Growth and Yield Performance of Grafted Tomato Varieties Under Protective Structures

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Abstract

Among the tomato varieties located in Mapandan, Mayantoc, Tarlac, Sherry significantly had longer vine length at 30, 60, and 90 days after transplanting,. It also had shorter days from flowering to first fruit picking. Moreover, besides havingmore number of fruit picking, Sherry had heavier fruits that were marketable with total and computed yields. All its protective structures significantly increased percentage survival with vine length at 90 DAT that had, promoted early flowering and fruit yields. In addition to these structures, polyethylene plastic increased vine length at 30 to 90 DAT and nylon net and AVRDC at 60 DAT. The AVRDC structure considerably increased number of fruit pickings, fruit weight with lower number of harvested fruits, and higher marketable, total and computed yields. Meanwhile, the nylon net structure also significantly increased fruit weight with lower number of harvested fruits that were marketable with total, and computed yields. There were no significant differences on percentage fruit setting and the number of days from 50% flowering to first fruit picking. Sherry grown under protective structures had significantly longer vine length at 60 and 90 DAT, and with higher fruit weight. Likewise, nylon net structure had also significantly increased the fruit weight of Sherry. CHT 501 and Season Red grown under nylon net structure also had significantly higher fruit weight. No significant interactions were noted between varieties and protective structures on percentage survival, vine length at 30 DAT, average number of harvested fruits, marketable, non-marketable, total and computed yields. This study aimed to determine the best grafted tomato variety in the above-mentioned location, as well as, to establish the best kind of protective structures from July 2006 to January 2007.

Keywords: off-season, grafting, AVRDC

Introduction

Tomato (*Lycopersicum esculentum*) is a popular fruit vegetable that is considered a secondary crop in the Philippines. This commodity is widely traded in the market considering its versatility of use, reasonable cost, and nutritive value (Wein, 1996).

Given its versatility, demand for tomato has been increasing; thus tomato is fast-becoming a significant source of income for farmers in the off-season cropping. This growing demand is expected to further boost the development of the tomato industry. In 1994, the total area grown to crops was recorded to be nearly 17,000 ha, which yielded over 150,000 MT of produce valued at PhP 1.0 B. Yet, local production is still not enough to satisfy the domestic demand. This reality is further aggravated by the extreme seasonality of tomato production in the Philippines (FRLD, 1995).

In the dry months, there is abundant supply for tomatoes but during the wet season, the yield is low resulting to a limited supply in the market coupled with poor quality produce that are sold at exorbitant prices.

To help resolve this shortage problem is the development of new technologies for off-season tomato production by the Asian Vegetable Research and Development Center (AVRDC), which included the use of protective structures (e.g. net houses), elevated plots mulched with plastic, and the use of grafted tomato (Palada and Wu, 1999).

The recommended protective structures used G.I. pipes (½ and ¾) and fine nylon nets. Farmers adopting this technology, however, improvised the construction of the structure purposely to re-

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duce costs using materials such as bamboos, combined with round iron bars, and covered with nets. Results showed significant yield of 2.5 kg/plant (Boncato, 2001) with acceptable quality to local consumers in terms of sizes and color.

In addition to the adoption of this technology, the appropriate cultural management practices of producing off-season quality tomato with the right tomato variety must be addressed.

Methodology

Land Preparation

An area of 227 m^2 with the use of tractor was divided into three block. Each block was further subdivided into 15 raised-bed plots with a dimension of 1.5 m x 3 m each using a hand hoe. Drainage canals were also constructed in between plots with a distance of 50 cm each.

Experimental Design and Treatments.

The experiment was laid out in 3 x 5 factorial, randomized, complete block experimental design (RCBD) with three replications. Factor A was the three tomato varieties namely: CHT 501, Sherry and Season Red, and the different protective structures. On the other hand, factor B was the use of different protective structures e.g. open field (control), nylon net, mosquito net, polyethylene plastic, and AVRDC structures.

Construction of Protective Structures

The different protective structures were constructed in accordance to the specified structures for each treatment before transplanting the grafted tomato seedlings. With the exception of AVRDC structure that uses ¾" GI pipe as posts and ½" GI/blue pipe as braces that are spaced at 1.0 m each post and covered with nylon/mosquito net, the others were constructed using bamboo as braces and posts spaced at 1.0 m each post covered with nets and polyethylene plastic having a dimension of 3 m wide and 3.2 m long.

Seed Material

'CHT 501' was procured from the AVRDC and the other two varieties, Sherry and Season Red were procured from the Harbest Agribusiness Corporation, Pasig City. These seeds were sown in seed boxes. After germination, the seedlings are ready for grafting when they are 3-4 weeks old. Then, after two weeks of grafting, seedlings of the three varieties grafted on EG 203 were transplanted in double rows with a distance of 50 cm x 75 cm between hills and rows respectivelyand with 12 grafted seedlings/plot. All dead seedlings were replaced one week after transplanting

Cultural Management, Care and Maintenance

Complete fertilizer at the rate of 60-60-60 kg N-P_2O_5-K_2O/ha was applied basally. This was followed by two side dressing of 45 and 30 kg N/ha at five weeks after transplanting and at first harvest. Organic fertilizer (mushroom compost) at the rate of 7 tons/ha was incorporated in the beds prior to transplanting of seedlings. Two weeks after transplanting, 2 m long bamboo sticks were installed and used as trellising materials.

The grafted plants were kept weed-free in the beds for 30 days from transplanting. Spraying was also done regularly to protect the plants against insect pests and diseases.

Data gathered on the Growth and Yield Parameters are the following: Plant survival (%), vine length (cm), number of days to flowering, fruit set (%), number of days from flowering to first fruit picking, and yield based on the average number and fruit weight of harvested fruits, marketable and non-marketable (kg/plot) and computed yield per hectare.

Results and Discussion

Percentage Plant Survival

Table 1 presents the percentage plant survival of three cherry varieties evaluated. Although the differences were not statistically significant, Sherry had higher percentage of survival. The results obtained in this study confirm the claim as mentioned above that different varieties differ in their survival adaptability in given environmental conditions of a particular locality.

All plants grown under protective structures had significantly higher plant survival compared with those grown in the open field condition (Table 1). Protective coverings/structures such as nylon nets and clear polyethylene plastic are important for off-season tomato production because they protect the crop against excessive rains. This is the main reason why farmers can produce tomato the whole year round. Burleigh et al. (2003) stated that protective shelters have great impact on plant survival during the months of July and August under tropical conditions.

There were no significant interaction effects detected between the varieties and protective structures on percentage plant survival.

Table 1. Percentage plant survival

Treatment	Mean (%)
Variety	
CHT 501	93.89_a
Sherry	97.78_a
Season Red	96.11_a
Protective Structure	
Open field	87.96_b
Nylon net	99.07_a
Mosquito net	94.45_a
Polyethylene plastic	100.00_a
AVRDC	98.15_a

Means with a common letter are not significantly different at 5% level by DMRT

Table 2 shows that at 30 DAT, Sherry and Season Red had significantly longer vine compared to CHT 501. However, at 30 and 90 DAT, Sherry had remarkably longer vines throughout the growing period. This shows that this type of tomato continuously grows almost indefinitely (FAO, 2000) and usually needs staking, an indication of its indeterminate growth habit. Also, the results showed that these varieties differ in their response to a given environmental condition due to their differences in genetic make-up. CHT 501 grown in La Trinidad, Benguet was generally shorter by 21 to 61 cm at 30 and 90 DAT as reported by De Jesus (2005), while the same tomato variety grown at Mayantoc, Tarlac was markedly taller ranging from 47 to 115 cm at same periods of measurements, indicating that warmer conditions favor faster growth and development of the plants.

Polyethylene plastic structure significantly increased vine length at 30 to 90 DAT compared to the plants grown in the open field conditions. However, plants grown under this structure at 30 DAT was statistically similar to those grown under nylon net and AVRDC structures. With the exception of the plants grown under mosquito net which were comparable to those grown in the open field at 60 DAT, the plants grown under the other structures had significantly longer vine than those grown in the open field. All the plants grown under the protective structures had considerably longer vines than those grown in the open field at 90 DAT.

Vine lengths of the three varieties grown under different protective structures were not significantly affected at 30 DAT. However, at 60 and 90 DAT, Sherry grown under protective structures had significantly longer vines than those grown in the open field as mentioned earlier.

Days from Flowering to First Fruit Picking and Number of Pickings

Table 3 shows the number of days from flowering to first fruit picking and the number of pickings. CHT 501 significantly took more days from flowering to first fruit picking than the other two varieties. On the other hand, Sherry had significantly more fruit pickings than the other two varieties that were comparable with each other.

The number of days from flowering to first fruit picking of the plants grown in the open field and under different protective structures were not significantly different. However, the number of fruit pickings was significantly more under AVRDC structures than those grown under the other structures and in the open field condition. Nonetheless, nylon and mosquito nets and polyethylene plastic had significantly higher number of fruit pickings than in open field condition. This result conforms to the given characteristics of earliness on the flowering and harvesting of fruits.

Furthermore, there was no significant interaction between varieties and protective structures on the number of days from flowering to first fruit picking and the number of fruit picking.

Table 2. Vine length at 30, 60 and 90 days after transplanting

Treatment	Number Of Days From Transplanting (Cm)		
	30	60	90
Variety			
CHT 501	47.51b	94.97b	115.65c
Sherry	70.85a	178.11a	222.31a
Season Red	69.53a	111.64b	131.34b
Protective Structure			
Open field	51.73c	113.34b	146.90b
Nylon net	63.84abc	130.67a	157.83a
Mosquito net	57.92bc	126.87ab	157.69a
Polyethylene plastic	73.28a	136.83a	159.07a
AVRDC	66.37ab	133.49a	160.68a

Table 3. Number of days from flowering to first fruit picking and number of fruit pickings

Treatment	Days from Flowering to First Fruit Picking	Number of Fruit Pickings
Variety		
CHT 501	38.40a	15.53b
Sherry	36.87b	16.73a
Season Red	36.80b	15.53b
Protective Structure		
Open field	38.33a	14.56c
Nylon net	37.56a	16.11b
Mosquito net	37.00a	16.00b
Polyethylene plastic	37.00a	16.00b
AVRDC	36.89a	17.00a

Means with a common letter are not significantly different at 5% level by DMRT

Average Number of Harvested Fruits and Fruit Weight

Season Red significantly produced more fruits compared to Sherry but was comparable to CHT 501. This indicates that Season Red produced more fruits but was smaller in size compared to the other two varieties. However, CHT 501 and Season Red had comparable number of fruits. Sherry variety, on the other hand, had fewer but heavier fruits.

On the average fruit weight, Season Red significantly produced lighter weight than Sherry having less fruit/kg but with heavier fruits. Yet, this was statistically similar to CHT 501. The average fruit weight of CHT 501 is supported via earlier trial by De Jesus (2005) which recorded an average fruit weight of 19.0 grams for CHT 501 that was grown in La Trinidad, Benguet and is comparable to those produced from the trials conducted in Mayantoc, Tarlac and some parts of Nueva Ecija. The Harbest.com (2000) had the same results in its trials conducted in Pangasinan. Based from the description of tomato varieties, Sherry weighs around 35 g/fruit; CHT 501 weighs around 20-25 g/fruit; while Season Red averages 20 g/fruit.

Plants grown in open field condition produced more fruits but were smaller in size compared to those grown under polyethylene plastic and mosquito net structures. Structures covered with nylon nets produced less but bigger fruits. This indicates that the protective structures were more effective in producing bigger sized fruits, thus, making them heavier. Reports made by Mateo et al. (2001) stated that the provision of protective structures to tomato plants during the hot-wet months resulted to more number of bigger fruits than in open field condition. The results of Mateo et al. (2001) on the use of protective structures supports the results of this study, in terms of the number of fruits produced, but not on the size of the fruits.

On the fruit weight, plants grown under AVRDC structure and nylon net structure produced significantly heavier fruits than those grown under mosquito net and polyethylene plastic structure including open field conditions. These results indicated that the nylon net and AVRDC protective structures were more effective in producing heavier fruits but with less fruit number. Moreover, reports made by Mateo et al. (2001) stated that provision of protective structures to tomato plants during the hot-wet months resulted to more and bigger fruits than in open field conditions. This statement confirmed the result obtained in this study that less fruit number resulted to heavier fruits and it also collaborates the findings of Burleigh et al. (2003), that using nylon net as protective covering improves the quality of tomato fruit.

There were no significant interaction effects between varieties and protective structures when it comes to the number of harvested fruits. However, there was significant interaction noted between the varieties and the different protective structures on the average weight/fruit. Sherry grown under AVRDC structure significantly produced the heaviest fruits compared to those grown in open condition and those grown under nylon net, mosquito net, and polyethylene plastic structure. Nevertheless, this was comparable to CHT 501 that was grown under nylon net structure, together with I Season Red that is either grown in AVRDC and nylon net structures. In addition, season Red grown in open field condition had the lightest fruit weight. This suggests that the three varieties responded differently to particular protective structures.

Marketable, Non-Marketable, Total Yield, and Computed Yield

The marketable, non-marketable, total yields per plot and computed yield per hectare were significantly different among the three varieties grown (Table 5). The marketable and total yields of Sherry were markedly higher with lower non-marketable fruit yield compared to CHT 501 and Season Red. Both of these had also comparable marketable, nonmarketable, and total yield. It has been proven that modern tomato cultivars and hybrids can grow well and produce fruits in climates far different from the site of origin. The low yield produced is explained by the low production of tomato in the tropics during the hot-wet season due to high temperatures, moisture and some major diseases like bacterial wilt (*Pseudomonas solanacearum*). The use of unadapted varieties and lack of appropriate cultural practices during

Table 4. Average number of harvested fruits and fruit weight

Treatment	Average Number of Harvested Fruits	Average Fruit Weight
Variety		
CHT 501	54.60ab	18.61ab
Sherry	43.60b	23.61a
Season Red	71.53a	14.21b
Protective Structure		
Open field	64.56a	16.18b
Nylon net	52.67c	20.26a
Mosquito net	57.00b	18.51b
Polyethylene plastic	56.89b	18.36b
AVRDC	51.78c	20.74a

Means with a common letter are not significantly different at 5% level by DMRT

rainy seasons are some constraints to tomato production.

Computed yield of Sherry up to the last harvest was markedly the highest compared to the yield of Season Red. While, the computed yield of CHT 501 was the lowest but was comparable to Season Red. These results conform to the given yield characteristics of the varieties (Harbest.com, 2000). Sherry is characterized to be vigorous, prolific bearer, tolerant to bacterial wilt and resistant to *Fusarium* wilt Race-1. Previous trials of researchers from Taiwan and the Philippines, particularly in the province of Tarlac, found that CHT 501 was excellent in yield. However, in the succeeding trials, this variety was no longer resistant to tomato yellow leaf curl virus (TYLCV) which had affected its yield performance (Boncato, 2001). On the other hand, CHT 261, a cherry type tomato, FMTT 22, a salad type and CL 143, a determinate fresh market-grown tomato variety under nylon net structures, gave better yields (Virtucio, 2002).

Compared to those grown I open field condition and other protective sturctures, tomatoes grown under AVRDC structures produced significantly higher marketable and total yield/plot that were comparable to nylon net structure . In addition, the marketable and total yield/plot of tomatoes grown under nylon net structure were also comparable to those grown under the mosquito net and polyethylene plastic structure in comparison to those grown in open field conditions. Aganon (2003) mentioned that rain shelters/protective structures made from GI pipes and covered with nylon nets (32 mesh) proved to be effective in increasing the yield of tomato.

The computed yield, therefore, was significantly affected by the different protective structures and open field conditions. Plants grown under AVRDC structure had the highest computed yield of 42.43 t/ha which was comparable to those under nylon net structure with 38.47 t/ha. Likewise, using nylon net produced computed yield of 38.47 t/ha that was comparable to those grown under polyethylene plastic and mosquito net structure with 35.64 and 33.58 t/ha, respectively. Finally, plants grown in open field condition registered the lowest computed yield of 18.27 t/ha.

These results confirmed earlier trials of the researchers in Taiwan (Palada and Wu, 1999) that there is a marketable yield of 34 t/ha from those grown under shelters during the hot-wet season in contrast to tomatoes grown in open field condition. Raised beds combined with protective shelters/structures have also been shown to en-

hance production of tomato. Aganon (2003), on the other hand, reported that grafted CHT 501 and CL5915 grown under protective shelters/structures yielded 21.75 and 13.45 t/ha respectively as compared to those in open field conditions which had a yield of 15.59 and 9.60 t/ha respectively. The yield of CHT 501 in the latter trial (Aganon, 2003) corroborates the result of this study. Also, Aganon (2003) mentioned that rain shelters/protective structures made from GI pipes and covered with nylon nets (32 mesh) proved to be effective in increasing the yield of tomato.

There was no significant interaction effect between varieties and protective structures on the marketable, non-marketable, total yield/plot, and computed yield per hectare.

Conclusions

Sherry, Season Red, and CHT 501 varieties are adapted to local conditions as shown by the high percentages of plant survival. Each variety exhibits its genetic characteristics in terms of days to flowering, fruit setting, and weight. Sherry is the most promising variety to grow for off-season, in terms of production of size, weight of fruits, and yield/ha.

Protective structures markedly affect percentage of plant survival that are indicated by vine length, number of days from transplanting to flowering, fruit weight, average number of fruits, and yield. Protective coverings/structures using nylon net and AVRDC were found effective on the number of fruit pickings, average fruit, marketable and total yield/plot, and computed yield per hectare. The combined effects of variety and protective structures affect the average fruit weight and growth performance of grafted tomato plants. Sherry variety grown under different protective coverings/structures had significantly affected its plant height at 60 and 90 DAT. Moreover, different treatment combinations that give the highest net income is Sherry variety grown under AVRDC and nylon net structures. Even protective shelters/structures under AVRDC had the highest cost of production. However, this said variety is more durable and lasts longer, offsetting cost of production in subsequent off-season production times.

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Table 5. Marketable, Non-marketable, Total yield and Computed Yield

TREATMENT	YIELD (kg/plot)			Computed Yield (t/ha)
	Marketable	Non-marketable	Total	
Variety				
CHT 501	11.60b	0.254a	11.86b	25.78b
Sherry	18.58a	23.61a	18.69a	41.28a
Season Red	13.32b	14.21b	13.59b	33.97ab
Protective Structure				
Open field	7.95c	0.092b	8.04c	18.27c
Nylon net	16.40ab	0.095b	16.50ab	38.47ab
Mosquito net	14.64b	0.233a	14.87b	33.58b
Polyethylene plastic	15.33b	0.349a	15.67b	35.64b
AVRDC	18.18a	0.289a	18.47a	42.43a

Within a column, means with a common letter are not significantly different at 5% level by DMRT

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