ENHANCING OFF-SEASON PRODUCTION THROUGH GRAFTED TOMATO TECHNOLOGY

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Tomato production in the Philippines during hot-wet months is very limited because of flooding, high temperature and occurrence of pest and diseases. Grafting tomato onto flood- and disease-resistant rootstock is a potential technology to overcome these abiotic and biotic problems. To explore the full potential of such technology, the study was conducted to identify high-yielding and heat-resistant tomato scions as well as flood- and bacterial wilt-resistant rootstocks. Furthermore, the benefits of rain shelter were assessed. Seeds of rootstocks and scions were grown separately in plastic trays consisting of 50 cells per tray. Prior to grafting, eggplant seedlings were grown for 4 weeks and tomato scions and rootstocks for 3 weeks. Apollo and CL 5915 were used as scions, H7996 (tomato) and EG203 (eggplant) as rootstocks.

Grafted plants, regardless of rootstocks and scions used, showed increased survival, number of fruits per plant and consequently yield compared to non-grafted plants. Non-grafted Apollo had almost zero survival at 90 DAT due to a very high incidence of bacterial wilt. CL5915 grafted onto EG203 yielded 28.1 t/ha while the same scion grafted onto H7996 yielded 22.1 t/ha, an increase of 332% and 240% over the non-grafted CL5915. Apollo grafted onto EG203 and H7996 yielded significantly lower than grafted CL5915, indicating low heat tolerance of Apollo. Non-grafted Apollo yielded 20 kg/ha as a result of its susceptibility of bacterial wilt. Provision of rain shelter to grafted tomato increased the yield by 340% over grafted plants grown in open field. Grafting and rain shelter significantly improved the yields of CL5915 and Apollo.

Keywords: Apollo, bacterial wilt, CL5915, eggplant, grafting, H7996, open field, plant survival, rain shelter, rainy-season tomato, rootstock, scion, tomato

INTRODUCTION

Tomato is one of the leading vegetable crops in the country both in terms of hectarage and volume of production (BAS 1997). The demand for the crop is year-round, owing to the versatility of its usage in both fresh and processed food preparation. A survey of the supply of tomato has shown erratic market behavior because of the seasonality of production (www.bar.gov.ph).

Production is concentrated during the cool months (from October to early February), which is the regular growing season. This results in a market glut from January to May and meager supply during rainy months (June to December). Tomato generally requires favorable temperature (18 - 24°C) for optimum fruit setting (Mateo et al 1999 & 2002); thus, it grows best during the cool months of November to February. It is not surprising that growing of tomato during rainy months is localized in upland hilly areas where temperature is not a constraint. Besides, flooding can easily be prevented because of the sloping nature of the terrain.
At this time of the year price of tomato ranges from ₱40 to ₱60/kg in contrast to ₱5 to ₱20/kg during the regular season.

Off-season production of tomato in the lowlands has always been a futile attempt because of the influence of unfavorable growing conditions specifically flooding, occurrence of bacterial wilt and high temperature and lack of suitable production technology. The existing varieties of tomato are generally susceptible to bacterial wilt and flooding, making them unsuitable for off-season production. Besides, current production technologies are designed for regular-season production.

In response, the Central Luzon State University (CLSU), in collaboration with the Asian Vegetable Research and Development Center (AVRDC), has been developing the grafting technology on tomato. The purpose of grafting is to physically combine the desirable characteristics of two separate plants into one plant – the grafted plant – in this case to provide a flood- and bacterial wilt-resistant rootstock to a high-yielding tomato scion. The technology is meant to increase tomato production during hot-wet months and at the same time increase farm productivity through the planting of a high-value crop (www.newsflash.org). The research was aimed at a) evaluating different rootstocks and scions in relation to tomato crop growth and yield, and (b) comparing the performance of grafted tomato grown during the hot-wet months in the lowlands under rain shelter on one hand and open field on the other.

**MATERIALS & METHODS**

Two studies were conducted for three years (WS 1999 - 2001) to determine the feasibility of growing grafted tomato during the wet season:

Study 1: Evaluation of rootstock and scions for increased tomato fruit production;

Study 2: Comparison of grafted tomato production in open field and under rain shelter.

**Study 1. Rootstock and scions**

**Seeding of eggplant and tomato**

Plastic trays of 50 cells with 5.0 cm diameter per cell were filled with carbonized ricehull mixed with fine sand at 1:1 ratio as growth medium, and seeded with 2 seeds of the eggplant variety EG203. One week after emergence the seedlings were thinned to a single plant per cell. Seeds of Apollo and CL5951 and Hawaii 7996 tomato varieties were likewise seeded on plastic trays a week later. As with the eggplant, 1 seedling was maintained per cell.

**Grafting & hardening**

The 3-week-old tomato scions were grafted onto 4-week-old eggplant and to 3-week old H7996 rootstock. The scions and rootstocks were cut at a 30° angle above the cotyledons and inserted into opposite ends of the latex tubing. The tube would protect the graft union from desiccation. It would later break harmlessly as the union took and the stem diameter enlarged. Grafted seedlings were transferred to a chamber with approximately 80 to 90% relative humidity for one week. The seedlings were sprayed with fungicide. They were transferred after 5 days to the hardening chamber, where they stayed for 3 to 4 days. They were sprayed with urea solution (2%) before they were transplanted to the field.

**Transplanting**

The seedlings were transplanted onto 2.5 x 5-m beds raised 30 cm high. There were two rows per bed with 1 meter between rows and 50 cm between hills. All the experimental plots were under rain shelters made of UV resistant plastic attached by clips to a metal pipe structure. Planting distance was 1 m between rows and ½ m between hills. The treatments were laid out in factorial randomized complete block design replicated 3 times. Planting was done 7 July 2000. Two weeks later, bamboo poles were erected about 5 cm away from each tomato hill for support. CL5915, an indeterminate variety, was pruned, maintaining 2 main stems.

**Fertilization and Chemical Application**

Organic fertilizer at the rate of 10 t/ha was incorporated into the beds prior to transplanting the seedlings. Complete fertilizer at the rate of 60-60-60 kg NPK was also basally applied followed by side-dressing of 45 kg N/ha at 5 weeks after transplanting and 30 kg N/ha at first harvest. Fertilizer was
applied every after 2 primings at the rate of 15-15-15 NPK. The total fertilizer rate during the entire growing period was 225-250-150 kg NPK/ha. Dithane M 45 was applied as needed to control black leaf spot while Fipronil and carbonate were applied to control fruitworm.

Study 2. Under open field and rain shelter

The same procedures described above for grafting, transplanting and fertilization were followed, except that only EG203 was used as rootstock. The plants were transplanted 17 July 2000 on beds provided with and without rain shelter. Beds were raised to 40 cm high, lined with plastic mulch and applied with 10 t/ha organic fertilizer plus 225-150-150 kg NPK/ha inorganic fertilizer.

RESULTS & DISCUSSION

Study 1. Rootstock and scions

Percent Plant Survival

The percentages of surviving plants among the treatments were determined from transplanting up to the last harvest. Percent survival of grafted Apollo on EG-203 and H7996 were significantly higher than the non-grafted Apollo plants (Figure 1). Apollo grafted to EG-203 registered 91.7% survival while Apollo grafted onto H7996 had 75.0%. Despite the numerical difference, the survival rates of the two grafts were statistically the same. The non-grafted Apollo plants had zero survival at the last harvest (90 DAT).

CL5915 grafted onto either rootstock had significantly higher plant survival than the non-grafted plants. The percentages of survival from the different rootstocks were 97.2 for EG-203, 91.7 for H7996 and 64.0% for non-grafted CL5915. Grafted CL5915 had similar survival rates with grafted Apollo. Between non-grafted plants, CL5915 had significantly higher survival rate than Apollo. It was noted that CL5915 was more tolerant to flooding and bacterial wilt than Apollo.

Number of fruits per plant

The number of fruits per plant of both varieties was significantly affected by grafting. The quantities of fruits in Apollo and CL5915 were tremendously increased with grafting regardless of rootstock. Non-grafted Apollo plants had an average of 4 fruits per plant, significantly lower than those from the non-grafted CL5915 (Figure 2).

Weight of fruits per plant

Weight of fruits per plant was increased significantly by grafting on both scions

![Figure 1. Percent survival of tomatoes grown under rainshelter](image)
Regardless of scion used, grafted plants produced bigger fruits, thus heavier weights than the fruits from the non-grafted.

Between scions, the weight of fruits harvested from CL5915 grafted onto EG-203 was twice higher than that of Apollo grafted to the same rootstock. Between Apollo and CL5915 grafted onto H7996, the weight of fruits was significantly higher in CL5915.
Note that even if Apollo produced more fruits, the fruits were smaller than those of CL5915, which explains the heavier weight of the fruits of the latter.

**Yield per hectare**

Grafted Apollo had markedly higher yield than the non-grafted ones (Figure 4). The yields were 12.2 t/ha from the EG203 and 9.1 t/ha from H7996 rootstocks. The non-grafted plants registered almost zero yield due to very low plant survival caused by flooding and bacterial wilt.

The mean yields of CL5915 were 28.1 t/ha grafted onto EG203 and 22.2 t/ha onto H7996. No significant yield difference was observed regardless of rootstock used. Grafted CL5915 yielded higher than the non-grafted ones. CL5915 grafted onto EG203 yielded 326% higher than the non-grafted, while CL5915 grafted onto H7996 yielded 236% higher than the non-grafted. Between Apollo and CL5915, CL5915 grafted onto EG203 significantly outyielded grafted Apollo. The yield difference was more than double. CL5915 grafted onto H7996 significantly outyielded Apollo grafted to H7996, but yielded similarly when grafted onto EG-203.

Grafted plants with mean yield of 17.9 t/ha significantly outyielded the non-grafted plants with 3.6 t/ha, or a yield difference of 14.3 t/ha, equivalent to 397%.

**Study 2. Under open field and rain shelter**

**Percent Survival**

The grafted plants grown under rain shelter had 79.8% survival, those grown in the open field 70.1%. While the difference was not significant, this indicated that provision of rain shelter spared the plants from adverse weather conditions, specifically from the damaging effects of raindrops. Plants in open field though grafted are prone to damage by raindrops. As raindrops fall, the leaves are injured, providing entry for plant pathogens that later infect the plants, resulting in death. Among the diseases that were observed at great magnitude on plants grown in the open field was the black spot. This was observed on leaves a day after rainfall occurrence. The disease progresses to younger leaves during continuous rainy days that later infects all the leaves. Once all the leaves are infected, the plants succumb to death due to absence of photosynthetic activity.

![Figure 4. Yield of grafted tomatoes grown under rain shelter](image-url)
Number & weight of fruits per plant

Provision of rain shelter to tomato plants during hot-wet months resulted in 7 more fruits per plant, indicating favorable effect of rain shelter on fruit setting. In the open field, heavy rains during the wet season oftentimes result in flower drops and poor fruit setting. Under sheltered conditions the raindrops’ kinetic energy is much reduced or dissipated by the nylon net, resulting in very tiny drops and no or little adverse effect on fruit setting.

Plants grown with rain shelter gave significantly heavier fruits than those without shelter. The average weight of fruits per plant was more than double over the weight of those grown without the provision of the rain shelter.

With bigger and more fruits from plants under rain shelter, the yield per plant was higher than that of plants in open field.

Yield

Tomato plants grown under rain shelter significantly outyielded those plants grown under open field with an increase in yield of 11.2 t/ha or 340%. The increase in yield is attributed to bigger and more fruits per plant and more plants that survived.

Plants in the open field were exposed to harsh weather conditions during the hot-wet months. The leaves were damaged by any or all of the following: 1) impact of raindrops, 2) strong wind, and 3) pests that attacked the plants through previously damaged leaves and stems.

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LITERATURE CITED

Mateo LG, TM Aganon, JR Burleigh, DR Cacho & AS. Caspillan. 2002. Proceedings of the National Academy of Science and Technology (NAST) 22nd Annual Scientific Meeting. p120
Opina VL, LM Dolores & MC Lit. Evaluation of host resistance in tomato during off-season against major diseases and insect pests. Philippine National Program on Vegetable Research, Development and Extension. Bureau of Agricultural Research, Quezon City
Philippine National Program on Vegetable Research, Development and Extension. Progress Report. Year 2. Bureau of Agricultural Research, Quezon City