GLOBAL JOURNAL OF BIOLOGY, AGRICULTURE & HEALTH SCIENCES
(Published By: Global Institute for Research & Education)
www.gifre.org

EFFECTS OF VARIETY, NITROGEN FORM AND APPLICATION TIMMING OF FUNGICIDE ON EARLY BLIGHT DISEASE ON TOMATO

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Abstract

The effect of tomato variety (open-pollinated and hybrid), nitrogen form (urea and ammonium nitrate) and the application time of the fungicide Ridomil Gold® MZ 68% on early blight disease of tomato was evaluated. A field trial was conducted for three consecutive growing seasons (2006/07, 2007/08 and 2008/09). In the growing seasons, early blight symptoms showed up naturally 12 weeks after sowing. The application of the fungicide at the onset of the disease significantly ($P \leq 0.05$) reduced disease incidence and increased tomato yield. Regarding disease incidence; the combination of the hybrid variety (Star 9008), use of ammonium nitrate fertilizer as a source of nitrogen and application of Ridomil Gold at the onset of the disease was significantly ($P \leq 0.05$) superior to all other combinations included in the experiment.

Keywords- Early blight; tomato variety; nitrogen form; application time.

1. Introduction

Early blight is one of the best-known and most economically important diseases caused by *Alternaria solani*. It is a ubiquitous disease of tomato and potato. The disease occurs over a wide range of climatic conditions and depends in large part on the frequency of foliage wetting from rainfall, fog, dew or irrigation, as well as nutritional status of foliage and cultivar susceptibility (Wharton 2009). The disease is most damaging on tomato in regions with heavy rainfall, high humidity and fairly high temperatures (24°-29°C). Epidemics can also occur in semiarid climates where frequent and prolonged night dew occurs (Chaerani and Voorrips 2006). Although, the loss due to early blight disease rarely exceeds 20% (Wharton and Kirk 2007), yield loss can be high when control measures are not probably adopted or not practiced (Shtienberg et al. 1996; Dillard et al. 1997). Early blight is responsible for a large proportion of total monetary loss sustained by tomato producers every growing season (Wharton and Kirk 2007). Dater and Mayee (1985) stated that the yield loss of tomato fruit was 78% recorded at 72% disease intensity and each 1% increase reduced tomato yield by 1.3%. Yield loss up to 79% from the disease has been reported from Canada, India, the United States of America and Nigeria (Chaerani and Voorrips 2006). In Sudan, yield loss of tomato fruit of 30.41% resulted from early blight disease as reported by Elbasheer (2004, un published data).

Control measures against the disease include a 3- to 5-year crop rotation, routine application of fungicides and the use of disease-free transplants (Sherf and MacNab 1986). Dita et al. (2007) reported that frequent fungicide spraying is commonly used to prevent crop loss. Chaerani and Voorrips (2006) stated that typically, fungicides are applied starting from two weeks after transplanting until two weeks before harvest at two- to three-weeks intervals. However, fungicide treatments are not economically feasible in all areas of the world and may not be effective under weather conditions favourable for epidemics (Herriot et al. 1986). Because early blight epidemics are polycyclic, growers heavily rely on fungicides application; which results in environmental pollution and increase production cost (Shtienberg et al. 1996; Lourenco et al. 2009). Moreover, control measures including rotation with non-host crops and sanitation are not entirely satisfactory since the fungus is primarily air-borne, has long survival ability in plant debris and has a wide solanaceous host range (Chaerani and Voorrips 2006).

Since, numerous research results indicated that nutrition of plants is one of the factors which has a measurable effect upon the course of disease development (Smith 1950), increased nutrition is prescribed as the first measure to control plant diseases (Veverka et al. 2007). Nutrition affects the rate of growth and the state of readiness of plants to defend them against pathogens attack (Agrios 2005). As regards to crop diseases, the most important impact is that of nitrogen which has an effect on vigour and plant growth. These two factors have an important impact on plant susceptibility to many diseases. Vigorous plants with rapid growth are generally more sensitive to obligate parasites and some pathogens are specifically more aggressive towards vigorous plants. However, most of the necrotic pathogens attack less vigorous plants with nitrogen deficiency. Therefore, either having high levels or low levels of nitrogen can both be detrimental to plant health and crop yields (Marschner 1999). Thomas (1948) stated "fertilization of high doses of nitrogen reduces early blight disease on tomato". Rotem (1994) reported that the practicability of such treatments is uncertain. Conversely, Huber and Watson (1974) stated "it is generally the form of nitrogen available to the host or pathogen that affects disease severity or resistance rather than the amount of nitrogen". Das and Western (1959) reported that damping-off of lettuce was doubled with NH4-N compared with NO3-N forms of nitrogen fertilizers. On the other

hand, cereal rust, and mildews generally increase with NO3-N and are reduced with NH4-N. While, *Botrytis fabae* on broad been and *Rhizoctonia solani* on bentgrass responded in an opposite manner (Huber and Watson 1974). Recently, Veverka et al. (2007) studied the sensitivity of some fungi including *Alternaria tenuissima* to urea and ammonium nitrate in a laboratory trial. The authors found that urea was the most toxic and ammonium nitrate inhibited the growth of fungi only in higher concentrations. They concluded that application of urea in practice can decrease the population of a pathogen not only by stimulation of antagonists, but also by direct toxic effect. The positive effect of urea on the control of fungal diseases is complex, expressing itself differently in acidic or alkaline soils. They also stated "sensitivity of fungi to a nitrogen form is varying among different strains of the same species".

Reducing the amount of chemicals used without crop losses is the final goal of most of the plant disease research. Therefore, this trial was conducted todetermine the effects of variety (i.e. open pollinated and hybrid), nitrogen form (urea and ammonium nitrate) and the application time of the fungicide Ridomil Gold® MZ 68% on early blight disease in tomato crop.

2. Materials and Methods

2.1 Site

A field experiment was conducted for three consecutive growing seasons (2006/07, 2007/08 and 2008/09). The experiment was conducted in the Demonstration Farm, Faculty of Agriculture, University of Khartoum (Latitude 15°40' N and longitude 32°32'E). The soil type is vertisol (Mubarak et al. 2010). The climate of the area has been described by Anon. (2000) as seasonal savana with annual rainfall of 161 millimeters (Metz 1991).

2.2 Treatments

The popular open pollinated variety, Peto 86, and the hybrid variety, Star 9008, were chosen for the study. The seeds were sown at the rate of 4-7 seeds in 10 cm plastic containers in the nursery. Each container contained 250g beat moss soil. Three weeks later in mid November, the seedlings were transplanted in the field at the rate of 2seedlings/hole and at 25cm spacing between holes on the north side of the ridge. Plants were irrigated weekly. A stand count was conducted two weeks after transplanting.

Urea 46% N and ammonium nitrate 23% N fertilizers were chosen as different sources of nitrogen. Both fertilizers were used at the rate of 100kg/fed. The fertilizers were applied in two split-doses of 50kg/fed four weeks and eight weeks after transplanting.

The fungicide used in the experiment was Ridomil Gold® MZ 68% WP (Metalaxyl L + Mancozeb) which was the only fungicide registered in Sudan for the control of early blight disease at the time of commencement of this experiment. The plants were divided into three equal categories each consisted of 16 plots. The plants in 16 plots were sprayed with the fungicide at the rate of 1kg/fed three weeks after transplanting, before the onset of the disease. A second spray was conducted two weeks after the first spray. The plants in another 16 plots were sprayed when the disease showed up nine weeks after transplanting anda second spray was conducted two weeks after the first spray. In the control treatment; comprising the remaining 16 plots; the plants were not sprayed. The fungicide applied by regular knapsack sprayer 10L at the rate of 1kg/Fed. The experimental design adopted was split split-plot. Variety was the main plot treatment, nitrogen form was the sub plot and fungicide application was the sub- sub plot treatment. Each treatment was replicated four times.

2.3 Sampling and measurement

Disease incidence was recorded weekly as percentage value. Recording of the data started when plants were 7 weeks old and continued up to harvest. Percent disease index (PDI) was recorded once at the end of each growing season. Data were recorded from five plants selected randomly in each plot. Arbitrary disease severity rating scale 0- 4 was adopted following Horsfall and Barratt (1945). In this scale, 0 = healthy plants (no visible disease symptoms), 1 = lesions occupying one quarter of the area of infected leaves, 2 = lesions occupying half the area of infected leaves, 3 = lesions occupying three quarters of the area of infected leaves, 4 = lesions occupying almost the entire leaf area. PDI was calculated following the formula of Mc Kinney (1925):

$$PDI = \frac{\text{Sum of grades of all plants rated}}{\text{Number of observations} \times \text{maximum grade value}} \times 100$$

The marketable yield is the total weight of harvested tomato fruits from which rotted and malformed fruits were discarded and expressed in ton/ha.

2.4 Statistical analysis

The percentage data were converted to square root and arcsine values (McDonald 2009). Then analysis of variance was accomplished in SAS 9.0 version, and the Duncan`s multiple range test (DMRT) (Gomez and Gomez 1984) was adopted to compare means.

3. Results and Discussion

3.1 Disease incidence

In the first growing season 2006/07 disease incidences ranging from 41.66 to 80.67 were recorded. The least disease incidence was recorded in plants of the hybrid variety, fertilized with ammonium nitrate and sprayed with the fungicide Ridomil Gold at the onset of the disease. The maximum disease incidence of 80.67 was recorded in plants of the open pollinated variety, fertilized with ammonium nitrate and sprayed with Ridomil Gold before the onset of the disease (Table. 1). Statistical analysis showed that the plants of the hybrid variety had significantly ($P \leq 0.05$) lower disease

incidence compared to the open pollinated variety (Table 4). The analysis showed that sowing of hybrid variety, the use of ammonium nitrate fertilizer as a source of nitrogen and the application of Ridomil Gold at the onset of the disease was significantly ($P \leq 0.05$) superior to all other combinations included in the experiment.

In season 2007/08, disease incidence ranged from 93.72 to 110.05. The least disease incidence was recorded in plants of the open pollinated variety, fertilized with ammonium nitrate and sprayed with the fungicide at the onset of the disease. The highest disease incidence of 110.05 was recorded in tomato plants of the hybrid variety and fertilized with ammonium nitrate as well as those fertilized with urea and no fungicide treatment (Table 2). Significant difference in disease incidence was detected between the hybrid and the open pollinated variety. On the other hand, no significant difference was detected between urea and ammonium nitrate as sources of nitrogen (Table 4). Spraying of Ridomil Gold at the onset of the disease remained the most effective in reducing disease incidence to a significant level.

By the end of the third growing season, the least disease incidence of 67.52 was recorded on plants of the hybrid variety, fertilized with urea and sprayed with the fungicide at the onset of the disease. The highest disease incidence of 89.43 was recorded in tomato plants of the open pollinated variety, and fertilized with urea (Table 3). Statistical analysis showed that the application of the fungicide at the onset of the disease significantly ($P \leq 0.05$) reduced the disease incidence (Table 4).

In this experiment, the hybrid variety showed relative resistance to early blight disease when compared with the open pollinated variety. This finding may be ascribed to the relative resistance of late cultivars which acts, in part, through the delayed formation of yield, a longer period of vegetative development and the favorable ratio of foliage to yield development (Rotem 1994).

3.2 Disease index

The least disease indexes of 2.46, 3.88 and 3.68 were recorded in seasons 2006/07, 2007/08 and 2008/09, respectively in the hybrid variety, fertilized with ammonium nitrate and sprayed with the fungicide at the onset of the disease (Table 5). The highest percent disease indexes of 3.33 and 4.93 were recorded on plants of the open pollinated variety, fertilized with ammonium nitrate and not sprayed with the fungicide in the first and the second growing season, respectively. In season 2008/09, the highest disease index of 4.65 was recorded for the hybrid variety, fertilized with ammonium nitrate and not sprayed with the fungicide. Remarkable reduction of diseases index due to the application of the fungicide at the onset of the disease was noticed in the three growing seasons, the reduction was significant ($P \leq 0.05$) in the third season (Table 6).

This finding indicates that severity of the disease is not affected by the variety. Moreover, no significant effect of nitrogen form was detected in reducing or increasing the percentage of early blight disease index (Table 6). In general, the percent disease index was less in the first season compared to the following two seasons. This is attributable to the fact that the species of the genus *Alternaria* are commonly found in the soil or on decaying plant tissues (Thomma 2003). Conducting the experiment in the same field for three consecutive seasons probably led to accumulation of the pathogen propagules. Thus, annual increase in disease incidence was detected. The increase of percent disease index with time in the same plot reflects the importance of crop rotation even with air-borne pathogens.

3.3 Yield

Table 7 showed the least marketable yield of 2.55ton/ha which recorded in the first growing season in the hybrid variety, fertilized with urea and not sprayed with the fungicide. In the second growing season, the least marketable yield of 16.07ton/ha was recorded in the hybrid variety, fertilized with ammonium nitrate and not sprayed with the fungicide. The least marketable yield of 4.47ton/ha was recorded in the third season for the open pollinated variety, fertilized with ammonium nitrate and not sprayed with the fungicide. In the three growing seasons, the highest marketable yields of 7.19ton/ha, 41.56ton/ha and 13.15ton/ha, respectively were recorded in the open pollinated variety, fertilized with urea and sprayed with Ridomil Gold at the onset of early blight disease symptoms (Table 7). It is concluded that sowing of the open pollinated variety, application of urea as a source of nitrogen and use of the fungicide Ridomil Gold at the onset of the disease was the best combination to attain the highest yield.

In this experiment, although all the treatments received the same amount of nitrogen regardless of its form, different impacts on early blight disease were observed. The least disease incidences in the three growing seasons were recorded when ammonium nitrate was used. This is in agreement with Huber and Watson (1974) who stated "it is generally the form of nitrogen available to the host or pathogen that affects disease severity or resistance rather than the amount of nitrogen". This suppression effect of ammonium nitrate on early blight disease is contradicting with the findings of Veverka et al. (2007) who studied the sensitivity of some fungi including *Alternaria tenuissima* to urea and ammonium nitrate in a laboratory trial and found that urea was the most toxic and ammonium nitrate inhibited the growth of *A. tenuissima* only at higher concentrations. This contradiction may be attributed to the fact that sensitivity of fungi to a nitrogen form varies among different strains of the same species as stated by Veverka et al. (2007). Also, Huber and Watson (1974) stated "most foliar diseases generally increase with NO3-N and are reduced with NH4-N".

So far, the main control measure of early blight disease is the routine applications of fungicides, which are usually applied from the time of emergence at approximately 7- to 10-days intervals (Wharton 2009). The results obtained from the three growing seasons proved that the application of Ridomil Gold at the onset of the disease reduces early blight disease to a significant level. This finding may be attributed to the fact that early blight disease rarely develops early but usually appears late in the growing season on mature foliage (Wharton and Kirk 2007) and often occurs initially on older foliage (MacDonald et al. 2007). The consistent results which have been reported for the effects of application of the Ridomil Gold at the onset of the disease on disease incidence, percent disease index and the marketable yield harvested imply that the application of fungicides at the onset of early blight disease should be adopted in any disease management strategy for controlling this disease.

4. Acknowledgement

The authors are thankful for Professor Magzoub Omer Bashir for his critical and proof reading of this article and Dr. Hani Eltilib for his valuable assistance in statistical analysis.

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Annexure:

Table 1: Early blight disease incidence in open pollinated (Peto 86) and hybrid (Star 9008) varieties under different treatments in season 2006/07

Treatments	Plants age (weeks)						
	12	**13**	**14**	**15**	**16**	**17**	**18**
OAmA	0.71^{c}	12.19^{ab}	26.73^{b}	32.03^{b}	40.27^{ab}	53.42^{ab}	78.84^{a}
OAmB	1.25^{c}	10.83^{ab}	24.92^{b}	30.58^{bc}	38.35^{abc}	53.95^{ab}	80.67^{a}
OAmC	0.71^{c}	19.90^{ab}	20.23^{bc}	24.22^{cd}	35.85^{abcd}	54.90^{ab}	77.66^{a}
OUA	1.15^{c}	13.05^{ab}	24.25^{b}	31.77^{b}	38.48^{abc}	50.48^{bc}	77.13^{a}
OUB	2.13^{abc}	21.09^{ab}	37.50^{a}	42.35^{a}	46.17^{a}	64.59^{a}	71.40^{a}
OUC	2.30^{abc}	16.53^{ab}	25.50^{b}	28.92^{bc}	36.56^{abcd}	58.39^{abc}	74.27^{a}
HAmA	1.18^{c}	7.13^{ab}	18.09^{bc}	21.98^{d}	25.68^{d}	34.06^{e}	41.66^{d}
HAmB	1.20^{c}	13.74^{ab}	19.87^{bc}	24.08^{cd}	27.27^{cd}	42.48^{cde}	44.78^{cd}
HAmC	2.19^{abc}	17.62^{ab}	20.12^{bc}	23.18^{cd}	27.80^{cd}	36.52^{de}	55.66^{b}
HUA	1.15^{bc}	7.48^{b}	8.94^{c}	18.38^{d}	34.47^{bcd}	40.68^{cde}	51.09^{bc}
HUB	1.53^{abc}	12.86^{ab}	20.73^{bc}	23.47^{cd}	34.57^{bcd}	45.67^{bcd}	55.06^{b}
HUC	2.98^{a}	24.26^{a}	24.26^{b}	31.99^{b}	38.07^{abc}	48.71^{bc}	55.85^{b}

*****Percentage data were transformed to Arc sine and root square. **Means followed by the same letter(s) are not significantly different at P≤0.05 according to Duncan's multiple range test (DMRT).

***Symbol: O**:Open pollinated tomato variety; **H**: Hybrid tomato variety; **Am**: Ammonium nitrate; **U**: Urea; **A**: Application of fungicide at the onset of the disease; **B**: Application of fungicide before the onset of the disease; **C**: No application of fungicide**.**

Table 2: Early blight disease incidence in open pollinated (Peto 86) and hybrid (Star 9008) varieties under different treatments in season 2006/07

Treatments	Plants age (weeks)						
	12	**13**	**14**	**15**	**16**	**17**	**18**
OAmA	0.71^{c}	12.19^{ab}	26.73^{b}	32.03^{b}	40.27^{ab}	53.42^{ab}	78.84^{a}
OAmB	1.25^{c}	10.83^{ab}	24.92^{b}	30.58^{bc}	38.35^{abc}	53.95^{ab}	80.67^{a}
OAmC	0.71^{c}	19.90^{ab}	20.23^{bc}	24.22^{cd}	35.85^{abcd}	54.90^{ab}	77.66^{a}
OUA	1.15^{c}	13.05^{ab}	24.25^{b}	31.77^{b}	38.48^{abc}	50.48^{bc}	77.13^{a}
OUB	2.13^{abc}	21.09^{ab}	37.50^{a}	42.35^{a}	46.17^{a}	64.59^{a}	71.40^{a}
OUC	2.30^{abc}	16.53^{ab}	25.50^{b}	28.92^{bc}	36.56^{abcd}	58.39^{abc}	74.27^{a}
HAmA	1.18^{c}	7.13^{ab}	18.09^{bc}	21.98^{d}	25.68^{d}	34.06^{e}	41.66^{d}
HAmB	1.20^{c}	13.74^{ab}	19.87^{bc}	24.08^{cd}	27.27^{cd}	42.48^{cde}	44.78^{cd}
HAmC	2.19^{abc}	17.62^{ab}	20.12^{bc}	23.18^{cd}	27.80^{cd}	36.52^{de}	55.66^{b}
HUA	1.15^{bc}	7.48^{b}	8.94^{c}	18.38^{d}	34.47^{bcd}	40.68^{cde}	51.09^{bc}
HUB	1.53^{abc}	12.86^{ab}	20.73^{bc}	23.47^{cd}	34.57^{bcd}	45.67^{bcd}	55.06^{b}
HUC	2.98^{a}	24.26^{a}	24.26^{b}	31.99^{b}	38.07^{abc}	48.71^{bc}	55.85^{b}

*****Percentage data were transformed to Arc sine and root square. **Means followed by the same letter(s) are not significantly different at P≤0.05 according to Duncan's multiple range test (DMRT).

***Symbol: O**:Open pollinated tomato variety; **H**: Hybrid tomato variety; **Am**: Ammonium nitrate; **U**: Urea; **A**: Application of fungicide at the onset of the disease; **B**: Application of fungicide before the onset of the disease; **C**: No application of fungicide**.**

Table 3: Early blight disease incidencein open pollinated (Peto 86) and hybrid (Star 9008) varieties under different treatments in season 2007/08

Treatments	Plants age (weeks)						
	12	**13**	**14**	**15**	**16**	**17**	**18**
OAmA	3.11^{ab}	25.98^{bc}	32.83^{bcd}	40.84^{bc}	55.15^{bcd}	60.82^{bc}	93.72^{d}
OAmB	3.24^{ab}	25.84^{bc}	35.86^{abc}	43.86^{abc}	58.18^{abc}	65.35^{abc}	100.72^{bcd}
OAmC	3.29^{ab}	29.65^{b}	34.97^{abcd}	44.98^{abc}	60.61^{abc}	65.21^{abc}	101.30^{abcd}
OUA	3.39^{ab}	23.16^{c}	27.15^{d}	37.90^{cd}	50.49^{d}	55.74^{c}	98.30^{cd}
OUB	3.62^{ab}	26.74^{bc}	30.13^{cd}	44.31^{abc}	58.12^{abc}	60.83^{bc}	96.91^{cd}
OUC	3.78^{a}	32.85^{a}	39.05^{ab}	52.77^{a}	58.39^{abc}	60.89^{bc}	104.52^{abc}
HAmA	2.38^{b}	21.05^{c}	28.88^{cd}	31.67^{d}	44.06^{d}	62.75^{abc}	98.36^{cd}
HAmB	3.50^{ab}	24.07^{bc}	32.23^{bcd}	45.55^{abc}	55.09^{bcd}	69.50^{ab}	104.94^{abc}
HAmC	3.93^{a}	32.31^{ab}	38.70^{ab}	49.52^{a}	76.59^{a}	82.54^{a}	110.05^{a}
HUA	2.30^{b}	20.20^{c}	31.40^{bcd}	38.18^{cd}	51.22^{cd}	60.43^{c}	98.95^{cd}
HUB	3.31^{ab}	30.02^{ab}	38.38^{ab}	47.36^{ab}	59.23^{bcd}	76.91^{a}	108.91^{ab}
HUC	3.98^{a}	29.26^{abc}	40.91^{a}	51.22^{a}	71.05^{ab}	76.72^{ab}	110.05^{a}

*Percentage data were transformed to Arc sine and root square. **Means followed by the same letter(s) are not significantly different at P≤0.05 according to Duncan's multiple range test (DMRT).

Symbol: O:Open pollinated tomato variety; **H**: Hybrid tomato variety; **Am**: Ammonium nitrate; **U**: Urea; **A**: Application of fungicide at the onset of the disease; **B**: Application of fungicide before the onset of the disease; **C**: No application of fungicide**.**

Table 4: Early blight disease incidencein open pollinated (Peto 86) and hybrid (Star 9008) varieties under different treatments in season2008/09

Treatments	Plants age (weeks)						
	12	**13**	**14**	**15**	**16**	**17**	**18**
OAmA	10.81^{b}	19.54^{c}	25.00^{d}	28.90^{d}	36.21^{e}	68.48^{bc}	70.73^{cd}
OAmB	13.38^{ab}	21.73^{bc}	26.52^{cd}	32.68^{cd}	51.83^{d}	72.30^{ab}	82.09^{ab}
OAmC	18.69^{ab}	25.21^{abc}	37.87^{ab}	44.31^{ab}	59.32^{bc}	79.22^{ab}	85.76^{ab}
OUA	16.12^{ab}	21.70^{bc}	26.79^{cd}	28.38^{d}	38.98^{e}	68.99^{bc}	73.73^{bcd}
OUB	19.29^{ab}	22.13^{bc}	29.78^{cd}	31.12^{cd}	53.03^{cd}	72.45^{ab}	78.66^{abc}
OUC	20.48^{ab}	26.98^{ab}	38.06^{ab}	41.30^{bc}	63.35^{ab}	87.21^{a}	89.43^{a}
HAmA	13.07^{ab}	20.26^{c}	24.89^{d}	28.89^{d}	37.94^{e}	60.94^{d}	72.10^{d}
HAmB	12.26^{ab}	24.63^{abc}	29.31^{cd}	35.96^{bc}	52.38^{cd}	72.85^{ab}	78.35^{abc}
HAmC	21.99^{a}	24.62^{abc}	36.04^{b}	42.83^{ab}	64.94^{ab}	76.91^{ab}	86.49^{ab}
HUA	19.11^{ab}	20.73^{bc}	30.09^{cd}	31.95^{cd}	48.97^{d}	62.13^{cd}	67.52^{d}
HUB	14.91^{ab}	24.22^{abc}	31.14^{c}	39.82^{b}	63.56^{ab}	71.94^{ab}	80.15^{ab}
HUC	20.45^{ab}	29.34^{a}	41.76^{a}	47.64^{a}	68.81^{a}	74.73^{ab}	84.96^{ab}

*****Percentage data were transformed to Arc sine and root square. ******Means followed by the same letter(s) are not significantly different at P≤0.05 according to Duncan's multiple range test (DMRT).

***Symbol: O**:Open pollinated tomato variety; **H**: Hybrid tomato variety; **Am**: Ammonium nitrate; **U**: Urea; **A**: Application of fungicide at the onset of the disease; **B**: Application of fungicide before the onset of the disease; **C**: No application of fungicide**.**

Table 5: ANOVA Table of disease incidences when plants age was 18 weeks in seasons 2006/07, 2007/08 and 2008/09

Treatments	Disease incidence		
	2006/07	2007/08	2008/09
Variety			
Peto 86	76.66[a]	9.49[b]	4.27
Star 9008	50.69[b]	9.78[a]	4.33
S.E (±)	2.852**	0.084*	0.063[ns]
Fertilizer			
Ammonium nitrate	63.21	9.60	4.28
Urea	64.14	9.67	4.32
S.E (±)	2.736[ns]	0.063[ns]	0.029[ns]
Fungicide application			
At (A)	62.18	9.39[b]	3.88[c]
Before (B)	62.98	9.67[ab]	4.39[b]
Control (C)	65.86	9.84[a]	4.631[a]
S.E (±)	2.348[ns]	0.084**	
CV. (%)	14.75	3.47	4.27

Ns: no significant differences between treatments, *significant differences between treatments, **: highly significant differences between treatments

Table 6: Early blight disease indexesin open pollinated (Peto 86) and hybrid (Star 9008) varieties under different treatments in seasons 2006/07, 2007/08 and 2008/09

Treatment	Means of Disease Indexes		
	2006/07	2007/08	2008/09
OAmA	3.12[a]	4.31[bc]	3.96[de]
OAmB	3.32[a]	4.42[abc]	4.20[cd]
OAmC	3.33[a]	4.63[a]	4.63[a]
OUA	3.01[a]	4.16[cd]	3.96[de]
OUB	3.11[a]	4.28[bc]	4.29[c]
OUC	3.37[a]	4.59[abc]	4.61[a]
HAmA	2.46[a]	3.88[d]	3.68[e]
HAmB	2.49[a]	4.38[abc]	4.58[abc]
HAmC	2.53[a]	4.31[bc]	4.65[ab]
HUA	2.69[a]	4.31[bc]	3.91[de]
HUB	2.77[a]	4.49[ab]	4.51[abc]
HUC	3.02[a]	4.45[abc]	4.64[ab]

*****Percentage data were transformed to Arc sine and root square.

******Means followed by the same letter(s) are not significantly different at P≤0.05 according to Duncan's multiple range test (DMRT).

***Symbol: O**:Open pollinated tomato variety; **H**: Hybrid tomato variety; **Am**: Ammonium nitrate; **U**: Urea; **A**: Application of fungicide at the onset of the disease; **B**: Application of fungicide before the onset of the disease; **C**: No application of fungicide**.**

Table 7: ANOVA Table of disease indexes when plants age was 18 weeks in seasons 2006/07, 2007/08 and 2008/09

Treatments	Disease indexes		
	2006/07	2007/08	2008/09
Variety			
Peto 86	3.21[a]	4.40[a]	4.27[a]
Star 9008	2.66[b]	4.30[a]	4.33[a]
S.E (±)	0.188**	0.058[ns]	0.063[ns]
Fertilizer			
Ammonium nitrate	2.88[a]	4.32[a]	4.28[a]
Urea	3.00[a]	4.38[a]	4.32[a]
S.E (±)	0.091[ns]	0.018[ns]	0.029[ns]
Fungicide application			
At (A)	2.82[a]	4.17[b]	3.88[c]
Before (B)	2.92[a]	4.39[a]	4.39[b]
Control (C)	3.06[a]	4.49[a]	4.63[a]
S.E (±)	0.122[ns]	0.057*	0.046**
CV. (%)	16.58	5.27	4.27

Ns: no significant differences between treatments, * significant differences between treatments, **: highly significant differences between treatments

Table 8: Marketable yield (ton/ha)in open pollinated (Peto 86) and hybrid (Star 9008) varieties under different treatments in seasons 2006/07, 2007/08 and 2008/09

Treatment	Yield (ton/ha)		
	2006/07	2007/08	2008/09
OAmA	5.37^{ab}	35.56^{ab}	8.35^{bc}
OAmB	4.81^{abc}	26.16^{bc}	8.00^{bc}
OAmC	5.03^{abc}	22.39^{cd}	4.47^{d}
OUA	7.19^{a}	41.56^{a}	13.15^{a}
OUB	4.41^{bc}	31.35^{b}	9.64^{b}
OUC	5.52^{ab}	31.83^{b}	8.19^{bc}
HAmA	4.81^{abc}	28.74^{bc}	6.94^{bcd}
HAmB	3.85^{bc}	24.32^{bcd}	6.15^{cd}
HAmC	3.96^{bc}	16.07^{d}	5.54^{cd}
HUA	3.12^{bc}	29.96^{bc}	6.10^{cd}
HUB	2.79^{bc}	24.78^{bc}	7.84^{bcd}
HUC	2.55^{c}	21.94^{cd}	5.16^{cd}

Means followed by the same letter are not significantly different at $P \leq 0.05$, according to Duncan` s Multiple Range Test (DMRT).

*__Symbol:__ **O**:Open pollinated tomato variety; **H**: Hybrid tomato variety; **Am**: Ammonium nitrate; **U**: Urea; **A**: Application of fungicide at the onset of the disease; **B**: Application of fungicide before the onset of the disease; **C**: No application of fungicide**.**