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Research Article

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Correlation And Regression Analysis On The Effects Of Shading And Mulching Materials on Growth And Yield Of Tomatoes Planted During The Rainy Season

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Keywords

correlation,
tomatoes,
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Abstract

Tomatoes during rainy seasons have low production in open field; thus, supply is low; consequently, the price is high. The potential of protected production should be explored; thus, the study was conducted to determine the correlation effects of microclimates like temperature and relative humidity under the tunnel or net covers on the growth and yield of off-season tomato; and higher net income among different treatments and treatment combinations. The Split-Split Plot in Factorial Randomized Complete Block was used. The treatments used were floating row covers, Eco-Friendly Net Covers (UV Film, EFNC Blue, EFNC Green), variety (Marimar F1 and Diamante Max F1), and mulching materials (Plastic mulch, Sawdust, Carbonized Rice Hull).On the correlation of the growth of tomato, it is shown that two varieties are positively correlated in the relative humidity that impeded the tunnel; for variety in the morning and afternoon gathering, respectively. The fruiting percentage of tomatoes was correlated to the relative humidity inside the tunnel. Diamante Max was not positively correlated. As regards the correlation of the weight of tomato to the relative humidity inside the tunnel; results show that there is a negative effect of relative humidity on the weight of tomato, Diamante Max. However, Marimar shows that there is a positive correlation between the weight of tomatoes in both morning and afternoon relative humidity.

Introduction

Situation Analysis

Tomato, (*Lycopersicum esculentum)* is an herbaceous annual in the family Solanaceae grew for its edible fruit. The plant can be erect with short stems or vine-like with long, spreading stems. The tomato plant can grow 0.7–2 m (2.3–6.6 ft) in height and as an annual, is harvested after only one growing season. Tomato may also be referred to as a love apple and originates from South America. (*https://plantvillage.org/topics/tomato/infos*). It is one of the most profitable crops in the country and it is the second most important fruit vegetable in the country in terms of area and volume of production. In 2001, a total of 17 700 hectares were planted to the crop, producing 173 700 metric tons valued at Php1, 808.7 million, which was equivalent to $36.17 million US dollars (Altoveros, C.N, and Borromeo, H.T., 2007).

A study conducted at Horticulture Research and Teaching Field of Edgerton University in Ngoro, Kenya showed that eco-friendly nets (EFNs) on germination and the performance of tomato seedlings. Tomato seeds were either raised in the open or under a permanent fine mesh net (0.4-mm pore diameter). Eco-friendly net covers modified the microclimate resulting in significantly higher day temperatures and relative humidity, compared with the open treatment. Nets increased temperature and relative humidity by 14.8% and 10.4%, respectively. Starting seeds under a net advanced seedling emergence by 2 days resulted in higher emergence percentage, thicker stem diameter, more leaves, and faster growth leading to early maturity of seedlings and readiness for transplanting. Netting improved root development by increasing root quantity and length (Gogu, Saisi, et al., 2012).

The most common tools by growers are managing the covers, by the use of the shading screens; mini tunnels that increase daytime air temperatures and can enhance the growth rates of the crops; covers that can protect crops from insects; and spun-bonded fabric that allows passage of rain and irrigation. Mini tunnels involve the placement of plastic or spun-bonded fabric sheets on metal hoops over the developing crop, resulting in a mini greenhouse effect. Plastic is usually clear and may be solid or perforated. The use of eco-friendly nets (EFNs) and floating row covers (FRCs) in protected cultivation was tested in Africa and Europe, respectively, and proved to be effective in microclimate modification. EFNs were also used in Kenya to improve tomato and cabbage transplant production. As a result of microclimate improvement, EFNs and FRCs have been reported to significantly alter air temperature and soil moisture which influence plant growth through changes in leaf characteristics, biomass accumulation, and relative growth rate leading to a better yield and crop quality (Gogu, Saide, et al., 2012).

The production of tomatoes during the rainy season is not the practice of common growers in the locality because of low production that causes the high price of the products. If only farmers know how to manage the cover then probably supply will be increased and prices is lower. On the other hand, rice hull is becoming a problem in rural areas, especially the operator of rice mill machines, most farmers are not aware of the use of carbonized rice hull as mulching materials for vegetables and sawdust are just burned and turned into ash without any beneficial impact on the soil and that can contribute to high carbon dioxide emission that can be obtained from burning. Using sawdust as mulching materials can enrich the soil when these materials are decomposed and incorporated into the soil during land preparation could be beneficial for it serves as a soil conditioner.

Objectives

The study generally aimed at evaluating the correlation and effects ofshading and mulching materials in terms of growth and yield of tomatoesplanted during the rainy season. Specifically, sought to determine the following:Correlation on temperature and relative humidity in the growth and yield of tomato plants.

Materials and Methods

Research Design

Split -Split Plot Design in Factorial Randomized Complete Block Design was employed having 10 experimental plants for each replication. Each plot has a dimension of 2m x 5.5 m with an alleyway of 1 m between plots and 1.5 m between replications with a total area of 594 square meters.

The different treatments were as follows:

Factor A- Eco-Friendly Net Covers (EFNCs)

C1- UV Film (Polyethylene) Control
C2- EFNC blue
C3- EFNC green

Factor B- Varieties of Tomatoes

V1- Diamante Max
V2- Marimar

Factor C –Mulching Materials

M1- Plastic Mulch Control
M2- Sawdust
M3- Carbonized Rice Hull

The Data Gathered were the following; the height of the plants at maturity, number of branches per plant, number of flowers per plant, fruit setting percentage, number of harvested fruits per plant weight of harvested fruits per plot, the weight of harvested fruits per tunnel. yield per plot, yield per hectare, temperature, and relative humidity inside the tunnel, this was measured using a multi-function anemometer placed 0.75 m above the mulch 10:00 am and 3:00 pm.

Analysis of Data

All data gathered were arranged, tabulated, presented, and analyzed based on the Randomized Complete Block Design. A post hoc test was done using Tukey's Honest Significant Difference to determine which among the treatment means were significantly different from the other treatment means, and the Statistical Procedures for Agricultural and Social Research were used in the statistical analysis of the data.

Results and Discussion

Correlation of Temperature Inside the Tunnel on the Plant Height and Yield of Tomato

The microclimatic conditions inside the tunnels of the eco-friendly net covers include the temperature of different gathering periods at 10:00 o'clock AM and 3:00 o'clock PM. Results of the mean internal temperature in the morning and in the afternoon were correlated to the different growth and yield parameters of tomato plants. Relationships are presented in scatter plots with regression equation (y=bx +a), coefficient of determination (R^2), and Pearson Product Moment correlations (r).as shown in Fig.1.

Regression Correlation on the Plant Height, Fruiting Percentage and Weight of Marketable Fruits of Tomato Plants

Eco-Friendly Covers and Mulch, growth at maturity, fruiting percentage, and weight of marketable fruits were correlated to the temperature in the morning and afternoon, as well as relative humidity in the morning and afternoon. These two microclimates were presumed influential to the growth and yield of crops, especially tomato and the new interventions under investigation. The relationship of growth at maturity of the two tomato varieties in the morning and afternoon temperature is presented in Figure 1 with y=2.6663 x +567, respectively. Diamante Max variety was not positively influenced by temperature in the morning and afternoon as presented in Figure 1 with y= 6.71 x +474.62. Similarly, temperature was negatively correlated to the growth of Marimar variety presented in Figure 1 with y= -13.413 x +881.7and = y=17.09x +440.96, respectively. This implies that the newly introduced management intervention like the use of Eco-Friendly covers failed to provide the ideal temperature in the morning and afternoon, instead

had caused stunting/dwarfing since the ideal height of tomato varieties used to have about 60-80cm height was not achieved. This corroborates the findings of Hatfield, J. L. and Prauger, J. H. (2015) that temperature is a primary factor affecting the rate of plant development. Moreover, warmer temperatures expected with climate change and the potential for more extreme temperature events will impact plant productivity. Pollination is one of the most sensitive phenological stages to temperature extremes across all species and during these developmental stages.

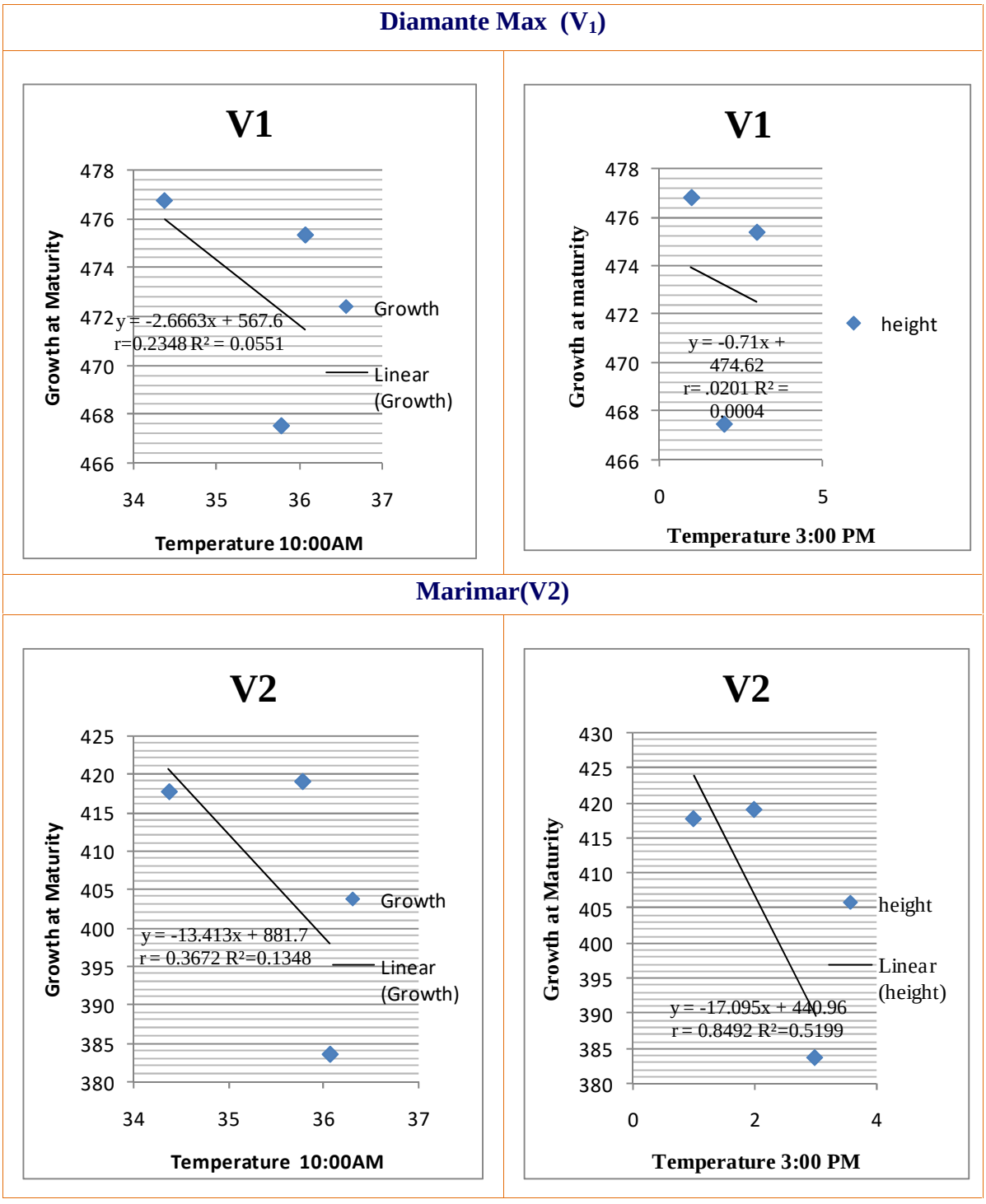

Figure 1. Relationships of temperature (10:00 AM and 3:00 PM) and height of tomato varieties at maturity

On the other hand, temperature both in the morning and afternoon as presented in Figure 2 favored the fruiting of Diamante Max variety as manifested by their positive correlation expressed in (y= 13.133x-111.58) and (y= 11.45x+330.57) in morning and afternoon, respectively; however, fruiting of Marimar tomato variety was favored by temperature only in the morning (y= 3.40x+470.09), but not in the afternoon (y=3.85+357.27). Results imply that the Diamante Max tomato variety was more responsive to temperature than the Marimar tomato variety.

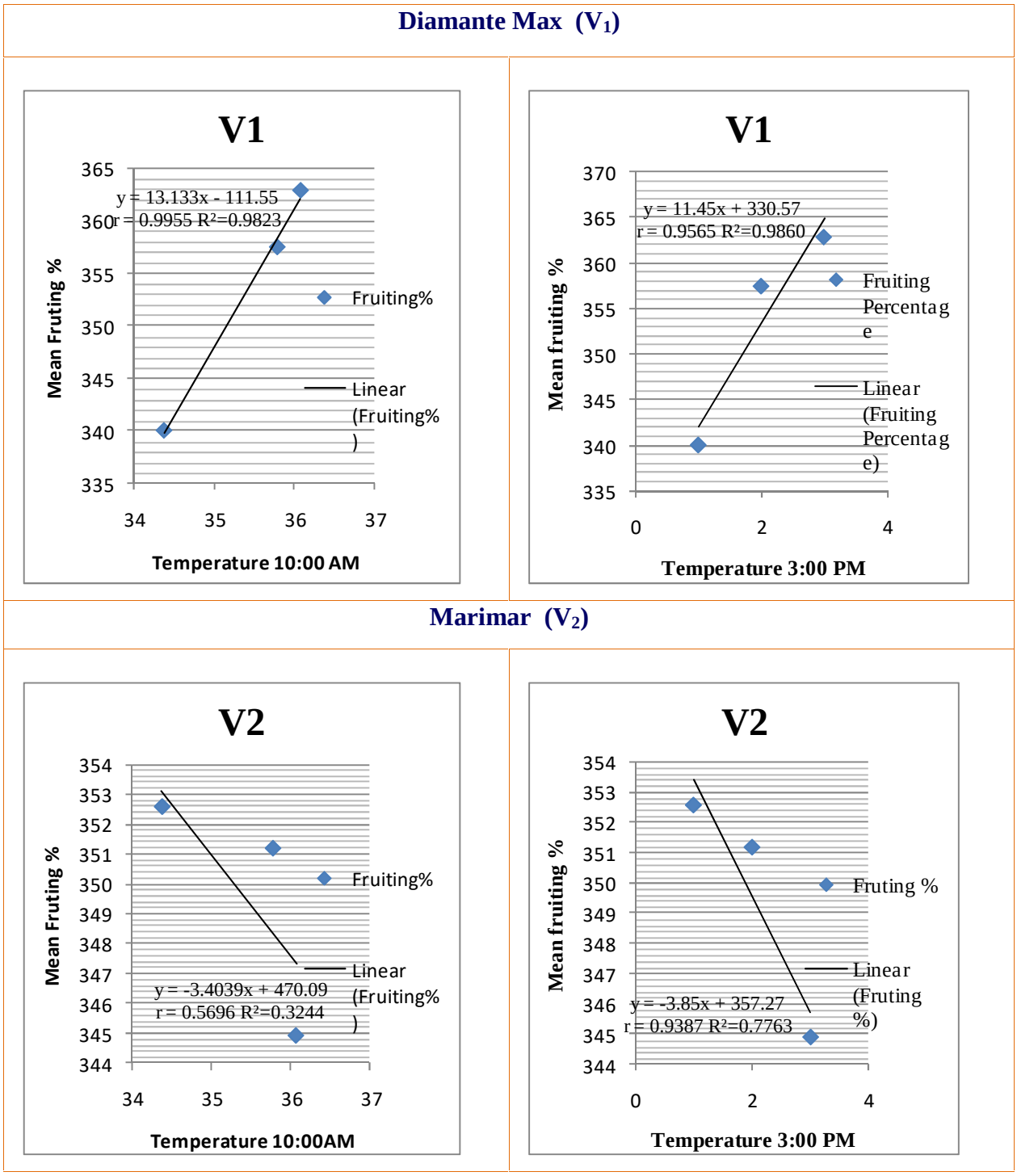

Figure 2. Relationships of temperature (10:00 AM to 3:00PM) and fruiting percentage of tomato varieties

Results cooperate with the findings of Harrel, et.al (2018) in the Mediterranean region where high summer temperatures have been proved to have a detrimental effect on the delicate tomato fruit set process. The flower to fruit set process was simultaneously monitored in fogged and unfogged shelters during the three-month Mediterranean summer season. Comparisons of pollen quality, fruit set rates and fruit yield revealed that mean daily temperatures of 25–26°C are the upper limit for proper fruit set and fruit yield for tomatoes grown in protected cultivation during the hot Mediterranean summer period. A moderate reduction of 1–1.5°C in mean daily temperatures together with the increased relative humidity from 50% to 70% during daytime improved the pollen grain's viability.

Moreover, the temperature was also correlated to the weight of marketable fruits yield of Diamante Maxas expressed in the equation y= 15.892x-179.93 in the morning and y=9.99x+362.78 in the afternoon respectively, as shown in Figure 3.

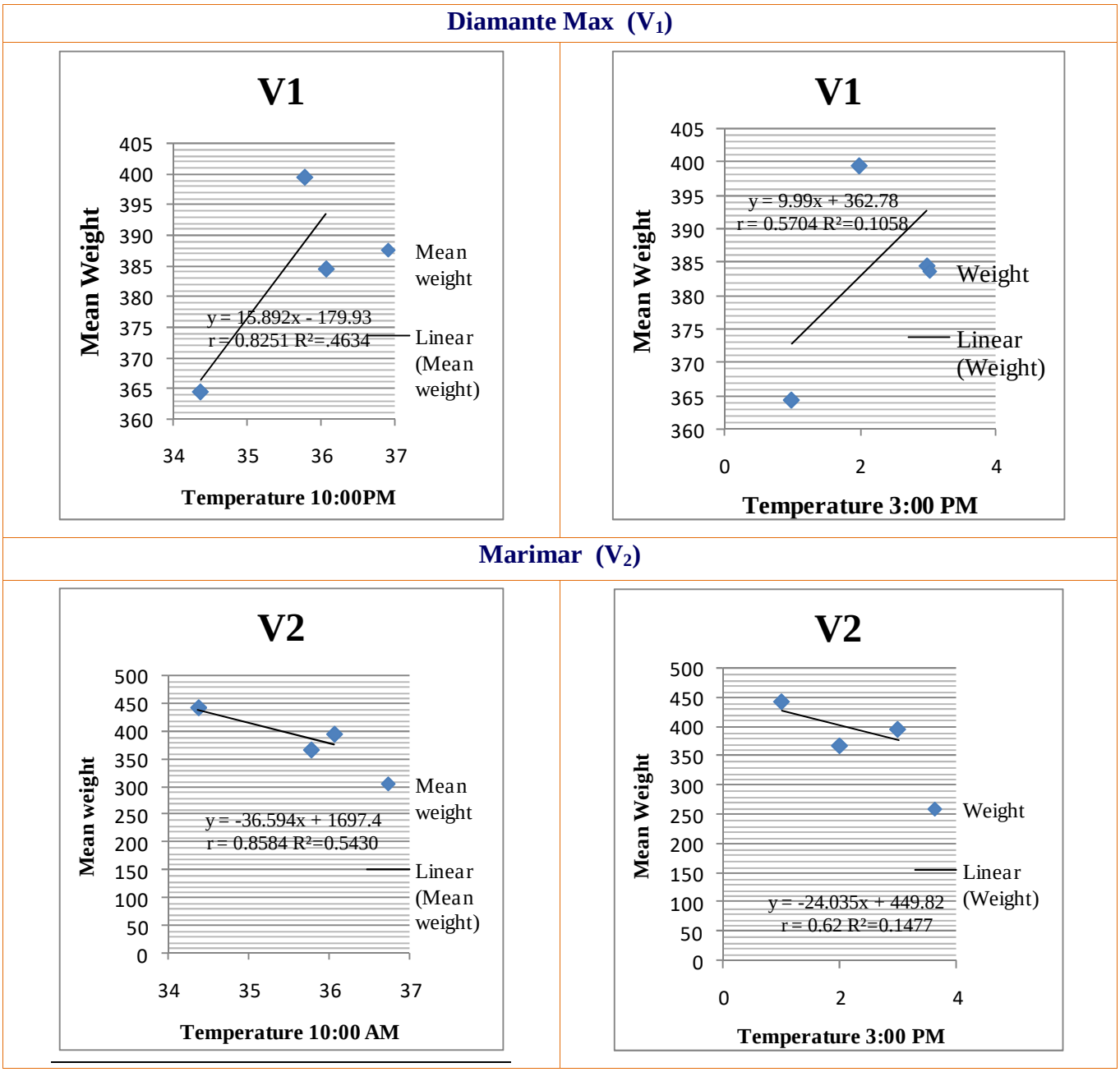

Figure 3. Relationships of temperature (10:00 AM and 3:00 PM) and weight of marketable fruit of tomato varieties per plot

Similarly, the Marimar tomato variety responded the same with a positive correlation of temperature to the weight of marketable fruits.

Correlation of Relative Humidity Inside the Tunnel on the Plant Height and Yield of Tomato

The microclimate conditions inside the tunnels at different gathering periods as reflected in Appendix Figure 4 to 6. The mean relative humidity is correlated to the growth and yield parameter of tomato plants. This relationship is presented by scatter plots with regression equation (y=bx+a), coefficient of determination (R^2), and Pearson Product Moment Correlation (r).

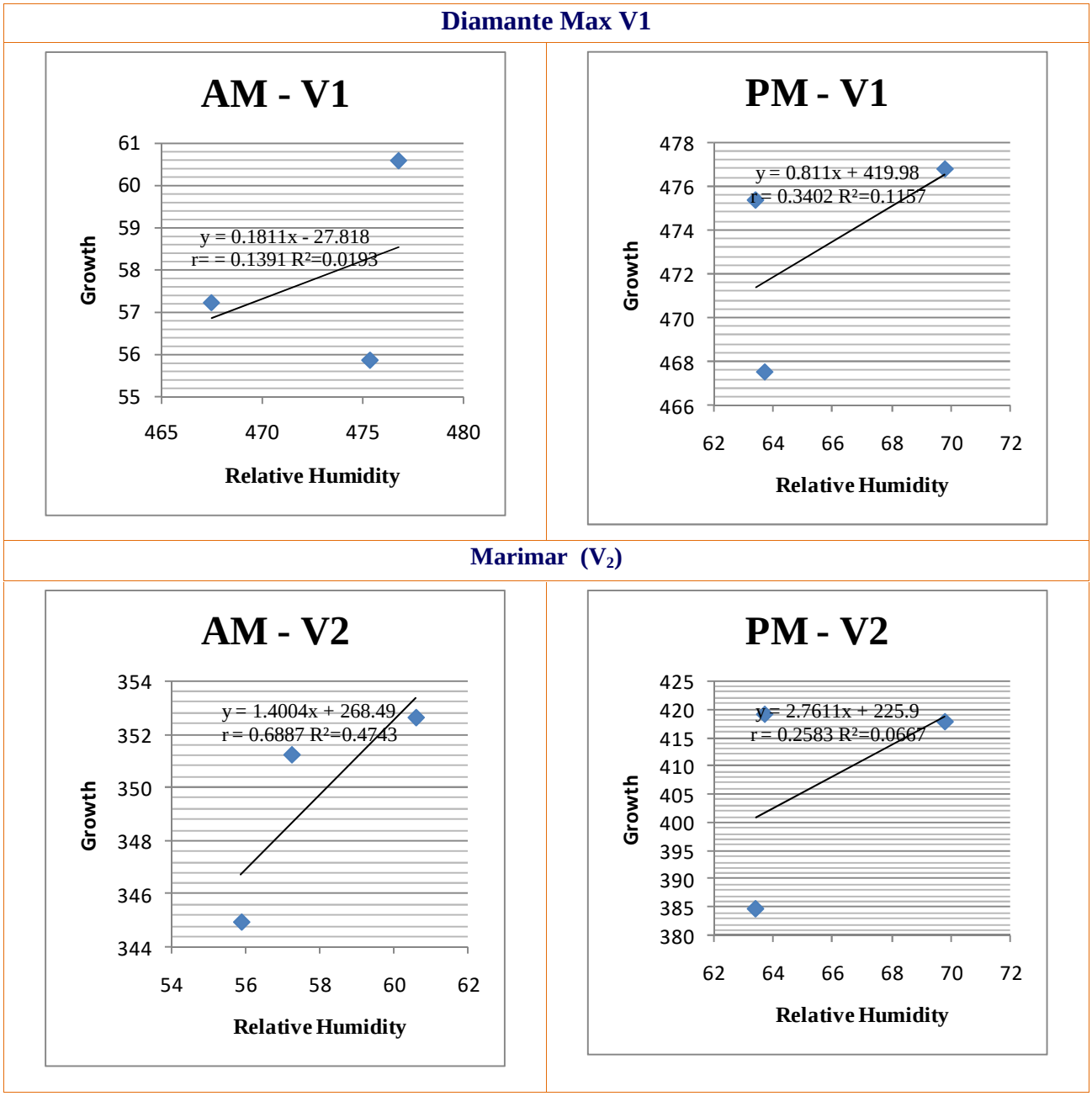

Figure 4. Relationships of relative humidity(10:00 AM and 3:00 PM) and growth at maturity of tomato varieties

Regression Correlation on the Growth, Fruiting Percentage, and Weight of Marketable Fruits of Tomato Plants

The correlation on the growth of tomato as presented in Appendix Figure 2 and the two varieties are positively correlated in the relative humidity that impeded the tunnel as presented by y= 0.8111 x – 27.818 , y= 0.811x + 419.98 on variety 1 and y = 1.4004 x + 268.49, y= 2.7611x+225.9 for variety in the morning and afternoon gathering, respectively. This goes with the statement of (polygon httm) that relative humidity levels was affected when the stomata on the undersides of their leaves/plants. Plants use stomata to transpire, or "breathe." When the weather is warm, a plant may close its stomata to reduce water losses. The stomata also act as a cooling mechanism. When ambient conditions are too warm for a plant and it closes its stomata for too long in an effort to conserve water, it has no way to move carbon dioxide and oxygen molecules, slowly causing the plant to suffocate on water vapor and its own transpired gases.

Correlation of Relative Humidity Inside the tunnel on the number of fruits per plant, fruiting percentage, and weight of fruits

The fruiting percentage of tomatoes was correlated to the relative humidity inside the tunnel as shown in Figure 5. Variety 1(Diamante Max) was not positively correlated as presented by y= 4x and y=0.2956x+170.09. This corroborates the findings of FAO (2018) that the increase in temperature above 40°C that will red own to low relative humidity will cause floral abortion and resulted in a low fruiting percentage. The decrease in fruiting percentage eventually reduces the yield per hectare. On the other hand, Variety 2 (Marimar) shows positive correlation with a y= 1.4004x +268.49 and y= 0.5906x-140.82. According to Buschermohle, et al. (2018), the relative humidity of the air surrounding hydroponic tomato plants should be maintained around 70% at night and 85% during the day. During higher humidity levels, tomato plants are more vulnerable to diseases such as grey mold, leaf mold, and powdery mildew. The results go with the statement of Auger (2020) that high humidity will cause pollen to clump, and again be unable to fertilize the female flower. Consecutive cool nights below 12° also cause blossom drop.

The correlation of weight of tomato to the relative humidity inside the tunnel is presented in Figure 6,

Results shows that there is a negative effect of relative humidity on the weight of tomato, specifically on variety 1(Diamante Max) with y= 12.578x -326.54, with the data points distributed almost evenly, with the slope of – (326.54). This means that there is a 0.326.54 cm decrease in the weight of the tomato inside the tunnel. However, Variety 2 (Marimar) on the same figure shows that there is a positive correlation on the weight of tomatoes both morning and after relative humidity which is supported by y=5.3984x + 695.33 and y= - 4.3089x + 665.54, respectively. This shows that Diamante Maxis positively correlated to the relative humidity inside the tunnel that favors the weight of the harvested plants. This means that every kilogram of the air in the respective space contains 75 percent of the maximum amount of water that it can hold for the given temperature. Yazisi and Kanyak (2009) states that a major problem in arid and semi-arid regions is the excessive heating of the tree canopy and fruit, especially those exposed to direct solar radiation. Under such conditions, fruit and leaf surface temperatures may reach very high levels having undesirable effects on fruit skin properties (e.g., sunburn). The surface temperatures of the fruits were measured with thermocouples throughout the season. The fruit surface temperatures that cause sunburn vary between 41°C and 47.5°C depending on air temperature. Maximum FST exceeded 47.5°C in some days of July, August, and September during the experimental period in the orchard. Maximum daily air temperatures were highly correlated with maximum FST and never exceeded 41-47.5°C in days when the maximum air temperature was below 30°C. Mean solar radiation between 610 Wm^{-2} and 900 Wm^{-2} was also highly correlated with maximum FST. The ratios of relative humidity around 70% and 80% inversely showed a correlation with maximum FST.

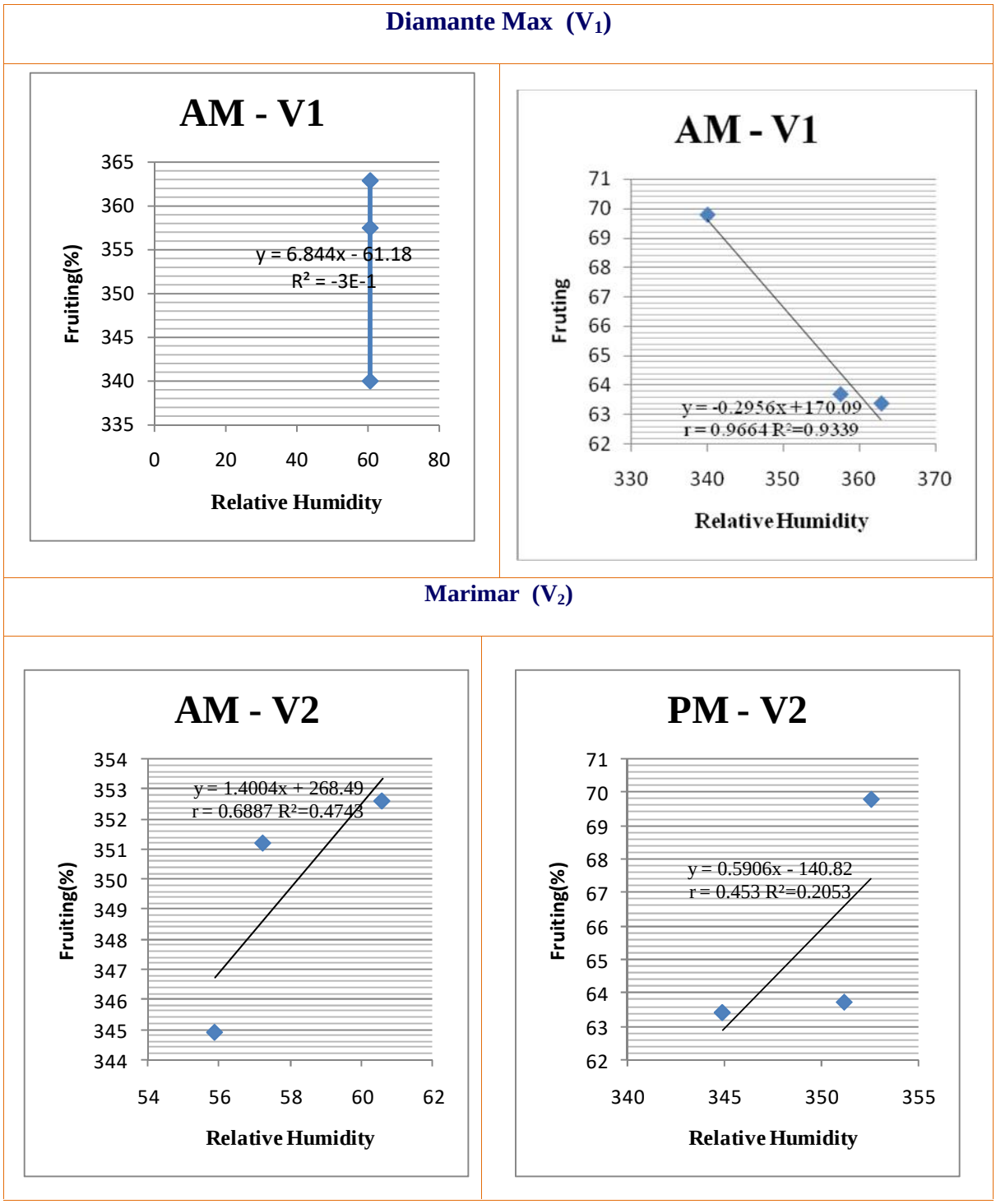

Figure 5. Relationships of relative humidity (10:00AM and 3:00 PM) and fruiting percentage of tomato varieties per plot

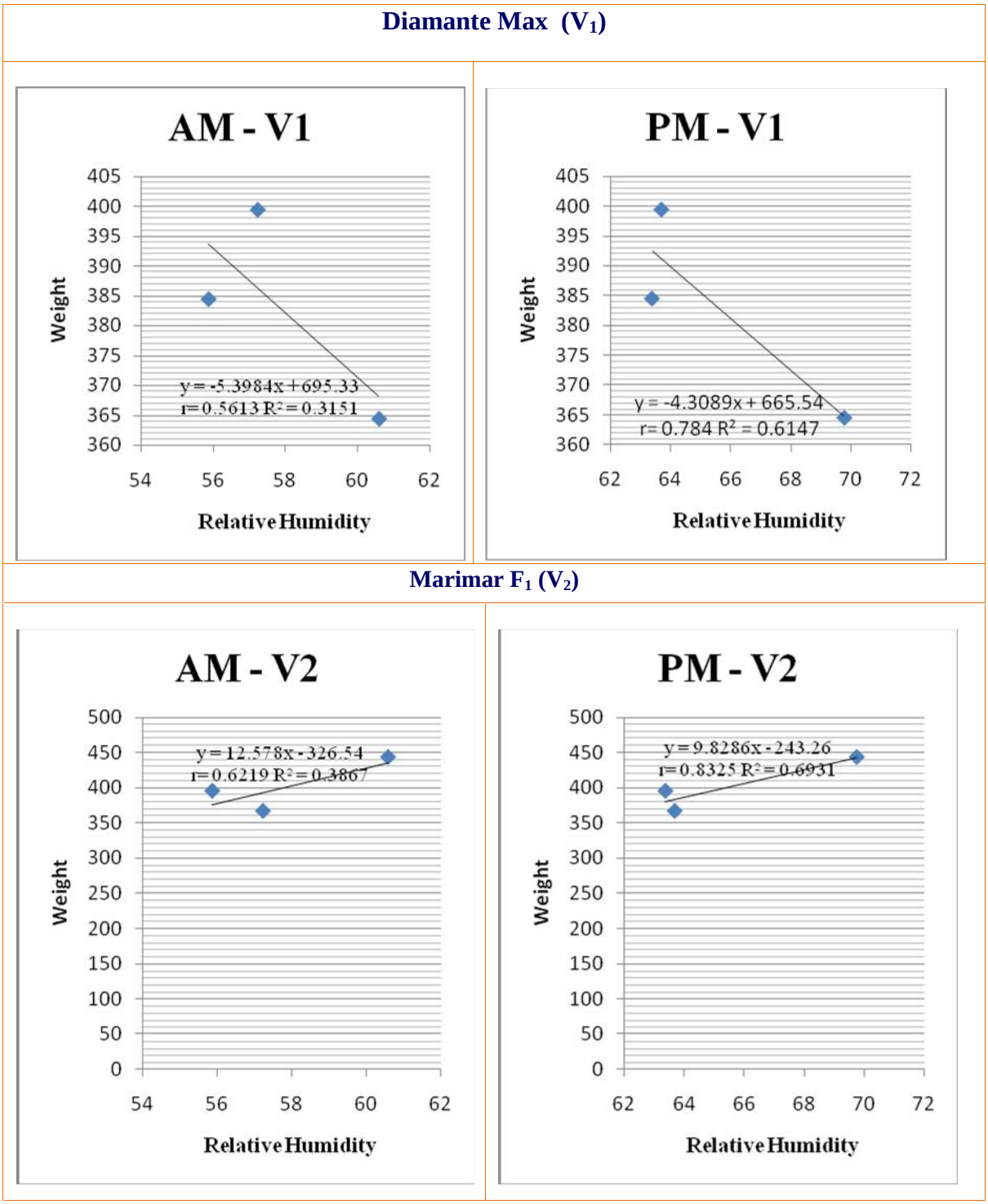

Figure 6. Relationships of relative humidity (10:00AM and 3:00 PM) and weight of tomato varieties at maturity

Summary

On the correlation of the growth of tomato, it is shown that two varieties are positively correlated in the relative humidity that impeded the tunnel; thus, y= 0.8111 x – 27.818, y= 0.811x + 419.98 on variety 1, and y = 1.4004 x + 268.49, y= 2.7611x+225.9 for variety in the morning and afternoon gathering, respectively.

The fruiting percentage of tomato was correlated to the relative humidity inside the tunnel. Variety 1(Diamante Max) was not positively correlated (y= 4x and y=0.2956x+170.09). The decrease in fruiting percentage eventually reduced the yield per hectare. On the other hand, Variety 2 (Marimar) shows positive correlation with (y= 1.4004x +268.49 and y= 0.5906x-140.82).

As regards the correlation of weight of tomato to the relative humidity inside the tunnel; results show that there is a negative effect of relative humidity on the weight of tomato, specifically on Variety 1(Diamante Max) with y= 12.578x - 326.54, with the data point distributed almost evenly, as the slope of – 326.54. This means that there is a 0.326.54 cm decrease in the weight of tomatoes inside the tunnel. However, Variety 2 (Marimar) shows that there is a positive correlation on the weight of tomatoes both morning and after relative humidity (y=5.3984x + 695.33 and y= - 4.3089x + 665.54, respectively).

Conclusions

Based on the results of the study, the following conclusions were derived; Higher temperatures inside the tunnel improved the growth of tomato plants in terms of height and number of branches per plant, but lowered the weight of marketable fruits per plot and yield per hectare; Relative humidity (%) had a downhill (negative) linear relationship with the growth of tomatoes, but increased the weight of marketable fruits per plot and yield per hectare.

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