.95
F	34	60.00	14.29	70.00	42.86	187.15	46.79
G	37	30.00	60.00	60.00	57.14	207.14	51.79

Appendix Table (2): Mean Percentage of Disease Incidence in Potato cv. Alpha (Season 2002/0003) Pre-spray I

Treatments	No. Of Plants	% Disease Incidence				Total	Mean Disease Incidence (%)
		RI	RII	RIII	RIV		
A	40	20.00	0.00	20.00	10.00	50.00	12.50
B	40	10.00	20.00	40.00	20.00	90.00	22.50
C	40	10.00	20.00	30.00	30.00	90.00	22.50
D	40	30.00	0.00	10.00	20.00	60.00	15.00
E	40	10.00	0.00	20.00	10.00	40.00	10.00
F	40	30.00	20.00	0.00	20.00	70.00	17.50
G	40	10.00	30.00	20.00	20.00	80.00	20.00

Appendix Table (3):Mean Percentages of Disease Incidence in Potato cv. Alpha (Season 2001/0002) Pre-spray II

Treatments	No. of Plants	% Diseased Plants				Total	Mean Disease Incidence (%)
		RI	RII	RIII	RIV		
A	39	100.00	100.00	88.89	40.00	328.89	82.22
B	33	70.00	80.00	83.33	57.14	290.47	72.62
C	35	70.00	57.14	100.00	87.50	314.64	78.66
D	36	90.00	30.00	90.00	83.33	293.33	73.33
E	34	70.00	77.78	90.00	100.00	337.76	84.44
F	34	90.00	28.57	90.00	85.71	294.28	73.57
G	37	100.00	80.00	100.00	85.71	365.71	91.43

ANOVA TABLE: Statistical Analysis of The Data in Table (3)

Source of variation	**d.f**	**ss**	**mss**	**F-calculated**	**F- tabulated**	
					5%	**1%**
Block	**3**	**2770.86**	**923.62**	**2.29**	**3.16**	**5.09**
Treatments	**6**	**1181.4**	**196.9**	**0.49**	**3.66**	**4.01**
Error	**18**	**7260.79**	**403.38**			

Appendix Table (4) : Mean Percentages of Disease Incidence in Potato cv. Alpha (2002/0003) Pre-spray II

Treatments	No. Of Plants	% Disease Incidence				Total	Mean Disease Incidence (%)
		RI	RII	RIII	RIV		
A	40	60.00	20.00	70.00	30.00	180.00	45.00
B	40	60.00	40.00	90.00	40.00	230.00	57.50
C	40	60.00	70.00	80.00	50.00	260.00	65.00
D	40	30.00	10.00	20.00	50.00	110.00	27.50
E	40	20.00	30.00	50.00	40.00	140.00	35.00
F	40	40.00	50.00	40.00	50.00	180.00	45.00
G	40	80.00	80.00	80.00	70.00	310.00	77.50

ANOUVA TABLE: Analysis of the data in Appendix Table (4)

Source of Variation	**d.f**	**ss**	**mss**	**F-calculated**	**F- tabulated**	
					5%	**1%**
Block	**3**	**1325.00**	**441.67**	**8.83**	**3.16**	**5.09**
Treatments	**6**	**10471.43**	**1745.25**	**34.90**	**3.66**	**4.01**
Error	**18**	**900.00**	**50.00**	########	###	###

Appendix Table (5) : Mean Percentage of Disease Severity in Potato cv. Alpha (2001 /0002)

Treatments	% Disease Severity				Total	Mean Disease Severity (%)
	RI	RII	RIII	RIV		
A	1.10	0.75	1.30	0.25	3.40	0.85
B	1.00	0.56	1.25	0.40	3.21	0.80
C	1.20	0.50	1.70	0.88	4.28	1.07
D	1.70	0.20	1.00	0.44	3.34	0.84
E	0.43	0.50	1.00	1.60	3.53	0.88
F	1.60	0.38	0.70	0.80	3.48	0.87
G	2.00	0.88	2.25	1.56	6.64	1.66

ANOVA TABLE: Statistical Analysis of The Data in Appendix Table (5)

Source of Variation	**d.f**	**ss**	**mss**	**F- calculated**	**F- tabulated**	
					5%	**1%**
Block	**3**	**2.9**	**0.97**	**5.71**	**3.16**	**5.09**
Treatments	**6**	**2.24**	**0.37**	**2.18**	**3.66**	**4.01**
Error	**18**	**3.02**	**0.17**	###############	###	###

Appendix Table (6): Mean Percentage of Disease Severity in Potato cv. Alpha (Season 2002/0003)

Treatments	% Disease severity				Total	Mean
	RI	RII	RIII	RIV		
A	1.50	1.40	1.40	1.40	5.70	1.43
B	1.50	1.30	1.40	1.40	5.60	1.40
C	2.40	1.10	1.50	1.70	6.70	1.68
D	1.40	1.40	1.20	1.30	5.30	1.33
E	1.60	1.30	1.20	1.50	5.60	1.40
F	2.50	1.40	1.50	1.30	6.70	1.68
G	1.60	1.70	1.60	2.30	7.20	1.80

ANOVA TABLE: Statistical Analysis of The Data in Appendix Table (6)

Source of Variation	**d.f**	**ss**	**mss**	**F-calculated**	**F-tabulated**	
					5%	**1%**
Block	**3**	**0.76**	**0.25**	**2.28**	**3.16**	**5.09**
Treatments	**6**	**0.81**	**0.14**	**1.56**	**3.66**	**4.01**
Error	**18**	**1.55**	**0.09**	##########	####	####

Appendix Table (7): Total Yield in Potato cv. Alpha (Season 2001/0002)

Treatments	Weight / Kg	Total	Mean	% Increase or Decrease

	RI	RII	RIII	RIV			
A	4.800	3.750	3.350	4.200	16.100	4.03	+ 3.07
B	3.700	4.750	4.300	4.500	17.250	4.31	+ 10.23
C	3.350	4.300	3.50	5.600	16.750	4.19	+ 7.16
D	4.200	3.700	4.450	5.950	18.300	4.58	+ 17.14
E	3.600	4.200	3.350	4.500	15.650	3.91	0.00
F	3.600	3.450	4.100	5.200	16.350	4.09	+ 4.60
G	3.500	3.850	3.700	4.600	15.650	3.91	#########

ANOVA TABLE: Statistical Analysis of The Data in Table (7)

Source of variation	d.f	ss	mss	F- calculated	F- tabulated	
					5%	1%
Block	**3**	**5.99**	**2.00**	**6.90**	**3.16**	**5.09**
Treatments	**6**	**1.36**	**0.23**	**0.79**	**3.66**	**4.01**
Error	**18**	**5.18**	**0.29**	###########	#####	#####

Appendix Table (8): Grading Of Potato cv. Alpha Tubers According to Size

Treatments	Total No. of Tubers	Tuber (%)						% of Total of Medium and Large Tubers	% Increase of Marketable Portion
		Small		Medium		Large			
		No	%	No	%	No	%		
A	210	83	39.52	64	30.48	63	30	60.48	+ 16.60
B	222	100	45.05	60	27.03	62	27.93	54.96	+ 5.96
C	241	112	46.47	72	29.88	57	23.65	53.53	+ 3.20
D	250	126	50.4	67	26.8	57	22.8	49.60	- 4.38
E	202	91	45.05	54	26.73	57	28.22	54.95	+ 5.94
F	209	90	43.06	68	32.54	51	24.44	56.98	+ 9.85
G	214	103	48.13	56	26.17	55	25.7	51.87	############

Appendix Table (9):Mean Percentage of Disease Incidence in Tomato cv. Peto 86(Season 2001/0002)Pre-spray I

Treatments	No. of Plants	Diseased Plants (%)				Total	Mean Disease Incidence (%)
		RI	RII	RIII	RIV		
A	40	80.00	100.00	90.00	80.00	350.00	87.50
B	40	50.00	100.00	100.00	100.00	350.00	87.50
C	40	70.00	70.00	70.00	100.00	310.00	77.50
D	40	70.00	100.00	100.00	100.00	370.00	92.50
E	40	90.00	80.00	80.00	100.00	350.00	87.50
F	40	80.00	100.00	80.00	70.00	330.00	82.50
G	40	80.00	90.00	80.00	70.00	320.00	80.00

Appendix Table (10) : Mean Percentages of Disease Incidence in Tomato cv.Peto 86(2002/0003) Pre- spray I

Treatments	No. of Plants	% Diseased Plants				Total	Mean
		RI	RII	RIII	RIV		
A	40	70.00	40.00	40.00	30.00	180.00	45.00
B	40	40.00	50.00	50.00	30.00	170.00	42.50
C	40	70.00	40.00	60.00	20.00	190.00	47.50
D	40	40.00	40.00	70.00	40.00	190.00	47.50
E	40	60.00	80.00	70.00	20.00	230.00	57.50
F	40	80.00	50.00	20.00	50.00	200.00	50.00
G	40	70.00	70.00	60.00	30.00	230.00	57.50

Appendix Table (11): Mean Percentage of Disease Incidence in Tomato cv. Peto 86 (Season 2002/0003) Pre-spray II

Treatments	No. of Plants	Disease Incidence (%)				Total	Mean Disease Incidence (%)
		RI	RII	RIII	RIV		
A	40	80.00	80.00	100.00	80.00	340.00	85.00
B	40	90.00	100.00	70.00	40.00	300.00	75.00
C	40	90.00	70.00	90.00	50.00	300.00	75.00
D	40	60.00	60.00	60.00	70.00	250.00	62.50
E	40	60.00	90.00	100.00	60.00	310.00	77.50
F	40	80.00	90.00	70.00	100.00	340.00	85.00
G	40	100.00	100.00	100.00	100.00	400.00	100.00

ANOVA TABLE: Statistical Analysis of The Data in Table (11)

Source of variation	**d.f**	**ss**	**mss**	**F- calculated**	**F -tabulated**	
					5%	**1%**
Block	**3**	**771.43**	**257.14**	**1.01**	**3.16**	**5.09**
Treatments	**6**	**3250**	**541.67**	**2.13**	**3.66**	**4.01**
Error	**18**	**4578.57**	**254.37**	**####**	**####**	**####**

Appendix Table(12): Mean Percentage of Disease Severity in Tomato cv. Peto86(Season 2001/0002)

Treatments	Severity (%)				Total	Mean
	RI	RII	RIII	RIV		
A	3.20	3.90	2.30	3.10	12.50	3.13
B	3.00	2.80	2.80	3.50	12.10	3.03
C	4.00	2.90	2.90	1.70	11.50	2.88
D	3.40	2.40	2.70	3.60	12.10	3.03
E	2.80	2.00	2.70	2.30	9.80	2.45
F	3.60	3.10	2.50	2.50	11.70	2.93
G	3.30	2.20	2.50	2.40	10.40	2.60

ANOVA TABLE: Statistical Analysis of The Data in Table (12)

Source of variation	**d.f**	**ss**	**mss**	**F- calculated**	**F- tabulated**	
					5%	**1%**
Block	**3.00**	**2.11**	**0.70**	**2.50**	**3.16**	**5.09**
Treatments	**6.00**	**1.46**	**0.24**	**0.86**	**3.66**	**4.01**
Error	**18.00**	**5.08**	**0.28**	#######	#####	###

Appendix Table (13): Mean Percentage of Disease Severity in Tomato cv. Peto86 (Season 2002/0003)

Treatments	Disease Severity (%)				Total	Mean
	RI	RII	RIII	RIV		
A	1.50	1.30	1.10	1.30	5.20	1.30
B	1.60	1.30	1.50	1.00	5.40	1.35
C	1.60	1.50	1.50	1.20	5.80	1.45
D	1.20	1.10	1.10	1.20	4.60	1.15
E	1.20	1.60	1.40	1.40	5.60	1.40
F	1.20	1.20	1.70	1.40	5.50	1.38
G	2.40	1.80	1.50	1.70	7.40	1.85

ANOVA TABLE: Analysis of The Data in Appendix Table (13)

Source of variation	**d.f**	**ss**	**mss**	**F- calculated**	**F- tabulated**	
					5%	**1%**
Block	**3**	**0.17**	**0.06**	**1.2**	**3.16**	**5.09**
Treatments	**6**	**1.12**	**0.19**	**3.8**	**3.66**	**4.01**
Error	**18**	**0.92**	**0.05**	########	###########	###########

Appendix Table (14): Total of Yield in Tomato cv. Peto 86(Season 2001/0002)

Treatments	Yield/unit Area				Total	Mean	% of Increase or Decrease
	RI	RII	RIII	RIV			
A	2.92	5.39	4.40	2.96	15.67	3.92	-16.47
B	4.29	4.39	7.16	4.61	20.45	5.11	11.89
C	2.24	4.67	7.54	3.83	18.28	4.57	-2.56
D	4.21	4.65	3.73	7.90	20.49	5.12	9.22
E	6.39	5.32	6.76	4.39	22.86	5.72	21.86
F	6.00	7.44	7.22	5.15	25.81	6.45	37.53
G	7.77	3.95	3.91	3.13	18.76	4.69	################

ANOVA TABLE: Analysis of the Data in Appendix (14)

Source of variation	**d.f**	**ss**	**mss**	**F-calculated**	**F-tabulated**	
					0.05	**0.01**
Block	**3.00**	**7.50**	**2.50**	**1.09**	**3.16**	**5.09**
Treatments	**6.00**	**19.09**	**3.18**	**1.38**	**3.66**	**4.01**
Error	**18.00**	**41.41**	**2.30**	#########	#########	#########

Appendix Table (15): Total Yield in Tomato cv. Peto 86 (Season 2002/0003)

Treatments	Yield/unit area				Total	Mean	% of Increase or Decrease
	RI	RII	RIII	RIV			
A	5.39	10.22	6.90	8.04	30.55	7.64	32.87
B	4.22	5.23	8.04	6.64	24.13	6.03	4.87
C	4.46	5.69	9.56	5.22	24.93	6.23	8.35
D	4.72	4.18	3.79	3.36	16.05	4.01	-30.26
E	4.84	6.16	8.00	6.67	25.67	6.42	11.65
F	3.91	5.43	8.42	7.75	25.51	6.38	10.96
G	7.63	3.70	4.60	7.06	22.99	5.75	############

ANOVA TABLE: Analysis of the Data in Appendix (15)

Source of variation	**d.f**	**ss**	**mss**	**F-calculated**	**F-tabulated**	
					0.05	**0.01**
Block	**3.00**	**94.38**	**31.46**	**11.16**	**3.16**	**5.09**
Treatments	**6.00**	**28.15**	**4.69**	**1.66**	**3.66**	**4.01**
Error	**18.00**	**50.70**	**2.82**	#########	########	#########

Appendix Table (16): Mean Percentage of Discarded Fruits in Tomato cv. Peto 86(Season 2001/0002)

Treatments	Discarded Fruits (%)				Total	Mean
	RI	RII	RIII	RIV		
A	21.84	28.95	18.75	35.11	104.65	26.16
B	14.04	20.66	25.49	19.29	79.48	19.87
C	17.65	8.80	29.03	31.03	86.51	21.63
D	22.45	15.09	30.39	16.76	84.69	21.17
E	15.67	9.22	22.37	10.92	58.18	14.55
F	17.52	47.09	12.12	15.22	91.95	22.99
G	11.24	25.25	23.81	33.70	94.00	23.50

Appendix Table (17) : Mean Percentage of Discarded Fruits in Tomato cv.Peto 86(Season 2002/0003)

Treatments	Discarded Fruits (%)				Total	Mean
	RI	RII	RIII	RIV		
A	44.35	29.57	20.22	39.16	133.30	33.33
B	37.36	35.34	17.61	27.61	117.92	29.48
C	25.23	32.84	33.97	41.73	133.77	33.44
D	31.37	31.53	38.20	45.45	146.55	36.64
E	44.23	33.12	28.80	33.81	139.96	34.99
F	50.54	35.00	32.00	28.97	146.51	36.63
G	52.60	52.63	66.43	45.34	217.00	54.25

Appendix Table(18): Mean Percentage of Disease Incidence in Tomato cv. Strain B(Season 2002/ 0003) Pre-spray I

Treatments	% of Diseased Plants				Total	Mean
	RI	RII	RIII	RIV		
A	50.00	80.00	100.00	90.00	320.00	80.00
B	60.00	70.00	80.00	80.00	290.00	72.50
C	70.00	60.00	40.00	50.00	220.00	55.00
D	40.00	50.00	50.00	80.00	220.00	55.00
E	40.00	90.00	90.00	70.00	290.00	72.50
F	70.00	60.00	20.00	60.00	210.00	52.50
G	20.00	70.00	30.00	80.00	200.00	50.00

Appendix Table (19): Mean Percentage of Disease Incidence in Tomato cv. Strain B (Season 2002/ 0003) pre-spray II

Treatments	No. of Plants	Diseased Plants (%)				Total	Mean of Disease Incidence (%)
		RI	RII	RIII	RIV		
A	40	70.00	90.00	100.00	100.00	360.00	90.00
B	40	70.00	80.00	100.00	90.00	340.00	85.00
C	40	100.00	80.00	70.00	80.00	330.00	82.50
D	40	40.00	60.00	80.00	90.00	270.00	67.50
E	40	50.00	100.00	100.00	90.00	340.00	85.00
F	40	60.00	80.00	70.00	90.00	300.00	75.00
G	40	80.00	90.00	70.00	90.00	330.00	82.50

ANOVA TABLE: Statistical Analysis of The Data in Table (19)

Source of variation	**d.f**	**ss**	**mss**	**F-calculated**	**F- tabulated**	
Block	**3**	**2010.72**	**670.24**	**3.43**	**5%**	**1%**
Treatments	**6**	**1342.86**	**223.81**	**1.15**	**3.16**	**5.09**
Error	**18**	**3514.28**	**195.24**	######	**3.66**	**4.01**

Appendix Table (20) Mean Percentage of Disease Severity in Tomato cv. Strain B (Season 2002/ 0003)

Treatments	RI	RII	RIII	RIV	Total	Mean
A	1.70	1.10	1.60	1.70	6.10	1.53
B	1.40	1.30	1.30	1.20	5.20	1.30
C	1.00	1.50	1.30	1.50	5.30	1.33
D	1.60	1.00	2.70	1.80	7.10	1.78
E	1.20	1.40	1.30	1.40	5.30	1.33
F	1.20	1.30	1.40	1.60	5.50	1.38
G	2.20	1.50	1.40	1.90	7.00	1.75

ANOVA TABLE: Statistical Analysis of The Data in Table (20)

Source of variation	**d.f**	**ss**	**Mss**	**F-calculated**	**F- tabulated**	
					5%	**1%**
Block	**3**	**1.25**	**0.42**	**6**	**3%**	**5%**
Treatments	**6**	**1.02**	**0.17**	**2.43**	**3.66**	**4.01**
Error	**18**	**1.19**	**0.07**	#########	#########	########

Appendix Table (21): Total Yield in Tomato cv. Strain B(Season 2002 /0003)

Treatments	Total Yield/ Unit Area				Total	Mean	% of Increase or Decrease
	RI	RII	RIII	RIV			
A	7.42	4.62	9.40	9.58	31.02	7.76	16.17
B	4.41	7.39	7.47	4.97	24.24	6.06	9.28
C	3.72	4.36	7.91	3.20	19.19	4.80	28.14
D	3.66	4.21	6.80	10.79	25.46	6.37	4.64
E	6.16	4.86	6.52	10.09	27.63	6.91	3.44
F	8.14	6.60	10.25	8.93	33.92	8.48	26.95
G	5.29	6.02	9.54	5.86	26.71	6.68	################

ANOVA Table: Statistical Analysis of The Data in Appendix Table (21)

Source of Variation	**d.f**	**ss**	**mss**	**F-calculated**	**F- tabulated**	
					5%	**1%**
Block	**3**	**43.85**	**14.62**	**4.51**	**3.16**	**5.09**
Treatments	**6**	**33.85**	**5.64**	**1.74**	**3.66**	**4.01**
Error	**18**	**58.36**	**3.24**	###########		

Appendix Table (22): Mean Percentage of Discarded Fruits in Tomato cv. Strain B (Season 2002/0003)

Treatments	Discarded Fruits (%)				Total	Mean
	RI	RII	RIII	RIV		
A	37.50	47.40	30.58	44.44	159.92	39.98
B	36.72	31.82	38.89	53.24	160.67	40.17
C	44.17	56.22	45.87	55.75	202.01	50.50
D	46.34	49.49	35.40	33.58	164.81	41.20
E	36.48	32.04	42.73	39.03	150.28	37.57
F	23.81	43.75	34.65	38.98	141.19	35.30
G	53.80	41.71	65.22	67.23	227.96	56.99