INFLUENCE OF MODE, TIME AND FREQUENCY OF IRRIGATION ON DISEASES OF TOMATOES AND EGGPLANTS IN THE JORDAN VALLEY

BY

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I hereby recommend that this thesis prepared under my direction by Mohammad Mustafa Younis entitled:

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I. INTRODUCTION

Jordan Valley is characterised by its warm climate in the winter season which allows growing vegetables at a time when the Middle East and Europe can not produce such crops. Tomatoes and eggplants constitute the most important vegetable crops in the Jordan Valley.

Sprinkler irrigation is a new technology adopted in the Jordan Valley to maximize the efficiency of irrigation practices, and to irrigate more land with the limited water supply available. An area of 94000 donums are expected to be put under sprinkler irrigation in 1979/1980 (Jordan Valley Authority, Personal communication).

Sprinkler irrigation affects the microclimate prevailing in the field and causes considerable decrease of temperature and increase of relative humidity at least during the time of irrigation and for various periods thereafter (Rotem *et al.*, 1972; Rotem and Cohen, 1966; Rotem and Palti, 1969). Sprinkling also lowers the leaf temperature during irrigation (Rotem and Palti, 1969). The change in temperature and moisture will support epidemic development of diseases to greater or lesser extents. Tomatoes and eggplants are subject to attack by various destructive diseases under sprinkler irrigation (Crossan and Lloyd, 1956; Rotem and Cohen, 1966). Many diseases are favored by sprinkling as compared to furrow irrigation. These include late blight and early blight of tomatoes, downy mildew of cucumbers, wilt of vegetables and a great number of bacterial diseases.

In the present investigation an attempt was made to survey the diseases of tomatoes and eggplants under different irrigation treatments.

II. REVIEW OF LITERATURE

Effect of Irrigation on the Development of Selected Vegetable Diseases.

Late blight of potato and tomato; *Phytophthora infestans* (Mont) DBy .

Harrison (1947) found that long periods of high humidity were more important than rainfall in the spread and development of late blight, which was relatively inactive unless 100% relative humidity (R.H.) prevailed for more than 15 hours. Palti and Netzer (1963) indicated that rainfall was a pre-requisite for late blight attack in the Jordan Valley and sprinkler irrigation increased this attack.

Crosier 1934, cited by walker (1957) reported that conidia of *P. infestans* were formed at a minimum relative humidity of 91% with an optimum of 100% and a temperature range of 3 to 26°C with an optimum of 18-22°C. The optimum temperature for formation of zoospores was 12°C. and for formation of germ tubes from sporangia was 25°C. The zoospores germinated most rapidly at 12° to 15°C. and the germ tubes from zoospores grew best at 21° to 24°C.

Qasem (1968) reported that the succession of cool humid nights with warm humid days during December-March in the Jordan Valley provided optimum conditions for the development of late blight disease on potatoes and tomatoes. Krasnyanskaya (1972) stated that high relative humidity and temperture (> 10°C) had the greatest effect on development of P. infestans on tomatoes. Antonellini (1974) found that relative humidity rather than temperature was decisive in outbreaks of late blight. Mean daily relative humidity of 65% and mean relative humidity greater than 90% for at least 6 hours for 3-4 days with corresponding temperature of 12.5°C and above during the day were necessary for epiphytotics.

Cox and Large (1960) found that furrow irrigation had no effect on late blight and suggested that the increasing use of sprinkler irrigation might have affected the incidence of late blight attack. The rate of sprinkler irrigation whether extending over 3 - 4 hours at each application or for the same amount of water over 10 - 12 hours, had little effect on late blight development (Rotem et al., 1962). Morning sprinkler irrigation had a greater effect than midday or evening sprinkler irrigation on the development of late blight (Rotem et al., 1970). Late blight was much more severe on plots receiving 8 - 11 sprinkler irrigations at 7 - 10 day intervals than on plots receiving 3 - 4 sprinkler irrigations at 21 - 28 day intervals (Rotem et al., 1962). The ability of late blight to develop in semi-arid conditions when nights were favorable for infection and sporulation depended on spore dispersal and survival, which were affected by hot and dry conditions. Dispersal of P infestans spores on a hot and dry day (max. 42°C, min. 15% R.H.) started early, reached a peak rapidly and stopped abruptly; dispersal on a cool and humid day (max. 22°C, min. 78% R.H.) started later, reached its peak gradually and decreased slowly. Dispersed and attached sporangia might survive for comparatively long periods of relatively adverse conditions and the sporangia might survive better under high rather than under low relative humidity (Rotem and Cohen, 1974).

Early blight of potato and tomato; Alternaria solani (Ell. + G. Martin) Sor.

Early blight of tomatoes was reported to be favored by moist conditions and moderately high temperature (Anonymous, 1943); in warm winters and high atmospheric and soil humidity, the infection with A. solani increased (Berger, 1938).

Conidia of *A. solani* germinated within 1-2 hours at temperatures from 6-34°C., and within 35-45 minutes at 28-30°C. Heavy dews with frequent rains seemed to be essential for abundant sporulation (Rands, cited by Walker, 1957 Nightingale and Ramsey, 1936).

Kasem (1968) reported that conditions prevailing during November-December and during March-April in the Jordan Valley favoured the development of early blight on tomatoes.

Moore (1942) indicated that the principal limiting factor in the infection of tomato seedlings by *A. solani*, was high humidity, although disease incidence was expected to increase with the advance in temperature. Other authors indicated that temperature had a greater effect than relative humidity on the incidence of *A. solani* on tomato (Treggi and Rainaldi, 1966). Under conditions almost lacking other sources of moisture, dew was the principal factor enabling the development of early blight epidemic (Rotem and Reichert, 1964; Hodosy, 1968).

Moore (1942) found that under favorable humidity, tomato seedlings developed more leaf lesions at 23.3°C than at 12.2° - 16.6°C. The optimum temperature for *A. solani* was found to be 26.6°C (Nightingale and Ramsey, 1936) or 28°C (Pound, 1951). The maximum was 35°C and the minimum was 1.7°C (Nightingale and Ramsey, 1936).

The dispersal of spores by sprinkling aided the infection of tomatoes by *A. solani* (Rotem and Palti, 1969). The spores were formed at night and dispersed during the following day (Bashi and Rotem, 1975), at noon (Rotem and Palti, 1969), or 4 - 5 hours after sunrise (Langenberg *et al*., 1977). During the night spore dispersal was usually at its lowest point, began to increase at 9 a.m., and reached a peak at 11 a.m. During the afternoon, a sharp drop occurred. The typical diurnal dispersal of *A. solani* spores was concentrated in a few of the driest and windiest hours of the day (Rotem, 1964). The spores were capable of surviving the dry hours of the day on which they were dispersed. The spores were incouraged to germinate by either dew or by sprinkler irrigation (Rotem and Palti, 1969). Early blight on potato appeared in many fields irrigated by the furrow system but only in trace amounts. Early blight was much more severe with sprinkler irrigation (Guthrie, 1958). Rotem and Reichert (1964) found that early blight epidemics occurred with sprinkler as well as with furrow irrigation, in comparatively rainy years as well as in dry years; and in the hot fall and relatively cool winter. Guthrie (1958) reported that *A. solani* destroyed all potato plots within 4 weeks under sprinkler irrigation, regardless of the time of sprinkling. Sprinkler system of irrigation provided moisture conditions suitable for a severe epiphytotic when the crop was frequently irrigated at 5 - 7 day intervals.

Powdery mildew; *Leveillula taurica* (Lev.) arn.

Powdery mildew of tomatoes and eggplants caused by *L. taurica*, conidial stage, *Oidiopsis taurica* (Tepper) was reported to be common and quite often destructive in Palestine and in the Jordan Valley(Palti, 1959 Qasem, 1970). The disease was seldom found on tomatoes in the coastal plain of Palestine (Chorin and Palti, 1951), but was serious in the Jordan Valley and seemed to be restricted to conditions of low humidity. On eggplants the disease was widespread in all parts of Palestine and appeared under both humid and dry conditions (Palti, 1959).

L. taurica was found only in its conidial stage (*Oidiopsis*) throughout the extended growing seasons of the host in the Jordan Valley (Mamluk *et al.*, 1980).

Powdery mildew of tomatoes developed better at 15 - 25°C than at 10 - 20°C (Reuveni and Rotem, 1973). The infection was favored at 18 - 24°C (Alexandri and Lemini, 1969) and was severe at a daily mean of approximating 25°C (Reichert and Palti, 1946). However the optimum and maximum temperature for *L. taurica* were 25 and above 30°C (Reuveni *et al.*, 1974).

Powdery mildew of tomato was severe in Palestine under favorable conditions of atmospheric humidity, 52 - 75% (Reichert and Palti, 1946), or 70 - 82% (Alexandri and Lemini, 1969).

O. taurica was less severe in tomato plots with sprinkler irrigation, and developed 30 - 40% more on furrow irrigated plots (Rotem and Cohen, 1966). The authors found that moisture periods of combined dew and sprinkling reduced the incidence of the pathogen.

Sclerotinia stem rot on eggplants and tomatoes; Sclerotinia sclerotiorum (Lib.) DBy.

Eggplants and tomatoes were severely injured by S. sclerotiorum. The limiting factor for Sclerotinia disease incidence was moisture which might be influenced by soil type, crops, culture, cloudiness, fogs and dew formation, as well as by rainfall (Moore, 1955).

Infection by S. sclerotiorum originated either from the mycelium, sclerotia or from the air-borne ascospores. Most infections with S. sclerotiorum observed occurred a foot or more above the soil line and could not have originated directly from the sclerotia in the soil, these infections resulted from air-borne ascospores developed in apothecia growing on the sclerotia. Ascosporic infection of tomato plants under natural conditions did not take place directly through healthy tissues, but only through an intermediary of dead tissue, which in this case could be dead flower parts (Purdy and Bardin, 1953). Sclerotia were the primary survival structures of the white mold fungus, _S. sclerotiorum_. The sclerotia produced either mycelium or apothecia depending on environmental conditions (Newton and Sequeira, 1972). Sclerotia were distributed within the vertical soil profile by land preparation and between fields by irrigation runoff water and any activity resulting in movement of infested soil. Irrigation water might disseminate the fungus into lowlying areas of a field where microclimatic conditions might be more favorable for disease development (Schwartz and Steadman, 1978). Ascospores were generally regarded as the principal primary inoculum of _S. sclerotiorum_ and direct mycelial infection by sclerotia in the field had been questioned because mycelium from a sclerotium could only infect over short distances. In tomatoes both aerial and basal infection were common (Lotham _et al_., 1976). According to Mufadi (1980) ascospores discharged from the apothecia developed on sclerotia were the most important source of infection with _S. sclerotiorum_ in the Jordan Valley.

The moisture, temperature and light were important in the production of apothecia of _S. sclerotiorum_ (Henson and Valleau, 1940). Production of apothecia was promoted by conditions which provided and maintained sufficient moisture. Thus, the irrigation furrow, especially the area near the plant stem where the canopy shaded the soil surface provided the most conducive environment for apothecial development. The majority of apothecia were produced adjacent to the plant stems near the irrigated furrow (Schwartz and Steadman, 1978). Numbers of apothecia and levels of aerial infection were not related to the amount of total monthly rain or to frequency of irrigation (Lotham _et al._, 1976).

In cultures S. _sclerotiorum_ grew best at 15° - 25°C, but it was able to grow and produce sclerotia in a range from 0° - 30°C. (Tanrikut and Vaughan, 1951). The maximum mycelial growth of _S. sclerotiorum_ took place at 23.9°C and the minimum at 7.2°.. (Brooks, 1940). Apothecia were formed at mean temperatures of 9.0° - 17.1°C within 14-day periods (Lotham _et al._, 1976), below 21.1°C within 28 - 34 days (Brooks, 1940). Apothecia released numerous ascospores at temperatures ranging from 4 - 32°C (Newton and Sequeira, 1972).

Tomato Fruit Rot

Several pathogens were reported to cause fruit rot of tomatoes, these were Rhizoctonia solani Kuehn, Pythium spp., S. sclerotiorum, Sclerotium rolfsii Sacc., Phytophthora parasitica Dast, Colletotrichum phomoides (Sacc.) Chester, Trichothecium roseum Link, and Alternaria tenuis Auct. In addition Fusarium roseum (LK) Snyd. and Hans., F. solani Snyd. and Hans., F. oxysporum Schlecht., Mucor spp. and Geotrichum spp. caused damage to injured fruits. (Jones and McCarter, 1974).

Under conditions of high soil moisture, tomato fruit rots caused by R. solani and Pythium spp. were expected to increase in severity. However, Rhizoctonia rot was much more prevalent than Pythium rot. Sprinkler irrigation increased the incidence of tomato fruit rot due to R. solani. Plots receiving four irrigations totaling approximately 4 inches of water in a 30-day period had significantly high incidence of tomato fruit rot caused by R. solani (Crossan and Lloyd, 1956).

Highest infection of tomato fruits caused by R. solani took place when the inoculated soil was at about 60% of its water holding capacity and the disease was produced at higher moisture levels up to satuaration. High atmospheric humidity was also essential for penetration of the tomato fruits. Once infection occurred, the disease was not affected by air humidity((Gonzalez and Owen, 1963).

The optimum temperature for tomato fruit rot caused by *R. solani* developed on detached fruits was 24°C. This was close to the optimum for fungus growth in culture (Gonzalez and Owen, 1963).

Tomato Fruit Cracking

Irrigation was found to be the most important factor associated with the cracking incidence in tomato production. Cracking of tomato fruits was a serious problem, where tomatoes were grown under heavy irrigation (Nassar, 1971). Cracking was found to be significantly greater with 15 and 20 inch water applications than with the 11 inch applications per season (Molenaar and Vincent, 1951). Cracking tendencies in tomatoes were as serious in the furrow-irrigated plots as in the sprikled plots (Molenaar and Vincent, 1951). Long irrigation intervals induced less fruit cracking while short irrigation intervlas caused more cracking (Nassar, 1971). Tomato cuticle cracking was observed to increase in fields subjected to 1.38 in. of rainfall when followed by warm temperatures of about 32.2°C 33.3°C for three days (Young, 1947).

III. MATERIALS AND METHODS

A. Description of the Experiment.

This research was carried out at Deir Alla Agricultural Experiment Station in the Jordan Valley, between October, 1st 1978 and April 10th 1979. The two vegetable crops used were: tomatoes Lycopersicon esculentum cv. Claudia Raf and eggplants Solanum melongena cv. black beauty. The experiment was designed as split-plot with two replications. It consisted of two main plots the first irrigated once a week and the second irrigated twice a week, and of three subplots with the following treatments: morning irrigation, on irrigation and furrow irrigation. The subplot consisted of five rows of each vegetable crop. Each subplot measured 12 x 10 meters, and contained 150 tomato plants and 90 eggplants. Eight meters were left among the subplots, twelve meters were left between the main plots and eight meters were left between the replicates. Tonato plants were spaced 0.3 meter apart in the row and the eggplants were spaced 0,5 meter.

Irrigation started at the beginning of October, 1978 and was terminated at the end of April 1979. Irrigation was not applied directly after rainfall or when the tensiometer readings were about zero. It was planned that both the morning and noon irrigations be started at the same time each day of irrigation, this was not possible because water was not consistently available throughout the day. The morning irrigations were started as close to 7:00 a.m. as possible. Similarly the noon irrigations were started at 11:00 a.m. as soon thereafter as water became available. Each irrigation was terminated when the soil reached field capacity, (tensiometer reading reached zero) according to the prevailing environmental conditions and time of the season. In general, irrigation duration was 3-4 hours in plots irrigated once a week and 2-3 hours in plots irrigated twice a week No fugnicide treatments were applied in the field during the experiment.

B. Instruments Used in the Experiment.

Sprinkler equipment consisted of two lateral lines in each main plot, having 16 rotary sprinklers with 0.4 cm. nozzles placed at 18 meters distance on 1m. risers from 5 cm. portable irrigation pipes. Sprinkers covered an area of 24 meters diam. and released 1 m^3. water per hour. The tensiometers were positioned in the first replication at 30.5 cm depths. One tensiometer was used per treatment.

C. Collection of Data, Evaluation of Disease Incidence and Severity and Pathogenicity Test.

Representative specimens were taken to the laboratory for isolation and positive diagnosis. Potato dextrose agar (PDA) was used for the isolation. Moist chambers were used to induce the growth of the fungi from the infected plant parts. The plant parts were examined microscopically after 48 hours to identify the causal agent.

Fifty tomato leaves were sampled randomly at two week intervals to estimate incidence and severity of late blight, early blight and powdery mildew. Also fifty tomato fruits were sampled randomly at two week intervals to estimate incidence and severity of tomato fruit rot and tomato fruit cracking. And all tomato plants in each experimental plot were examined to estimate incidence and severity of *Sclerotinia* stem rot.

Twenty five eggplant leaves were sampled randomly at two week intervals to estimate incidence and severity of powdery mildew and leaf spot. And all plants in each experimental plot were examined to estimate incidence and severity of *Sclerotinia* stem rot and *Fusarium* wilt on eggplants.

Disease incidence was determined as follows:

$$\text{Disease incidence} = \frac{\text{No. infected (leaves/fruits/plants)}}{\text{Total No. (leaves/fruits/plants)}} \times 100$$

Disease incidences were converted to Arcsin values which were used in the analysis of variance.

To indicate disease severity on infected leaves and plants, the following numerical rating system was used:

0: no infection : (N_1) designated the number of leaves or plants in this category).

1: mild : (N_2) less than 25% of the leaf or plant surface affected.

2: moderate : (N_3) 26 to 50% of the leaf or plant surface affected.

3: severe : (N_4) 51 to 75% of the leaf or plant surface affected.

4: very severe : (N_5) 76 to 100% of the leaf or plant surface affected.

This rating system was used to calculate the disease severity as follows:-

$$\text{Disease severity} = \frac{0 \times N_1 + 1xx\, N_2 + 2 \times N_3 + 3 \times N_4 + 4 \times N_5}{N_1 + N_2 + N_3 + N_4 + N_5}\,*$$

Disease incidence and severity, were recorded without reference to the environmental conditions.

Duncan's Multiple Range Test (DMRT) was used in the statistical analysis for incidence and severity of the disease.

* This formula was developed by Littauer et al (1946), see Rotem et al (1962).

Pathogenicity test was conducted to prove the pathogenicity of *Fusarium oxysporum* isolated from wilted tomato plants as well as eggplants.

Eggplant seeds cv. "black beauty" were sown in 20 pots on April 17th, 1979 and the pots were placed in the greenhouse of the Faculty of Agriculture. There were 10 seedlings in each pot. The seedlings were thinned to 3 seedlings per pot three weeks after planting. The seeldings were inoculated with 5 isolates of *F. oxysporum*. Two isolates were obtained from eggplant stems, the other two isolates were obtained from eggplant leaves, and the fifth isolate was obtained from tomato stems. From each isolate three petri dishes were used to inoculate three pots. Five pots were used as a control. Twenty cubic centimeters of distilled water were added to each petri dish and the surface of the petri dish was scraped to get as many mycelial fragments and conidia as possible. Then the suspension was poured into three holes around the first seedling. This process was repeated two more times to inoculate the other two seedlings in the pot. All pots were inoculated in the same way. Observations for wilt were made at five-day interval and the test was finally evaluated after 25 days of inoculation.

IV. RESULTS

A. Effect of Irrigation on the Development of Tomato Diseases.

1. Late blight; *Phytophthora infestans* (Mont.) DBy.

Evaluation of late blight disease on tomatoes began when the first symptom appeared on tomato leaves on January 31, 1979 and was terminated on March 29, 1979 during which six observations were recorded. The disease attacked all above ground parts and fruits (Fig. 1).

Analysis of variance for incidence of late blight on tomatoes indicated significant differences among frequencies of irrigation used, among treatments and among the interactions between frequencies of irrigation and treatments (App.I). Among treatments, sprinkling in the morning induced the highest disease incidence and was followed with sprinkling at noon, while furrow irrigation induced the least disease incidence. Concerning frequencies of irrigation, sprinkling twice a week had a higher disease incidence than sprinkling once a week. With each frequency sprinkling in the morning yielded in a higher disease incidence than sprinkling at noon and furrow irrigation (Tab. 1).

Analysis of variance for the severity of late blight on tomatoes indicated significant differences among frequencies of irrigation used, among treatments and among the interactions between frequencies of irrigation and treatments (App. 11). Among treatments, sprinkling in the morning induced the highest disease severity and was followed with sprinkling at noon, while furrow irrigation induced the least disease severity. Among frequencies of irrigation, twice a week induced higher significant level of severity than did irrigation once a week. The interaction between frequencies of irrigation and treatments was also significant, at each frequency level sprinkling in the morning induced the highest significant level of severity and was followed by sprinkling at noon. Furrow irrigation induced the least severity at both frequencies(Tab. 1).

The data presented indicated that sprinkler irrigation increased the incidence and severity of late blight. Morning sprinkling proved this increase more than noon sprinkling. Frequency of sprinkler irrigation had also influenced the increase in the incidence and severity of the disease. The development of late blight on tomatoes under different irrigation treatments is shown in figure (2).

Table 1 : Means of incidence and severity of late blight of tomato caused by Phytophthora infestans under different irrigation treatments.

	Incidence			Severity		
Treatment \ Frequency	Once	Twice	Treatment $\bar{X}$	Once	Twice	Treatment
Furrow	14.5 a	16.5 a	15.5 e	0.36 a	0.38 a	0.37 e
Sprinkler morning	32.5 c	58.17 d	45.34 f	0.7867c	1.1333d	0.96 f
Sprinkler noon	22.67 b	38 c	30.34 g	0.6084b	0.8567c	0.7325 g
Frequency $\bar{X}$	23.22 h	37.56 i		0.585 h	0.79 i	

Means followed by different letters within columns and/or rows differ significantly at 5% level (DMRT).

Figure 1: Late blight of potato and tomato (Phytophthora infestans) on tomato stem, leaves and fruits.

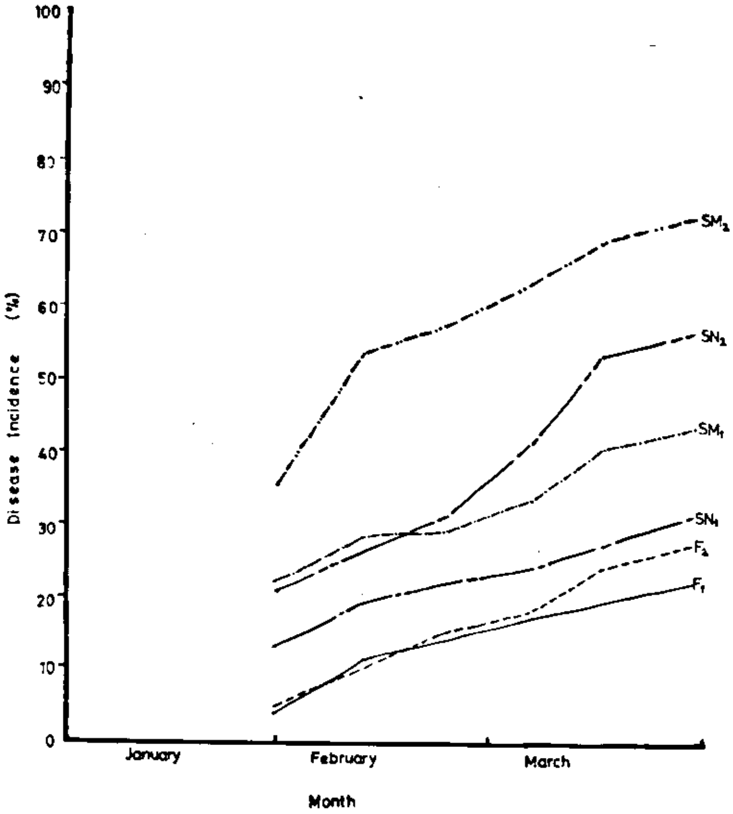


Figure 2: The development of late blight (Phytophthora infestans) on tomatoes under different irrigation treatments.

F_1 : Furrow irrigation once a week.

F_2 : Furrow irrigation twice a week.

SM_1: Morning sprinkler irrigation once a week.

SM_2: Morning sprinkler irrigation twice a week.

SN_1: Noon sprinkler irrigation once a week.

SN_2: Noon sprinkler irrigation twice a week.

2. Early blight; <u>Alternaria solani</u> (Ell.+G.Martin) Sor.

Evaluation of early blight disease on tomatoes began when the first symptom appeared on tomato leaves on December 10, 1978 and was terminated on March 27, 1979, during which nine observation were recorded. The disease attacked all above ground parts and fruits (Fig. 2).

Analysis of variance for incidence of early blight on tomatoes indicated no significant difference among frequencies of irrigation used, but there were significant differences among treatments and among the interactions between frequencies of irrigation and treatments (App. III). Among treatments, there were no significant differences in the effect of sprinkler irrigation in the morning or at noon on the incidence of the disease, but both sprinkling in the morning and at noon induced higher disease incidences than furrow irrigation. Concerning frequencies of irrigation, sprinkling twice a week had a higher disease incidence than sprinkling once a week. Within each frequency, there were no differences between means of incidence for sprinkler irrigation in the morning and at noon; but each of them had a higher disease incidence than furrow irrigation (Tab. 2).

Analysis of variance for the severity of early blight on tomatoes indicated significant differences among frequencies of irrigation used, among treatments and among the interactions between frequencies of irrigation and treatments (App. IV). Among treatments, there were no differences between the effect of sprinkler irrigation in the morning and at noon on the severity of the disease, but both sprinkling in the morning and at noon induced higher disease severity than furrow irrigation. Among frequencies of irrigation, twice a week induced higher significant level of severity than did irrigation once a week. Within each frequency, there were no differences between means of severity for sprinkler irrigation in the morning and at noon; but both of them had higher disease severity than furrow irrigation (Tab. 2).

The data presented indicated that sprinkler irrigation increased the incidence and severity of early blight. Time of irrigation had no effect on the disease. Frequency of sprinkler irrigation had increased the incidence and severity of the disease, while the frequency of furrow irrigation did not influence the incidence or the severity of the disease. The development of early blight on tomatoes under different irrigation treatments is shown in figure (4).

Table 2 : Means of incidence and severity of early blight of tomato caused by <u>Alternaria solani</u> under different irrigation treatments.

Frequency / Treatment	Incidence			Severity		
	Once	Twice	Treatment $\bar{X}$	Once	Twice	Treatment $\bar{X}$
Furrow	22.78 a	21.45 a	22.12 d	0.2356 a	0.2689 a	0.2523 d
Sprinkler morning	40.78 b	58 c	49.39 e	0.5967 b	1.0478 c	0.8223 e
Sprinkler noon	43.78 b	56.89 c	50.34 e	0.4811 b	1.0211 c	0.7511 e
Frequency $\bar{X}$	35.78 f	45.45 f		0.4378 f	0.7793 g	

Means followed by different letters within columns and/or rows differ significantly at 5% level (DMRT).

Figure 3: Early blight of potato and tomato (*Alternaria solani*) on: A. tomato leaves B. tomato fruits.

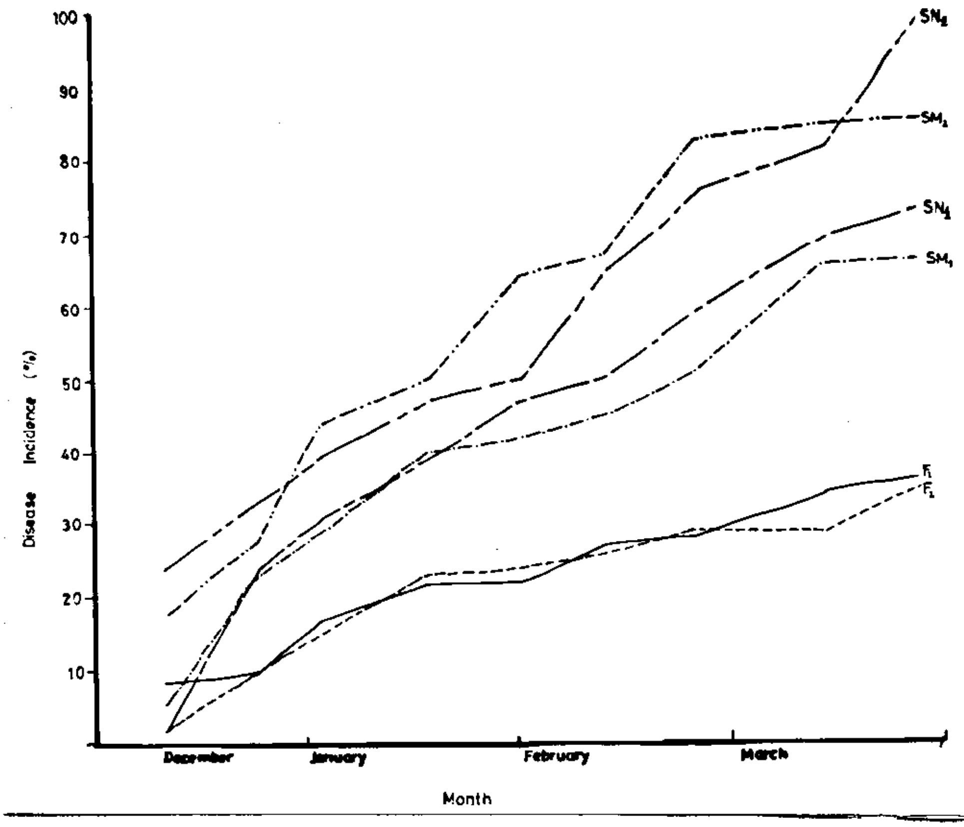


Figure 4: The development of early blight (<u>Alternari solani</u>) on tomatoes under different irrigation treatments.

F_1 : Furrow irrigation once a week.

F_2 : Furrow irrigation twice a week.

SM_1 : Morning sprinkler irrigation once a week.

SM_2 : Morning sprinkler irrigation twice a week.

SN_1 : Noon sprinkler irrigation once a week.

SN_2 : Noon sprinkler irrigation twice a week.

3. Powdery mildew; Leveillula taurica (Lev.) Arn.

Evaluation of powdery mildew disease on tomatoes began when the first symptom appeared on tomato leaves on December 10, 1978, and was terminated on March 24, 1979, during which nine observations were recorded. The disease was found in its conidial stage (Oidiopsis taurica Tipper) throughout the experiment. Powdery mildew of tomatoes developed better in the furrow-irrigated plots (Fig. 3).

Analysis of variance for the incidence of powdery mildew on tomatoes indicated no significant differences among frequencies of irrigation used, but there were significant differences among treatment and among the interactions between frequencies of irrigation and treatment (App. V). Among treatments, there were no differences in the effect of sprinkler irrigation in the morning or at noon on the incidence of the disease, but furrow irrigation induced the highest disease incidence. Concerning frequencies of irrigation, sprinkling once a week had a higher disease incidence than sprinkling twice a week. Within each frequency, furrow irrigation had a higher disease incidence than both sprinkling in the morning and at noon, but there were no differences between means of incidence for sprinkler irrigation in the morning or at noon in their effect on the incidence of the disease (Tab. 3).

Analysis of variance for the severity of powdery mildew on tomatoes indicated significant differences among treatments used, but indicated no significant differences among frequencies of irrigation and among the interactions between frequencies of irrigation and treatments (App. VI). Among treatments, there were no differences in the effect of sprinkler irrigation in the morning or at noon on the severity of the disease, but furrow irrigation had a higher disease severity than sprinkling in the morning or at noon. Concerning frequencies of irrigation, once or twice a week had no difference in their effect on the severity of the disease. Within each frequency, there were no differences between means of incidence for sprinkler irrigation in the morning and at noon, or for furrow irrigation (Tab. 3).

The data presented indicated that powdery mildew was more severe in the furrow-irrigated plots than in the sprinkler-irrigated plots. Time of sprinkler irrigation had no effect on the disease. Frequency of sprinkling had no effect on the incidence or severity of the disease. Frequency of furrow irrigation influenced the incidence but did not influence the severity of the disease. The development of powdery mildew on tomatoes under different irrigation treatments is shown in figure (6).

Table 3 : Means of incidence and severity of Powdery mildow of tomato caused by <u>Leveillula taurica</u> under different irrigation treatments.

Frequency / Treatment	Incidence			Severity		
	Once	Twice	Treatment	Once	Twice	Treatment
Furrow	29.22 a	18.67 b	23.94 d	0.3767 a	0.2934a	0.335 c
Sprinkler morning	4.56 c	3.11 c	3.83 e	0.0722 b	0.0356b	0.0539 d
Sprinkler noon	3.78 c	4.56 c	4.17 e	0.0489 b	0.0478b	0.0483 d
Frequency $\bar{X}$	12.52 f	8.78 g		0.1659 e	0.1256e	

Means followed by different letters within columns and/or rows differ significantly at 5% level (DMRT).

Figure 5: Severe attack with powdery mildew of tomatoes. (Leveillula taurica) in furrow irrigated plots.

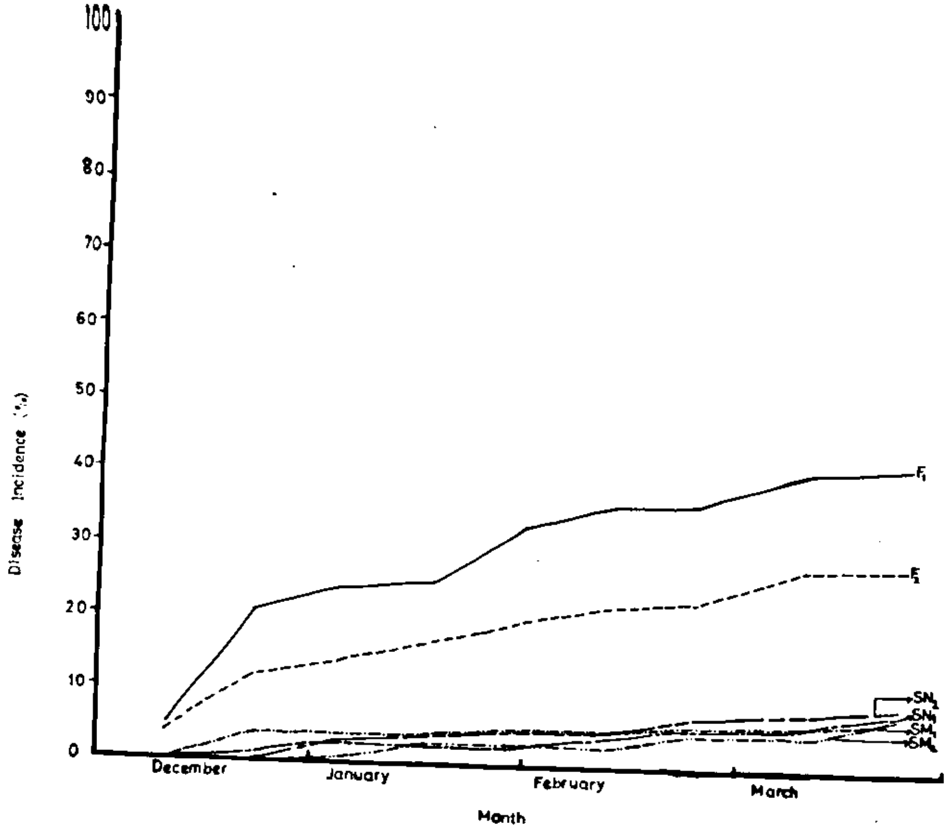


Figure 6: The development of powdery mildew (<u>Leveillula taurica</u>) on tomatoes under different irrigation treatments.

F_1 : Furrow irrigation once a week.

F_2 : Furrow irrigation twice a week.

SM_1: Morning sprinkler irrigation once a week.

SM_2: Morning sprinkler irrigation twice a week.

SN_1: Noon sprinkler irrigation once a week.

SN_2: Noon sprinkler irrigation twice a week.

4. Sclerotinia stem rot; Sclerotinia sclerotiorum (Lib.) DBy.

Evaluation of Sclerotinia stem rot on tomatoes began when the first symptom appeared on tomato stems on January 17, 1979 and was terminated on April 8, 1979, during which seven observations were recorded. The disease attacked the stem and the fruits of tomatoes (Fig. 4).

Analysis of variance for incidence and severity of Sclerotinia stem rot on tomatoes indicated no significant differences among frequencies of irrigation used, among treatments and among the interactions between frequencies of irrigation and treatments (App. VII, VIII; Tab. 4).

The data presented indicated that sprinkler and furrow irrigation had similar effect on Sclerotinia stem rot disease. Time and frequency of irrigation had also no effect on the disease. The development of Sclerotinia stem rot on tomatoes under different irrigation treatments is shown in figure (8).

Table 4 : Means of incidence and severity of Sclerotinia stem rot of tomato caused by Sclerotinia sclerotiorum **under** different irrigation treatments.

Frequency / Treatment	Incidence			Severity		
	Once	Twice	Treatment $\bar{X}$	Once	Twice	Treatment $\bar{X}$
Furrow	1.66 a	1.14 a	1.4 b	0.0336 a	0.0293 a	0.0315 b
Sprinkler morning	1.29 a	2.55 a	1.92 b	0.0265 a	0.0664 a	0.0465 b
Sprinkler noon	2.78 a	2.28 a	2.53 b	0.065 a	0.06 a	0.0625 b
Frequency $\bar{X}$	1.91 c	1.99 c		0.0417 c	0.0519 c	

Means followed by the same letters within columns and/or rows do not differ significantly at 5% level (DMRT).

Figure 7: Sclerotinia stem rot (Sclerotinia sclerotiorum) on tomatoes.

5. Tomato fruit rot.

Evaluation of tomato fruit rot began when the first symptom appeared on tomato fruits on January 28, 1979 and was terminated on March 30, 1979 during which nine observations were recorded. The disease attacked the fruits and was caused by several pathogens (Fig. 5). The pathogens isolated from the rotted fruits and the frequencies of their isolations are presented in Table (5).

Table 5 : The frequency of tomato fruit rot pathogens isolated from 50 tomato fruits.

Pathogens	Frequency of isolation
Sclerotinia sclerotiorum	58%
Rhizoctonia solani Kuehn	50%
Phytophthora infestans	50%
Alternaria solani	40%
Fusarium solani (Mart.) Appel and Wr.	30%
Fusarium oxysporum	10%
Trichothecium roseum Link	4%
Cladosporium fulvum Cke	4%
Rhizopus stolonifer Ehr.	4%

Analysis of variance for incidence of tomato fruit rot indicated significant differences among frequencies of irrigation used and among treatments, but it indicated no significant differences among the interactions between frequencies of irrigation and treatments (App. IX). Among treatments, there were no significant differences between the effect of sprinkler irrigation in the morning and at noon on the incidence of the disease, but each of them induced a higher disease incidence than furrow irrigation. Concerning frequencies of irrigation, sprinkling twice a week caused a higher percentage of fruit rot than sprinkling once a week. Within each frequency, there were no significant differences between means of incidence for sprinkler irrigation in the morning and at noon; but both of them induced higher disease incidences than furrow irrigation (Tab. 6).

The data presented indicated that sprinkler irrigation increased the incidence of tomato fruit rot. Time of sprinkler irrigation did not influence the incidence of the disease. The incidence was much more in plots sprinkled twice a week than in plots sprinkled once a week. Frequency in furrow-irrigated plots had no effect on the incidence of tomato fruit rot.

Table 6 : Means of incidence of tomato fruit rot under different irrigation treatments.

Treatment \ Frequency	Once	Twice	Treatment $\bar{X}$
Furrow	5.34 a	7.23 a	6.29 d
Sprinkler morning	11.45 b	19.11 c	15.28 e
Sprinkler noon	11.89 b	18.11 c	15.00 e
Frequency $\bar{X}$	9.56 f	14.82 g	

Means followed by different letters within columns and/or rows differ significantly at 5% level (DMRT).

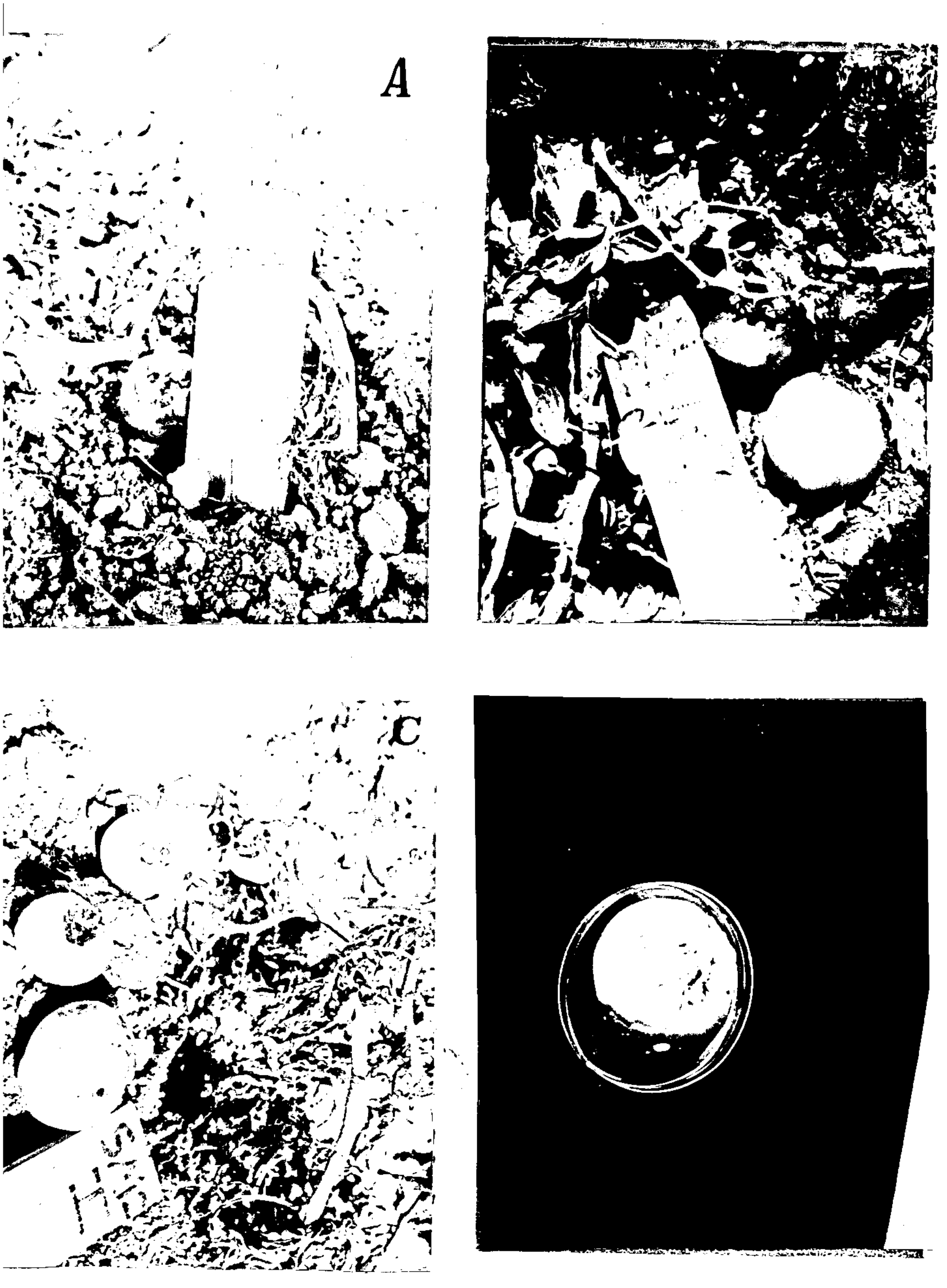
Figure 8: Tomato fruit rot incited by several Pathogens.

A: Sclerotinia sclerotiorum.

B: Alternaria solani.

C: Phytophthora infestans.

D: Fusarium solani.


A
C

6. Tomato fruit cracking

Evaluation of tomato fruit cracking began when the first symptom appeared on tomato furits on January 28, 1979 and was terminated on March 30, 1979 during which nine observations were recorded (Fig. 6).

Analysis of variance for incidence of tomato fruit cracking indicated significant differences among frequencies of irrigation used and among treatments, but indicated no significant differences among the interactions between frequencies of irrigation and treatments (App. X). Among treatments, there were no significant differences between the effect of sprinkler irrigation in the morning or at noon on the incidence of the disease, but in each of them the incidence of fruit cracking was higher than in furrow irrigation. Concerning frequencies of irrigation, sprinkling twice a week caused higher percentage of cracking than sprinkling once a week. Within each frequency, there was no significant difference between means of incidences for sprinkler irrigation in the morning and at noon; but both of them induced a higher disease incidence than furrow irrigation (Tab. 7).

The data presented indicated that sprinkler irrigation increased the incidence of tomato fruit cracking considerably. Time of sprnkler irrigation had no effect on the incidence of the disease. Frequency of irrigation had an effect on the disease. Irrigating twice a week increased the incidence of the disease

Table 7 : Means of incidence of tomato fruit cracking under different irrigation treatments.

Treatment \ Frequency	Once	Twice	Treatment X̄
Furrow	2.89 a	6.56 b	4.73 e
Sprinkler morning	10.89 c	17.22 d	14.06 f
Sprinkler noon	10.56 c	15.78 d	13.17 f
Frequency X̄	8.11 g	13.19 h	

Means followed by different letters within columns and/or rows differ significantly at 5% level (DMRT).

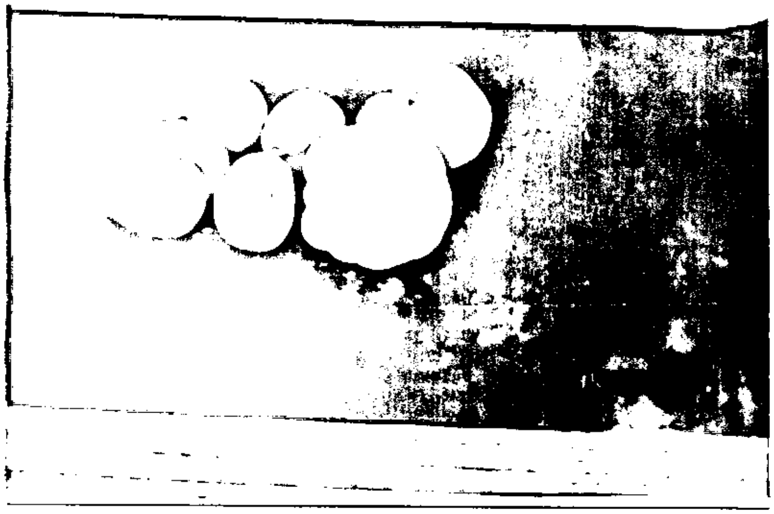


Figure 9 : Cracking on tomato fruits.

B. Effect of Irrigation on the Development of Eggplant Diseases:

1. Sclerotinia stem rot, Sclerotinia sclerotiorum (Lib.) DBy.

Evaluation of Sclerotinia stem rot disease began on January 17, 1979 and was terminated on April 8, 1979 during which seven observations were recorded. The disease attacked the eggplants and caused white stem rot (Fig. 7).

Analysis of variance for incidence and severity of Sclerotinia stem rot on eggplants indicated no significant differences among frequencies of irrigation, treatments, and among the interactions between frequencies of irrigation and treatments (App. XI, XII; Tab. 8).

The data presented indicated that sprinkler or furrow irrigation had no significant effect on the incidence and severity of the disease. Time of irrigation did not influence the disease and frequencies of irrigation used had no effect either.

Table 8 : Means of incidence and severity of Sclerotinia stem rot of eggplant caused by Sclerotinia sclerotiorum under different irrigation treatments.

Frequency / Treatment	Incidence			Severity		
	Once	Twice	Treatment $\bar{X}$	Once	Twice	Treatment $\bar{X}$
Furrow	21.01 a	13.58 a	17.3 b	0.6915 a	0.4729 a	0.5822 b
Sprinkler morning	11.32 a	10.8 a	11.06 b	0.33 a	0.3486 a	0.3393 b
Sprinkler noon	9.54 a	10.37 a	9.96 b	0.3108 a	0.3522 a	0.3315 b
Frequency $\bar{X}$	13.96 c	11.58 c		0.4441 c	0.3912 c	

Means followed by the same letters within columns and/or rows do not differ significantly at 5% level (DMRT).

Figure 10: Sclerotinia stem rot (Sclerotinia sclerotiorum) with sclerotia in the pith of eggplants.

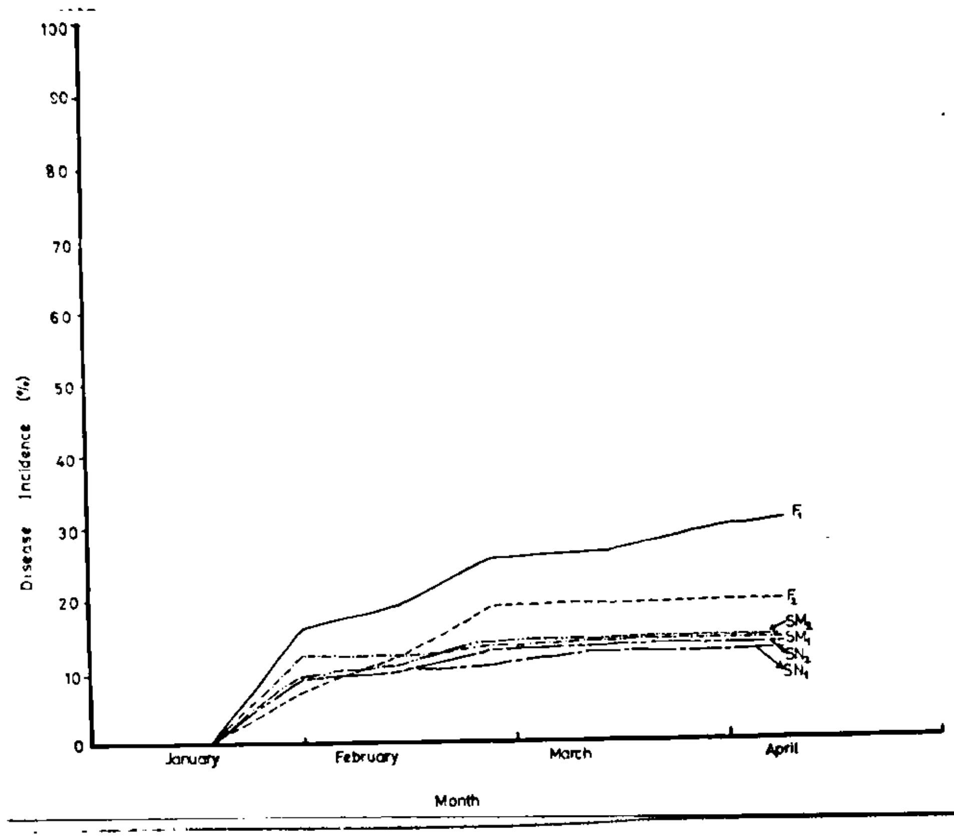


Figure 11: The development of Sclerotinia stem rot (Sclerotinia sclerotiorum) on eggplants under different irrigation treatments.

F_1 : Furrow irrigation once a week.

F_2 : Furrow irrigation twice a week.

SM_1 : Morning sprinkler irrigation once a week.

SM_2 : Morning sprinkler irrigation twice a week.

SN_1 : Noon sprinkler irrigation once a week.

SN_2 : Noon sprinkler irrigation twice a week.

2. *Fusarium* wilt; *Fusarium oxysporum* Schlecht.

Evaluation of *Fusarium* wilt disease began when the first symptom appeared on eggplants on February 27, 1979 and was terminated on April 10, 1979 during which five observations were recorded (Fig. 8).

Analysis of variance for incidence and severity of *Fusarium* wilt on eggplants indicated no significant differences among frequencies of irrigation used, among treatment and among the interactions between frequencies of irrigation and treatments (App. XIII, XIV; Tab. 9).

The data presented indicated that *Fusarium* wilt disease was not affected with the mode, time, and frequency of irrigation.

Tests carried out to prove the pathogenicity of different isolates of *Fusarium oxysporum* showed that all isolates, whether from eggplants or tomatoes, were pathogenic and virulent to eggplant (Fig. 9).

Some of the inoculated seedlings showed wilt symptoms after 5 days of inoculation, however all seedlings were wilted after 25 days of inoculation.

Table 9 : Means of incidence and severity of *Fusarium* wilt of eggplant caused by *Fusarium oxysporum* under different irrigation treatments.

Frequency / Treatment	Incidence			Severity		
	Once	Twice	Treatment $\bar{X}$	Once	Twice	Treatment $\bar{X}$
Furrow	5.16 a	2.89 a	4.03 b	0.181 a	0.098 a	0.14 b
Sprinkler morning	9.23 a	2.6 a	5.92 b	0.367 a	0.081 a	0.224b
Sprinkler noon	6.85 a	3.5 a	5.18 b	0.269 a	0.091 a	0.18 b
Frequency $\bar{X}$	7.08 c	3.0 c		0.272 c	0.09 c	

Means followed by the same letters within columns and/or rows do not differ significantly at 5% level (DMRT).

Figure 12: Fusarium wilt of eggplants (Fusarium oxysporum).

Figure 13: A: Inoculated eggplant seedlings with different isolates of Fusarium oxysporum. B: Healthy seedlings as a control.

3. Leaf spot; Alternaria solani (Ell.+G. Martin) Sor.

Evaluation of leaf spot disease on eggplants began when the first symptom appeared on eggplant leaves on January 30, 1979 and was terminated on March 27, 1979 during which five observations were recorded.

Analysis of variance for incidence of leaf spot on eggplants indicated no significant difference among frequencies of irrigation used, but there were significant differences among treatments and among the interactions between frequencies of irrigation and treatments (App. XV). Among treatments, there were no significant differences between sprinkling in the morning or sprinkling at noon on the incidence of the disease, but each of them induced higher disease incidence than furrow irrigation. Concerning frequencies of irrigation, twice a week induced a higher disease incidence than irrigation once a week. Within each frequency, there were no differences between means of incidences for sprinkler irrigation in the morning and at noon; but each of them had a higher disease incidence than furrow irrigation (Tab. 10).

Analysis of variance for the severity of leaf spot on eggplants indicated significant difference among frequencies of irrigation used, among treatments and among the interactions between frequencies of irrigation and treatments (App. XVI). Among treatments, there were no significant differences between irrigation in the morning or irrigation at noon on the severity of the disease, but both of them induced higher disease severity than furrow irrigation. Among frequencies of irrigation, twice a week induced higher significant level of severity than did irrigation once a week. The interactions between frequencies of irrigation and treatments were also significant, at each frequency level, there were no significant differences between means of severity for sprinkler irrigation in the morning and at noon; but each of them induced a higher disease severity than furrow irrigation (Tab. 10).

The data presented indicated that sprinkler irrigation increased the incidence and severity of leaf spot disease on eggplants compared with the furrow irrigation. Time of irrigation had no effect on the disease. Frequency of sprinkler irrigation did not influence the incidence of the disease but influenced the severity of the disease. Frequency of furrow irrigation did not affect the incidence or the severity of the disease.

Table 10 : Means of incidence and severity of leaf spot of eggplant caused by <u>Alternaria solani</u> under different irrigation treatments.

Frequency / Treatment	Incidence			Severity		
	Once	Twice	Treatment $\bar{X}$	Once	Twice	Treatment $\bar{X}$
Furrow	40.0 a	46.4 a	43.2 c	0.22 a	0.3 a	0.26 d
Sprinkler morning	79.6 b	83.6 b	81.6 d	0.652 b	1.216 c	0.934 e
Sprinkler noon	75.2 b	86.4 b	80.8 d	0.632 b	1.164 c	0.898 e
Frequency $\bar{X}$	64.93 e	72.13 c		0.5013f	0.8933g	

Means followed by different letters within columns and/or rows differ significantly at 5% level (DMRT).

4. Powdery mildew; Leveillula taurica (Lev.) Arn.

Powdery mildew of eggplant appeared for the first time on 7th, March, 1979 on furrow-irrigated treatments, but with nigligible incidence and severity. On the same day rain fell down and the disease development stopped. Data were taken thereafter two times, on 20-3 and on 29-3-1979. The data showed that the disease incidence and severity were more on furrow treatments irrigated once a week than on treatments irrigated twice a week.

V. DISCUSSION

The results obtained from this research indicated that watering by sprinkler irrigation rather than by furrow irrigation favored the development of late blight, early blight, tomato fruit rot, tomato fruit cracking as well as leaf spot on eggplants These results agreed with others who studied tomato and eggplant diseases under differnt modes of irrigation. Cox and Large (1960), Rotem *et al.* (1962) and Rotem and and Palti (1969) showed that late blight developed on sprinkler irrigated plots and was almost absent on furrow irrigated plots and Guthrie (1958); Rotem and Palti (1969) found similar results when early blight of tomatoes was studied. The later authors found that sprinkler irrigation precipitated the spores of *Phytophthora infestans* and *Alternaria solani* from the air, splashed them about, and provided the moisture necessary for abundant sporulation and germination of the conidia and the successful establishment of the pathogen in the host. Tomato fruit rot and tomato fruit cracking were also favaored by sprinkler irrigation. Sprinkler irrigation provided a layer of free water on tomato fruits which aided the growth of the fungi and caused tomato fruit rot. Crossan and

Lloyd (1956) found that sprinkler irrigation increased the incidence of tomato fruit rot due primarily to Rhizoctonia solani. More water might have been applied to the sprinkled plots consequently the plants took up more water which raised their turgor pressure and caused the epidermis to rapture and led to fruit cracking (Molenaar and Vincent, 1951).

Powdery mildew of tomatoes and eggplants in the Jordan Valley was suppressed under sprinkler irrigation. The disease had higher significant incidence and severity under furrow irrigation than under sprinkler irrigation. The causal agent required low humidity level which was provided when the plots were furrow irrigated.

Sclerotinia stem rot of tomatoes and eggplants and Fusarium wilt of eggplants developed with sprinkler as well as with furrow irrigation. Both sprinkler and furrow irrigation might have provided and maintained sufficient moisture in the area near the plant stem where the canopy shaded the soil surface and provided the most conducive environment for apothecia and ascospore germination and for mycelial growth (Newton and Squeira, 1972; Schwartz and Steadman, 1977).

In the Jordan Valley late blight on tomatoes had higher incidence and severity when tomato plants were sprinkled in the morning than at noon. The effect of sprinkling on late blight development was connected with the time of spore dispersal and survival under climatic conditions. The sporangia of *P. infestans* dispersed early in the morning, usually about 3 hours after sunrise (Rotem *et al*., 1970), and failed to survive dry days. Consequently late blight development was more serious under sprinkler irrigation in the morning than at noon. Sprinkler at noon might come too late to rescue spores if the preceding hours had been very dry, but might find some viable spores which might germinate if atmospheric humidity had been at a fairly high level. These results agreed with Rotem *et al*. (1970), who found that under marginal conditions sprinkler irrigation encouraged blight and morning irrigation had greater effect than midday irrigation.

Late blight, early blight, tomato furit rot, tomato fruit cracking and leaf spot of eggplant were found in this research to be more severe when the plants were sprinkled twice a week than when they were sprinkled once a week.The higher humidity periods might have assisted late blight, early blight on tomatoes, and leaf spot on eggplants to develop more than on plots sprinkled only once a week. The plants were not wetted by furrow irrigation, so irrigating once or twice a week did not induce any effect on incidence and severity of these diseases. These results agreed with those of Rotem *et al*.(1962)

and Guthrie (1958). Sprinkler irrigation added more water, and the free water on the fruits aided the germination, growth, and penetration of the fungi causing tomato fruit rot. Consequently this disease was more serious when tomatoes were sprinkled twice a week than once a week. In furrow irrigation the fruits were not wetted whether they were watered once or twice a week, so there was no effect on tomato fruit rot in furrow irrigated plots.

Crossan and Lloyd (1956) found that tomato plots receiving four sprinkler irrigations in a 30-day periods had a significantly higher incidence of tomato fruit rot caused primarily by Rhizoctonia solani. Fruits of tomatoes irrigated twice a week took up more water than fruits of tomatoes irrigated once a week resulting in high turgor pressure which caused the rapture of the epidermis and led to cracking. Nassar (1971) found that more cracking was induced in plots receiving heavy irrigation through the season. In contrast, low soil moisture reduced cracking. He also found that intervals between irrigations had little effect on tomato fruit cracking.

Frequency of sprinkler irrigation had no effect on development of powdery mildew on tomatoes or eggplants. However powdery mildew on furrow irrigated plots receiving one irrigation per week was more serious than on those receiving two irrigations per week. It appeared that furrow irrigation twice a week had some effect on the microclimate of the foliosphere as the incidence and severity of powdery mildew was less with furrow irrigation twice a week.

Sclerotinia stem rot of tomatoes and eggplants and *Fusarium* wilt of eggplants were not affected with the frequency of irrigation whether the plants were irrigated by sprinkler or furrow irrigation. Whether irrigation was once a week or twice a week, disease incidence and severity were not affected. Contradicting results were found by Schwartz and Steadman (1977) who found that irrigating the plots at 5 day intervals increased apothecial production, especially when compared to irrigating at 10 day intervals. However, there were no reports available on the influence of frequency of furrow irrigation on apothecial production or disease incidence.

Pathogenicity test

The pathogenicity tests indicated that all isolates tested of *Fusarium oxysporum* whether from eggplants or tomatoes were pathogenic and virulent to eggplants. The results obtained showed that the isolates used were not host specific, however this needs further investigation.

VI. SUMMARY

This research was carried out between October, 1978 and April 1979 in the Jordan Valley to survey in a quantitative way the diseases of tomatoes and eggplants under different modes, times, and frequency of irrigation. Diseases of tomatoes and eggplants studied were late blight and early blight of tomatoes, tomato fruit rot and cracking, *Sclerotinia* stem rot, powdery mildew of tomatoes and eggplants, *Fusarium* wilt and leaf spot of eggplants.

Diseases favored by sprinkler as compared to furrow irrigation were: late blight and early blight of tomatoes, tomato fruit rot, tomato fruit cracking, and leaf spot of eggplants. Powdery mildew of tomatoes and eggplants was supressed under sprinkler irrigation. However, mode of irrigation whether sprinkler or furrow, did not influence the incidence and severity of *Sclerotinia* stem rot of tomatoes and eggplants or *Fusarium* wilt of eggplants.

Out of all diseases favored by sprinkler irrigation only late blight of tomates was affected by the time of sprinkling; sprinkling in the morning increased the disease

more than sprinkling at noon.

Plots receiving two sprinkler irrigations every week had a significantly high incidence and severity of the following diseases: late blight and early blight of tomatoes, tomato fruit rot and tomato fruit cracking. Leaf spot of eggplants had only a high mean of severity when eggplants were sprinkled twice a week, but frequency of sprinkling did not influence the incidence of the disease. Also frequency of sprinkling did not influence the incidence and severity of powdery mildew of tomatoes, Sclerotinia stem rot of tomatoes and eggplants and Fusarium wilt of eggplants. Furrow-irrigated plots twice a week increased the incidence of tomato fruit cracking and decreased the incidence and severity of powdery mildew of tomatoes and eggplants, but did not influence the incidence or severity of late and early blight of tomatoes, tomatoes fruit rot and leaf spot of eggplants, and Sclerotinia stem rot of tomatoes and eggplants, or the severity of powdery mildew of tomatoes.

Pathogenicity test showed that all isolates tested of F. oxysporum isolated from eggplants or tomatoes were pathogenic to eggplant seedlings.

VII. Arabic Summary

الملخص العربـــــــــي

أجريت هذه الدراسة على نباتات البندورة والباذنجان فى الفترة الواقعـــة ما بين تشرين أول ١٩٧٨ ونيسان ١٩٧٩م فى منطقة وادى الأردن باستخـــدام طريقتى الرى بالرشاشات وبالخطوط واستخدمت ست معاملات هى رى بالرشاشـــات مرة واحدة فى الاسبوع ومرتين فى الاسبوع، صباحا وظهرا ، ورى بالخطوط مرة واحده ومرتين فى الاسبوع، وذلك لدراسة تأثير هذه المعاملات على أمراض كل من البندوره والباذنجـــــان .

واستعملت أثناء التجربة معاملات زراعية متشابهة ما عدا الرى . وكانت النتائج تؤخذ بانتظام كل اسبوعين مرة لتقدير نسبة الاصابة بكل مرض على حدة ، وشدة الاصابة بهذا المرض. كذلك أجريت العدوى على بادرات الباذنجان لمعرفة الفطر المسبب لذبول الباذنجان .

وأظهرت النتائج أن الرى بالرشاشات يزيد من نسبة وشدة الاصابة لمعظـــم الامراض التي أصيبت بها البندورة والباذنجان وهى : اللفحة المبكرة والمتأخـــرة فى البندورة ، وعفن وتشقق ثمار البندورة وتبقع أوراق الباذنجان .

أما مرض البياض الدقيقى على البندورة والباذنجان فقد تبين أن الرى بالخطوط يزيد من نسبة وشدة الاصابة به اذا ما قورنت بالرى بالرشاشات. وهناك أمراض لم تظهر فروقا معنوية بين الرى بالرشاشات أو بالخطوط وهى : العفن الأبيض فـــى البندورة والباذنجان وذبول الفيوزاريوم فى الباذنجان .

كما أظهرت النتائج أن موعد الرى بالرشاشات كان مهما بالنسبة لمرض اللفحـــة المتأخرة فى البندورة حيث أن الرى بالرشاشات صباحا يزيد من نسبة وشـــــدة

المرض عنه ظهرا . أما الأمراض الأخرى فلا يوجد تأثير لموعد الرى بالرشاشات عليها .

كما أن الرى بالرشاشات مرتين فى الاسبوع يزيد من الاصابة بالأمراض التاليه : اللفحة المتأخرة والمبكرة على البندورة ، عفن ثمار البندورة ، تشقق ثمار البندورة ، وتبقع أوراق الباذنجان ، لكن لا يظهر أثر تكرار الرى بالرشاشات مرتين أسبوعيا على زيادة الاصابة بالأمراض التالية : العفن الأبيض والبياض الدقيقى على البندورة والباذنجان وذبول الفيوزاريوم فى الباذنجان . أما الرى بالخطوط مرتين أسبوعيا فقد تبين أنه يؤثر على زيادة الاصابة بتشقق ثمار البندورة ولكنه لا يؤثر على اللفحة المتأخرة والمبكرة فى البندورة وعفن ثمار البندورة وتبقع أوراق الباذنجان كما أنه لا يؤثر على شدة الاصابة بمرض البياض الدقيق على البندورة ولكنه يؤثر على زيادة نسبة الاصابة بهذا المرض .

وأظهرت تجربة العدوى الاصطناعية أن الفطر <u>Fusarium</u> <u>oxysporum</u> المعزول من الباذنجان والبندورة قد سبب ذبولا لأشتال الباذنجان خلال ٢٥ يوما من العدوى .

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IX. APPENDICES

Appendix I: Means of incidence of late blight (*Phytophthora infestans*) on tomatoes under different irrigation treatments.

Irrigation treatments	Replication	Means of % incidence*		Arcsin values	
		Once	Twice	Once	Twice
Furrow	I	15.33	16	23.03	23.58
	II	13.67	17	21.72	24.35
Sprinkler morning	I	30.67	56.67	33.65	48.85
	II	34.33	59.67	35.85	50.59
Sprinkler noon	I	21.67	37	27.76	37.47
	II	23.67	39	29.13	38.65

Analysis of variance

Source of variation	df	SS	MS	Observed F	Required 5%	Required 1%
Frequency X treatment plots	11	2695.3[illegible]	245.03			
Frequency plots	3	625	208.33	612.73		
Blocks	1	8.33	8.33	24.5	161	4052
Frequency	1	616.33	616.33	1812.74	161	4052
Error (a)	1	0.34	0.34			
Treatments	2	1780.27	890.14	423.88	6.94	18
Frequency X treatment	2	281.63	140.82	67.06	6.94	18
Error (b)	4	8.41	2.1			

* Incidence percentages were taken on samples of 50 leaves and each incidence mean was the average of six readings.

Appendix II: Means of severity of late blight(*Phytophthora infestans*) on tomatoes under different irrigation treatments.

Irrigation treatment	Replication	Means of severity*	
		Once	Twice
Furrow	I	0.3533	0.3433
	II	0.3667	0.4167
Sprinkler morning	I	0.7533	1.1133
	II	0.8200	1.1533
Sprinkler noon	I	0.5967	0.8300
	II	0.6200	0.8833

Analysis of variance

Source of variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Frequency X treatment	11	0.8981	0.0816			
Frequency plots	3	0.1325	0.0442			
Blocks	1	0.0061	0.0061	20.3333	161	4052
Frequency	1	0.1261	0.1261	420.3333	161	4052
Error(a)	1	0.0003	0.0003			
Treatments	2	0.7083	0.3542	1180.6666	6.94	18
Frequency X treatment	2	0.056	0.028	93.3333	6.94	18
Error(b)	4	0.0013	0.0003			

* Severity was estimated using a scale of (0-4) ; severity readings were determined on samples of 50 leaves and each severity mean was the average of six readings.

Appendix III: Means of incidence of early blight(*Alternaria solani*) on tomatoes under different irrigation treatments.

Irrigation treatment	Replication	Means of % incidence*		Arcsin values	
		Once	Twice	Once	Twice
Furrow	I	25.11	21.56	30.07	27.69
	II	20.44	21.33	26.85	27.49
Sprinkler morning	I	43.78	60.44	41.44	51
	II	37.78	55.56	37.94	48.22
Sprinkler noon	I	43.56	57.56	41.32	49.37
	II		56.22	4.55	48.56

Analysis of variance

Source of variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Frequency X treatment plots	11	933.63	84.88			
Frequency plots	3	101.05	33.68			
Blocks	1	8.81	8.81	14.44	161	4052
Frequency	1	91.63	91.63	150.21	161	4052
Error (a)	1	0.61	0.61			
Treatments	2	762.23	381.12	249.1	6.94	18
Frequency X treatments	2	64.24	32.12	20.99	6.94	18
Error (b)	4	6.11	1.53			

* Incidence percentages were taken on samples of 50 leaves and each incidence mean was the average of nine readings.

Appendix IV: Means of severity of early blight (*Alternaria solani*) on tomatoes under different irrigation treatments.

Irrigation treatment	Replication	Means of severity*	
		Once	Twice
Furrow	I	0.2422	0.2756
	II	0.2289	0.2622
Sprinkler morning	I	0.5778	1.0644
	II	0.6156	1.0311
Sprinkler noon	I	0.5000	0.9578
	II	0.4622	1.0844

Analysis of variance

Source of variation	df	SS	MS	Observed F	Required F	
					5%	1%
Frequency X treatment plots	11	1.2782	0.1162			
Frequency plots	3	0.3509	0.117			
Blocks	1	0.0004	0.0004	0.57	161	4052
Frequency	1	0.3498	0.3498	499.71	161	4052
Error (a)	1	0.0007	0.0007			
Treatment	2	0.7718	0.3859	167.78	6.94	18
Frequency X treatments	2	0.1463	0.0732	31.83	6.94	18
Error (b)	4	0.0092	0.0023			

* Severity was estimated using a scale of (0-4); severity readings were dtermined on samples of 50 leaves and each severity mean was the average of nine readings.

Appendix V: Means of incidence of Powdery mildew (Leveillula taurica) on tomatoes under different irrigation treatments.

Irrigation treatment	Replication	Means of incidence* %		Arcsin values	
		Once	Twice	Once	Twice
Furrow	I	31.33	18.89	34.02	25.77
	II	27.11	18.44	31.37	25.4
Sprinkler morning	I	4.89	4.22	12.79	11.83
	II	4.22	2	11.83	8.13
Sprinkler noon	I	4	5.56	11.54	13.69
	II	3.56	3.56	10.94	10.94

Analysis of variance

Source of variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Frequency X treatment plots	11	906.21	82.38			
Frequency plots	3	34.02	11.34			
Blocks	1	10.13	10.13	17.77	161	4052
Frequency	1	23.32	23.32	40.91	161	4052
Error (a)	1	0.57	0.57			
Treatments	2	834.23	417.12	401.08	6.94	18
Frequency X treatments	2	33.82	16.91	16.26	6.94	18
Error (b)	4	4.14	1.04			

* Incidence percentages were taken on samples of 50 leaves and each incidence mean was the average of nine readings.

Appendix VI: Means of severity of powdery mildew (*Leveillula taurica*) on tomatoes under different irrigation treatments.

Irrigation treatment	Replication	Means of severity*	
		Once	Twice
Furrow	I	0.4222	0.3089
	II	0.3311	0.2778
Sprinkler morning	I	0.0800	0.0511
	II	0.0644	0.0200
Sprinkler noon	I	0.0533	0.0578
	II	0.0444	0.0378

Analysis of variance

Source of variation	df	SS	MS	Observed F	Required F	
					5%	1%
Frequency X treatment plots	11	0.2286	0.0208			
Frequency plots	3	0.0082	0.0027			
Blocks	1	0.0032	0.0032	16	161	4052
Frequency	1	0.0048	0.0048	24	161	4052
Error (a)	1	0.0002	0.0002			
Treatments	2	0.2150	0.1075	215	6.94	18
Frequency X treatments	2	0.0035	0.0018	3.6	6.94	18
Error (b)	4	0.0019	0.0005			

* Severity was estimated using a scale of (0-4); severity readings were determined on samples of 50 leaves and each severity mean was the average of nine readings.

Appendix VII: Means of incidence of Sclerotinia stem rot (Sclerotinia sclerotiorum) on tomatoes under different irrigation treatments.

Irrigation treatment	Replication	Means of % incidence*		Arcsin Values	
		Once	Twice	Once	Twice
Furrow	I	3.21	1.56	10.31	7.27
	II	0.11	0.71	1.81	4.8
Sprinkler morning	I	2.57	4.59	9.28	12.39
	II	0.00	0.50	0.00	4.05
Sprinkler noon	I	3.56	4.56	10.94	12.39
	II	2.00	0.00	8.13	0.00

Analysis of variance

Source of variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Frequency X treatment plots	11	229.03	20.82			
Frequency plots	3	160.37	53.46			
Blocks	1	159.79	159.79	280.33	161	4052
Frequency	1	0.01	0.01	0.0175	161	4052
Error (a)	1	0.57	0.57			
Treatments	2	7.34	3.67	0.3929	6.94	18
Frequency X treatments	2	23.96	11.98	1.28	6.94	18
Error (b)	4	37.36	9.34			

* Incidence percentages were taken on samples of 150 plants and each incidence mean was the average of seven readings.

Appendix VIII: Means of severity of Sclerotinia stem rot (Sclerotinia sclerotiorum) on tomatoes under different irrigation treatments.

Irrigation treatment	Replication	Means of severity *	
		Once	Twice
Furrow	I	0.0643	0.0400
	II	0.0029	0.0186
Sprinkler morning	I	0.0529	0.1257
	II	0.0000	0.0071
Sprinkler noon	I	0.0757	0.1200
	II	0.0543	0.0000

Analysis of variance

Source of variation	df	SS	MS	Observed F	Required F	
					5%	1%
Freuqncy X treatment plots	11	0.0214	0.0019			
Frequency plots	3	0.0146	0.0049			
Blocks	1	0.013	0.013	10	161	4052
Frequency	1	0.0003	0.0003	0.23	161	4052
Error (a)	1	0.0013	0.0013			
Treatments	2	0.0019	0.001	1.11	6.94	18
Frequency X treatments	2	0.0013	0.0007	0.78	6.94	18
Error (b)	4	0.0036	0.0009			

* Severity was estimated using a scale of(0-4); severity readings were determined on 150 plants and each severity mean was the average of seven readings.

Appendix IX: Means of incidence of tomato fruit rot under different irrigation treatments.

Irrigation treatment	Replication	Means of % incidence*		Arcsin values	
		Once	Twice	Once	Twice
Furrow	I	6	7.78	14.18	16.22
	II	4.67	6.67	12.52	15
Sprinkler morning	I	10.67	18.89	19.09	25.77
	II	12.22	19.33	20.44	26.06
Sprinkler noon	I	12.89	19.33	21.05	26.06
	II	10.89	16.89	19.28	24.27

Analysis of variance

Source of variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Frequency X treatment plots	11	256.71	23.34			
Frequency plots	3	61.9	20.63			
Blocks	1	1.92	1.92	48	161	4052
Freqnency	1	59.94	59.94	1498.5	161	4052
Error (a)	1	0.04	0.04			
Treatments	2	182.56	91.28	85.31	6.94	18
Frequency X treatments	2	7.99	4.	3.74	6.94	18
Error (b)	4	4.26	1.07			

* Incidence percentages were taken on samples of 50 tomato fruits and each incidence mean was the average of nine readings.

Appendix X : Means of incidence of tomato fruit cracking under different irrigation treatments.

Irrigation treatment	Repli-cation	Means of % incidence*		Arcsin values	
		Once	Twice	Once	Twice
Furrow	I	2.44	6.22	8.91	14.42
	II	3.33	6.89	10.47	15.23
Sprinkler morning	I	9.56	16	18.05	23.58
	II	12.22	18.44	20.44	25.4
Sprinkler noon	I	10.89	14.89	19.28	22.71
	II	10.22	16.67	18.63	24.12

Analysis of variance

Source of variation	df	SS	MS	Observed F	Required F	
					5%	1%
Frequency X treatment plots	11	311.05	28.28			
Frequency plots	3	77.94	25.98			
Blocks	1	4.49	4.49	112.25	161	4052
Frequency	1	73.41	73.41	1835.25	161	4052
Error (a)	1	0.04	0.04			
Treatments	2	230.02	115.01	169.13	6.94	18
Frequency X treatments	2	0.36	0.18	0.26	6.94	18
Error (b)	4	2.73	0.68			

* Incidence percentages were taken on samples of 50 tomato fruits and each incidence mean was the average of nine readings.

Appendix XI: Means of incidence of *Sclerotinia* stem rot (*Sclerotinia sclerotiorum*) on eggplants under different irrigation treatments.

Irrigation treatment	Replication	Means of % incidence*		Arcsin values	
		Once	Twice	Once	Twice
Furrow	I	28.89	10.36	32.52	18.81
	II	13.13	16.79	21.22	24.20
Sprinkler morning	I	11.57	11.30	19.91	19.64
	II	11.06	10.29	19.46	18.72
Sprinkler noon	I	9.04	8.50	17.46	16.95
	II	11.04	12.23	18.44	20.44

Analysis of variance

Source of variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Frequency X treatment plots	11	192.71	17.52			
Frequency plots	3	38.65	12.88			
Blocks	1	0.66	0.66	0.02	161	4052
Frequency	1	8.76	8.76	0.30	161	4052
Error (a)	1	29.23	29.23			
Treatments	2	77.65	38.83	2.8	6.94	18
Frequency X treatments	2	20.84	10.42	0.75	6.94	18
Error (b)	4	55.57	13.89			

* Incidence percentages were taken on samples of 90 plants and each incidence mean was the average of seven readings.

Appendix XII: Means of severity of Sclerotinia stem rot(Sclerotinia sclerotiorum)on egg-plants under different irrigation treatments.

Irrigation treatment	Replication	Means of severity*	
		Once	Twice
Furrow	I	0.9329	0.3700
	II	0.4500	0.5757
Sprinkler morning	I	0.3429	0.3671
	II	0.3171	0.3300
Sprinkler noon	I	0.2986	0.2686
	II	0.3229	0.4357

Analysis of variance

Source of variation	df	SS	MS	Observed F	Required F	
					5%	1%
Frequency X treatment plots	11	0.3655	0.0332			
Frequency plots	3	0.0663	0.0221			
Blocks	1	0.0019	0.0019	0.03	161	4052
Frequency	1	0.0084	0.0084	0.15	161	4052
Error (a)	1	0.056	0.056			
Treatments	2	0.1626	0.0813	3.42	6.94	18
Frequency X treatments	2	0.0414	0.0207	0.87	6.94	18
Error (b)	4	0.0952	0.0238			

* Severity was estimated using a scale of (0-4); severity readings were determined on 90 plants and each severity mean was the average of seven readings.

Appendix XIII: Means of incidence of *Fusarium* wilt (*Fusarium oxysporum*) on eggplants under different irrigation treatments.

Irrigation treatment	Replication	Means of % incidence*		Arcsin values	
		Once	Twice	Once	Twice
Furrow	I	5.71	2.66	13.81	9.46
	II	4.6	3.11	12.39	10.14
Sprinkler morning	I	5.32	2.3	13.31	8.72
	II	13.13	2.89	21.22	9.81
Sprinkler noon	I	3.95	1.62	11.54	7.27
	II	9.75	5.37	18.24	13.44

Analysis of variance

Source of variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Frequency X treatment plots	11	176.83	16.08			
Frequency plots	3	123.08	41.03			
Blocks	1	37.2	37.2	16.17	161	4052
Frequency	1	83.58	83.58	36.34	161	4052
Error (a)	1	2.3	2.3			
Treatments	2	6.77	3.39	0.38	6.94	18
Frequency X treatment	2	11.88	5.94	0.68	6.94	18
Error (b)	4	35.1	8.78			

* Incidence percentages were taken on samples of 90 plants and each incidence mean was the average of five readings.

Appendix XIV: Means of severity of *Fusarium* wilt (*Fusarium oxysporum*) on eggplants under different irrigation treatments.

Irrigation treatment	Replication	Means of severity*	
		Once	Twice
Furrow	I	0.188	0.072
	II	0.174	0.124
Sprinkler morning	I	0.206	0.050
	II	0.528	0.112
Sprinkler noon	I	0.158	0.026
	II	0.380	0.156

Analysis of variance

Source of variation	df	SS	MS	Observed F	Required F	
					5%	1%
Frequency X treatment plots	11	0.2229	0.0203			
Frequency plots	3	0.1564	0.0521			
Blocks	1	0.0499	0.0499	7.34	161	4052
Frequency	1	0.0997	0.0997	14.66	161	4052
Error (a)	1	0.0068	0.0068			
Treatments	2	0.0143	0.0072	0.91	6.94	18
Frequency X treatment	2	0.0206	0.0103	1.3	6.94	18
Error (b)	4	0.0316	0.0079			

* Severity was estimated using a scale of (0-4); severity readings were determined on samples of 99 plants and each severity mean was the average of five readings.

Appendix XV: Means of incidence of leaf spot (*Alternaria solani*) on eggplants under different irrigation treatments.

Irrigation treatment	Replication	Means of incidence*		Arcsin value	
		Once	Twice	Once	Twice
Furrow	I	43.2	44.8	41.09	42.02
	II	36.8	48.0	37.35	43.85
Sprinkler morning	I	80.8	84.0	64.01	66.42
	II	78.4	83.2	62.31	65.8
Sprinkler noon	I	77.6	87.2	61.75	69.04
	II	72.8	85.6	59.08	67.7

Analysis of variance

Source of variation	df	SS	MS	Observed F	Required F	
					5%	1%
Frequency X treatment plots	11	1565.36	142.31			
Frequency plots	3	82.21	27.4			
Blocks	1	5.65	5.65	1.06	161	4052
Frequency	1	71.24	71.24	13.39	161	4052
Error (a)	1	5.32	5.32			
Treatments	2	1464.8	732.4	770.95	6.94	18
Frequency X treatment	2	14.55	7.28	7.66	6.94	18
Error (b)	4	3.8	0.95			

* Incidence percentages were taken on samples of 25 leaves and each incidence mean was the average of five readings.

Appendix XVI: Means of severity of leaf spot(*Alternaria solani*) on eggplants under different irrigation treatments.

Irrigation treatment	Replication	Means of severity*	
		Once	Twice
Furrow	I	0.216	0.264
	II	0.224	0.336
Sprinkler morning	I	0.624	1.192
	II	0.680	1.240
Sprinkler noon	I	0.648	1.144
	II	0.616	1.840

Analysis of variance

Source of variation	df	SS	MS	Observed F	Required F	
					5%	1%
Frequency X treatment plots	11	1.7645	0.1604			
Frequency plots	3	0.4654	0.1551			
Blocks	1	0.0031	0.0031	2.3846	161	4052
Frequency	1	0.461	0.461	354.62	161	4052
Error (a)	1	0.0013	0.0013			
Treatments	2	1.1502	0.5751	958.5	6.94	18
Frequency X treatment	2	0.1465	0.0733	122.1667	6.94	18
Error (b)	4	0.0024	0.0006			

* Severity was estimated using a scale of (0-4); severity readings were determined on samples of 25 leaves and each severity mean was the average of five readings.