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# Appropriate planting dates and plastic mulch for increasing common tomato varieties yield in South Texas

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**In South Texas, most of tomato (*Lycopersicon esculentum* Mill.) crops are produced on plastic mulch due to the elevated temperatures and solar radiations. The study objectives were to; Determine the suitable planting dates for increasing tomato varieties production under different planting dates in early spring and late winter, and evaluate the influence of using the plastic mulch (black and white. In the Spring season, nine tomato varieties (four rounds and five roma) were grown. The round varieties were the Torero, Mykonos, Shourouq, and TAM Hot-Ty, and the roma varieties were Prunus, Rio Grande, Seri, DRP-8551, and SV8579TE. The best five varieties from the spring season and two more varieties were selected for evaluation in the fall including; SV8579ET, Mykonos, DRP-8551, TAM-HOT-T4, Shourouq, Tycoon, and Everglade. All the tomato varieties were evaluated during the Spring season under three different planting dates (from late-February till late-March) and three mulching treatments (black, white plastic mulch, and bare soil); and during the fall season during two planting dates (from early to mid-September) and two mulching treatments (black and white plastic mulch). Higher average marketable yields were observed in the spring season than the fall season. The best varieties during the spring season were DRP-8551, SV8597TE, Shourouq, and Seri with yields ranging from 68,630 to 57,237 kg/ha, whereas the best varieties in the fall; were DRP-8551, SV8597TE, and Tycoon with yields ranging from 47,123 to 60,674 kg/ha. In both seasons, white plastic mulch resulted in higher yields compared to the black and bare tomato yields.**

**Key words:** Planting dates, plastic mulch, tomato yield.

## INTRODUCTION

Tomato is one of the most important vegetables grown under open field as well as protected structures throughout the world (Singh et al., 2015). High temperature is one of the main limitations to extend the production period throughout the year because it decreases tomato productivity by reducing flower production and/or fruit set (Hossain et al., 2013). Due to the conditions of high ambient temperature and solar radiation during the spring and summer seasons in South Texas, most of tomato (*Lycopersicon esculentum* Mill.)

crops are produced on plastic mulch of diverse colors. The benefits associated with the use of plastic mulches have been reported in several studies (Liakatas et al., 1986; Lamont, 1993). The color of the mulch has several effects on the phenology of the crop and possibly on the variety of the crop being grown. Black polyethylene plastic mulch is the standard plastic mulch used in vegetable production (Gordon et al., 2010). Researchers indicate that black mulch is recommended during the spring to warm the soil (Hatt et al., 1995; Lamont, 1993). Black plastic mulch increased number of fruit in tomato by five fruits per plant compared to bare ground (Díaz-Pérez and Batal, 2002). Higher yields have also been obtained using clear plastic for many crops such as strawberries (Fragaria sp.) (Johnson and Fennimore, 2005). Hatt et al. (1995) and Schalk and Robbins (1987) indicated that in the summer and fall, aluminum or white colored mulches are preferred because these mulches heat the soil less than black mulch. Ashrafuzzaman et al. (2011) also reported that the highest weed dry weight was recorded with the transparent plastic and the lowest with the black plastic. Brown and Brown (1992) reported earlier harvest of tomato in aluminum followed by silver and black mulch, respectively. Therefore, research indicates that crop responses to colored mulches are inconsistent, depending on the season, the year, and the region (Csizinszky et al., 1995). Ham et al. (1993) reported that white-on black and silver mulches reflect 48 and 39% of shortwave radiation, respectively. Also, the results reported by Gordon et al. (2010) indicate that tomatoes in red mulches set fruit earlier and produced more ripe fruit than plants grown in black plastic. In addition to, the use of plastic mulches to increase tomato yield production, the selection of the appropriate planting date could lead to obtaining the maximum yields for some varieties. Crop breeding programs try to develop varieties resistant to heat to extend the tomato production windows and achieve better market opportunities in each region. However, managing the crops by using different varieties, planting dates and plastic colors may also extend the production windows. Planting date is an important factor in crop production that can affect plant maturity, harvest date, yield, and quality. The results reported by (Gent, 1992) showed that a two-week delay in planting resulted in delayed fruit maturity by two weeks for early season HT tomato production. Selecting appropriate planting dates may lead to greater yield and contribute to better vegetable quality (Kleinhenz and Wszelaki, 2003). Rogers and Wszelaki (2012) reported that tomato planted earlier in high tunnels yielded more marketable fruit during the production season than plants established on later planting dates. However, planting dates appropriate for one cultivar may not be suitable for another and this statement may also be true for different varieties. For some plant species, different planting dates affect vegetative growth but don't affect reproductive growth (Cebert et al., 1990). The objectives of this study were, to determine the suitable planting dates for increasing tomato varieties production under three different planting dates for early spring and two planting dates for the late winter, and to evaluate the influence of the plastic mulch (black and white) on these varieties.

## MATERIALS AND METHODS

Field studies were conducted in the Spring and Fall of 2016 at Texas A&M AgriLife Research and Extension Center, Weslaco, Texas (26.1595° N, 97.9908° W) in Willacy fine sandy loam soil with 0 to 1% slope. Climate conditions were characterized as semi-arid. The mean daily maximum temperature is 45°C in August while the minimum temperature is 2°C in January. The area receives a mean annual rainfall of 509.8 mm.

### Spring experiments

Three treatments were established in a split plot laid on a randomized complete design with three raised beds covered with black or white plastic mulch and one with bare ground. A set of three raised beds were established, in three different planting dates. Nine tomato varieties, five roma (Prunus, Rio Grande, Seri, DRIP-8551, and SV8579TE) and four round (Torero, Mykonos, Shourouq, TAM Hot-Ty) were evaluated. The varieties were selected according to certain factors which include tolerance and resistance to diseases, local heirloom tomato and based on farmer preferences to grow certain varieties in this region. Each plot was replicated three times, and four plants per plot was established. In each plot tomato plants were spaced 0.46 m between plants and 2 m between rows. There was a spacing of 1.2 m between plots and the average plant density was 10,760 plants $ha^{-1}$. The TAM Hot-T4 and SV8579TE varieties were developed by the TAMU program of Dr. Crosby, whereas Seri, Mykonos, Shourouq, and DRP-8551 were developed by Seminis (St. Louis, Missouri, USA). Torero and Prunus were developed by De Ruiter (Monsanto Invest B.V., Amstelveen The Netherlands). Tomato seedlings were planted in 128 cell trays and kept in the greenhouse, and around 90% of the seeds germinated.

### Fall experiments

The same experimental design was followed, however only seven varieties, two planting mulches and two planting dates were evaluated (Table 1). The best five varieties from the spring trial were selected for the fall trial evaluation. In addition, two more varieties suggested by the farmers were selected for the study. The varieties evaluated during the fall were the SV8579ET, Mykonos, DRP-8551, TAM-HOT-T4, Shourouq, and Tycoon which is a commonly grown variety during the fall season in this region, and Everglade, which is a new variety introduced in this region. Only the white and black plastic were evaluated during the fall season

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**Table 1.** Planting and harvest dates established during the two experimental periods (Spring and Fall seasons) in Weslaco, TX.

| Planting date | Harvest date | | |
|---|---|---|---|
| **Spring season** | **1st Harvest** | **2nd Harvest** | **3rd Harvest** |
| 1st (29 February 2016) | 19 May 2016 | 25 May 2016 | 9 June 2016 |
| 2nd (15 March 2016) | 30 May 2016 | 30 May 2016 | 9 June 2016 |
| 3rd (31 March 2016) | 14 June 2016 | 20 June 2016 | |
| **Fall season** | | | |
| 1st (6 September 2016) | 21 Dec 2016 | 4 Jan 2017 | 17 Jan 2017 |
| 1st (19 September 2016) | 21 Dec 2016 | 4 Jan 2017 | 17 Jan 2017 |

because these were the ones that produced better results in the spring experiment.

The tomato varieties were transplanted to the field six weeks after germination. The tomato transplanting trays were placed outside the greenhouse for acclimatization and hardening two days before transplanting them into the field. Black on white embossed non-degradable plastic mulch with dimensions of 1.8 m x 732 m and 0.032 mm of thickness was used. Prior to the laying of the mulch, beds were raised using a tractor with a rolling cultivator unit, and the drip tape was injected into the soil to a depth of 5 cm. The plastic mulch was placed with the white side facing up. Holes were punctured into the plastic mulch at the correct spacing before transplanting.

In both seasons, the fertilization was applied through irrigation. Different formulated liquid fertilizers were used at various stages of the plant but applying the same amounts to all treatments and replications. Fertilization was applied weekly following common recommendations for South Texas (Dainello and Anciso,2004). After transplanting, the focus was on developing a good root system so fertilizer with a higher concentration of phosphorus was used, whereas during the foliage development, a fertilizer with high nitrogen was used. Regarding the flowering and fruiting stages micro and macronutrients were added for nutrition of the plants to obtain the best results. Tomato plants were irrigated with a subsurface drip irrigation system for all the treatments during the two growing seasons. The drip tubing has a nominal discharge of 0.75 L $h^{-1}$ per emitter and each emitter is spaced every 30 cm (Streamline, Netafim, Riverside, CA 92507). Plants were irrigated the same day they were transplanted. During the growing season, irrigation was applied when a soil moisture sensor (Watermark Soil Moisture Sensor, Irrometer Co, Riverside, CA 92507) installed at a depth of 30 cm reached 20 cb. One watermark sensor was installed in each bed about 5 cm from the drip line and placed only in one variety (the same variety at different beds). An irrigation depth of approximately 12 mm was applied in each irrigation. Pests such as downy mildew, powdery mildew, whiteflies, thrips, worms and mites, as well as weeds were kept under control with some chemical applications as recommended for the South Texas region (Dainello and Anciso, 2004).

#### Data collection and statistical analysis

Tomato fruits were manually harvested at maturity between 10 to 12 weeks after transplanting and were weighed per plot to estimate the gross yield per each treatment. The marketable yields excluding tomatoes affected with fruit disorders (catface, cracking, puffiness, zippering or affected with diseases) were collected and analyzed statistically using regression mixed model for analysis split plot designs at 5% level of significance.

## RESULTS

### Spring season

During the Spring season, a statistically significant difference was observed by the effect of planting date, plastic color, and variety on tomato yield (Table 2). The planting dates evaluated during the spring season were from February 29 (first planting date) to 31 March 2016 (third planting date). Significant differences were observed among the yield of the three planting dates (P=0.0156). The highest average yield was observed for the second planting date (53, 20 kg/ha) and a significant decrease in yield was observed during the first and third planting dates with 47,566 and 45,484 kg/ha, respectively. No significant difference was observed between the first and last planting dates (Table 3).

Significant differences on yield were observed between the two plastic treatments and the bare ground soil treatment (P =<0.0001). The white plastic resulted in a higher average yield (for all the planting season dates and tomato varieties) with a yield of 70,444 kg/ha followed by the black plastic and bare soil treatments with 45,185and 30,741 kg/ha respectively (Table 4).

A significant difference was observed among the tomato varieties (P=<0.0001). Table 5 shows that the highest tomato yields were observed for the SV8579TE (60,234 kg/ha), DRP-8551 (56,481kg/ha), and Shourouq with 53,427 kg/ha. No significant difference on average yield was observed among these varieties. Similar yields were observed for TAM-Hot-Ty, Seri, Mykonos, and Prunus with an average yield of 50,468 kg/ha. The lowest yields were observed for the Torero and Rio Grande varieties with 35,729 and 31,367 kg/ha respectively.

There was a significant effect of the planting date and the plastic mulch (*P*=0.0017) during the spring season. The highest average tomato yields were obtained using the white plastic during the second and first planting dates with 76,986 and 71,857 kg/ha, respectively (Table 6). The second highest yields were observed for the third planting date using the white plastic with 62,487 kg/ha and second planting date using the black plastic with 54,448 kg/ha. The third highest yields were observed for

**Table 2**. Results of the analysis of variance for the spring and fall seasons.

| Source of variance | F ratio | *Prob* > F |
|---|---|---|
| **Spring season** | | |
| Planting date | 5.9188 | 0.0156* |
| Plastic | 146.4336 | <.0001* |
| Planting date x Plastic | 4.5695 | 0.0017* |
| Variety | 9.3781 | <.0001* |
| Variety x Plastic | 1.2126 | 0.2648 |
| Variety x Planting date | 2.53 | 0.0018* |
| Variety x Planting date x Plastic | 0.9347 | 0.5726 |
| **Fall season** | | |
| Planting date | 2.2588 | 0.2455 |
| Plastic | 12.1473 | 0.0251* |
| Plastic x Planting date | 44.7531 | <.0001* |
| Variety | 15.0265 | <.0001* |
| Variety x Plastic | 1.9402 | 0.1008 |
| Variety x Planting date | 0.2751 | 0.9456 |
| Variety x Planting date x Plastic | 4.1715 | 0.0028* |

* Refers to Significance at P= 0.05.

**Table 3.** Average yields of the tomatoes varieties for three planting dates during the Spring season.

| Planting date | | | Yield (kg/ha) |
|---|---|---|---|
| 2nd planting | A | | 53,320 ± 1633 |
| 1st planting | | B | 47,567 ± 1633 |
| 3rd planting | | B | 45,484 ± 1633 |

± Represents the standard error. Planting dates not connected with same letters, are significantly different at P=0.005.

**Table 4**. Average yields of tomato varieties using the white and black plastic, and bare soil during the spring season (the three planting dates), and the white and black plastic during the fall season (the two planting dates).

| Treatment | | | | Yield (kg/ha) |
|---|---|---|---|---|
| **Spring season** | | | | |
| White | A | | | 70,444± 1,627 |
| Black | | B | | 45,185± 1,626 |
| Bare | | | C | 30,741± 1,629 |
| **Fall season** | | | | |
| White | A | | | 41,413± 4200 |
| Black | | B | | 23,811± 4198 |

± Represents the standard error. Treatments not connected by same letters are significantly different at *P*= 0.05.

the first and third planting dates using the black plastic and the third planting date of the bare soil with 42,161, 38,947, and 35,016 kg/ha, respectively. The lowest treatments were observed for the first and second planting dates using bare soil with 28,681 and 28,525 kg/ha, respectively. The highest yields were generally observed in the first two planting dates using the white and black plastics and the opposite was observed for the bare soil, in which the last planting date resulted in higher yields.

**Table 5**. Average yield for each tomato variety under the three treatments and three planting dates during the spring season, and the two-plastic mulch in two planting dates during the fall season.

| Variety | | | | | | Yield (kg/ha) |
|---|---|---|---|---|---|---|
| **Spring season** | | | | | | |
| SV8579TE | A | | | | | 60234± 3020 |
| DRP-8551 | A | B | | | | 56481± 3022 |
| Shourouq | A | B | | | | 53427± 3024 |
| TAM Hot-ty | | B | | | | 51651± 3021 |
| Seri | | B | | | | 51101± 3032 |
| Mykonos | | B | | | | 50788± 3048 |
| Prunus | | B | | | | 48333± 3024 |
| Torero | | | C | | | 35729± 3031 |
| Rio Grande | | | C | | | 31367±3011 |
| **Fall season** | | | | | | |
| Varieties | | | | | | Yield (kg/ha) |
| Tycoon | A | | | | | 59,164± 4551 |
| SV8579TE | A | | | | | 58,602± 4629 |
| DRP-8551 | | B | | | | 47,252± 4537 |
| Mykonos | | | C | | | 32,565± 4583 |
| Everglade | | | | C | D | 31,819± 4617 |
| Shourouq | | | | C | D | 29,284± 4508 |
| TAM-HOT-ty | | | | | D | 21,292± 4597 |

± Represents the standard error. Varieties not connected by same letters are significantly different at P=0.05.

**Table 6.** Average tomato yields for the combination between planting dates and treatments during the spring and fall season. ± Represents the standard error. Combinations not connected by same letters, are significantly different at P=0.05.

| Planting dates x treatments | | | | | | Yield (kg/ha) |
|---|---|---|---|---|---|---|
| **Spring season** | | | | | | |
| 2nd planting, White | A | | | | | 76,986± 2943 |
| 1st planting, White | A | | | | | 71,857± 2943 |
| 3rd planting, White | | | B | | | 62,489± 2943 |
| 2nd planting, Black | | | B | | | 54,448± 2938 |
| 1st planting, Black | | | | C | | 42,161± 2938 |
| 3rd planting, Black | | | | C | | 38,947± 2938 |
| 3rd planting, Bare | | | | C | D | 35,016± 2940 |
| 1st planting, Bare | | | | | D | 28,681± 2940 |
| 2nd planting, Bare | | | | | D | 28,525± 2940 |
| **Fall season** | | | | | | |
| White, 2nd planting | A | | | | | 59,603± 4543 |
| White, 1st planting | | | B | | | 41,979± 4536 |
| Black, 1st planting | | | B | | | 40,568± 4543 |
| Black, 2nd planting | | | | C | | 17,838± 4543 |

There was significant effect of planting date on the tomato variety yield (P=0.0018). Table 7 shows that the highest tomato yields were observed for the DRP-8551 variety-first planting date and SV8597TE- second planting date, with 68,555 kg/ha. The average yields of the tomato varieties TAM-HOT-Ty- second planting, SV8579TE-first planting, Shourouq-second planting, Shourouq- first planting, Prunus-second planting, Seri-

**Table 7.** Average tomato yields for the combinations among the plastic mulch treatments, three planting dates, and varieties during the spring season. ± Represents the standard error. Combinations not connected by same letters are significantly different at P=0.05.

| Varieties x Planting date | | | | | | | | | | | | Yield (Kg/ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DRP-8551, 1st planting | A | | | | | | | | | | | 68,630± 5257 |
| SV8579TE, 2nd planting | A | | | | | | | | | | | 68,480± 5253 |
| TAM Hot-ty, 2nd planting | A | B | | | | | | | | | | 64,769± 5255 |
| SV8579TE, 1st planting | A | B | C | | | | | | | | | 59,729± 5253 |
| Shourouq, 2nd planting | A | B | C | D | | | | | | | | 58,677± 5261 |
| Shourouq, 1st planting | A | B | C | D | E | | | | | | | 58,147± 5261 |
| Prunus, 2nd planting | A | B | C | D | E | | | | | | | 57,382± 5261 |
| Seri, 1st planting | A | B | C | D | E | | | | | | | 57,237± 5273 |
| Mykonos, 2nd planting | A | B | C | D | E | | | | | | | 55,892± 5300 |
| Prunus, 3rd planting | A | B | C | D | E | F | | | | | | 54,062± 5261 |
| DRP-8551, 3rd planting | | B | C | D | E | F | | | | | | 53,438± 5257 |
| SV8579TE, 3rd planting | | B | C | D | E | F | | | | | | 52,491± 5253 |
| Mykonos, 3rd planting | | B | C | D | E | F | G | | | | | 51,034± 5300 |
| TAM Hot-ty, 3rd planting | | B | C | D | E | F | G | | | | | 50,496± 5255 |
| Seri, 2nd planting | | | C | D | E | F | G | | | | | 49,715± 5273 |
| DRP-8551, 2nd planting | | | C | D | E | F | G | H | | | | 47,376± 5257 |
| Seri, 3rd planting | | | C | D | E | F | G | H | | | | 46,351± 5273 |
| Mykonos, 1st planting | | | C | D | E | F | G | H | I | | | 45,439± 5300 |
| Torero, 2nd planting | | | | D | E | F | G | H | I | J | | 44,008± 5272 |
| Shourouq, 3rd planting | | | | | E | F | G | H | I | J | | 43,456± 5261 |
| TAM Hot-ty, 1st planting | | | | | | F | G | H | I | J | K | 39,687± 5255 |
| Torero, 1st planting | | | | | | | G | H | I | J | K | 36,243± 5272 |
| Rio Grande, 2nd planting | | | | | | | | H | I | J | K | 33,581± 5238 |
| Prunus, 1st planting | | | | | | | | H | I | J | K | 33,556± 5261 |
| Rio Grande, 3rd planting | | | | | | | | | I | J | K | 31,090± 5238 |
| Rio Grande, 1st planting | | | | | | | | | | J | K | 29,429± 5238 |
| Torero, 3rd planting | | | | | | | | | | | K | 26,935±5272 |

first planting, Mykonos-second planting, and prunus-third planting varieties were not significantly different, and their yields ranged from (64,769 to 54,062 kg/ha). Similar yields were recorded for the DRP8551- Third planting date, SV8579TE-third planting, Mykonos-third planting and TAM-HOT-Ty-third planting with no significant differences and yields ranging from 53,438 to 50,496 kg/ha. The lowest yields (below 36,243 kg/ha) were observed for Rio Grande-first, second, and third planting dates, prunus-first planting date and torero-third planting date. Whereas, there was no effect of the plastic mulch on the tomato varieties (P= 0.2648).

## Fall season

During the fall season, only the white and black plastic were evaluated since they produced the highest yields during the spring season. The white plastic mulch resulted in higher tomato yield (41,413 kg/ha) than the black plastic (23,811 kg/ha) during the two planting dates of the fall season (Table 4).

A highly significant effect of the plastic mulch and planting date combination (P=0.0001) was observed on tomato yield (Table 2). The highest yield was observed for the white plastic-second planting date with 59,603 kg/ha, followed by the white plastic-first plastic date with 41,979 kg/ha and black plastic-first planting date with 40,568 kg/ha. The lowest yield was observed for the black plastic-second planting with 17,838 kg/ha (Table 6). During the fall season, only seven varieties were evaluated. The Torero and the Rio Grande varieties were not included in the fall study because of the low yield attained during the spring season. The tomato yields of the different varieties were statistically different (P=<0.0001), (Table 2). The highest yields were observed for the Tycoon and SV8579TE with 58,883 kg/ha, followed by the DRP8551 with 47252 kg/ha. The next lower yields were observed for Mykonos, Everglade, and Shourouq with 32,565, 31,819, and 29,284 kg/ha, respectively. The lowest yield was observed for the TAM-HOT-Ty variety with 21,292 kg/ha (Table 5).

A non-significant effect was observed of the planting date on the variety. However, a significant effect of the plastic, under the two planting dates was observed for the tomato varieties (P=0.0028). The highest yields were

**Table 8**. Average tomato yields for the combinations among the plastic mulch treatments, two planting dates, and varieties during the fall season.

| Variety x Planting date x Plastic mulch | | | | | | | | | | | | | Yield (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tycoon, 2nd planting, White | A | | | | | | | | | | | | 97,632± 8516 |
| DRP-8551, 2nd planting, White | A | B | | | | | | | | | | | 79,332± 8141 |
| SV859TE, 2nd planting, White | | B | | | | | | | | | | | 74,563± 8675 |
| Tycoon, 1st planting, Black | | B | C | | | | | | | | | | 68,565± 8313 |
| SV859TE, 1st planting, Black | | B | C | D | | | | | | | | | 65,723± 8565 |
| Tycoon, 1st planting, White | | | C | D | E | | | | | | | | 52,783± 8143 |
| SV859TE, 1st planting, White | | | C | D | E | F | | | | | | | 48,937± 8598 |
| DRP-8551, 1st planting, Black | | | C | D | E | F | | | | | | | 48,160± 8386 |
| Shourouq, 1st planting, White | | | C | D | E | F | | | | | | | 48,036± 8095 |
| Everglade, 2nd planting, White | | | C | D | E | F | | | | | | | 46,986± 8623 |
| DRP-8551, 1st planting, White | | | C | D | E | F | G | | | | | | 46,301± 8386 |
| Mykonos, 2nd planting, White | | | C | D | E | F | G | | | | | | 45,489± 8657 |
| SV859TE, 2nd planting, Black | | | | D | E | F | | H | | | | | 45,185± 8672 |
| Shourouq, 2nd planting, White | | | | D | E | F | G | H | I | | | | 41,604± 8555 |
| Mykonos, 1st planting, White | | | | | E | F | G | H | I | | | | 40,162±8598 |
| Everglade, 1st planting, White | | | | | E | F | G | H | I | J | | | 36,858± 8626 |
| TAM-HOT-Ty, 2nd planting, White | | | | | E | F | G | H | I | J | K | L | 31,614± 8597 |
| Everglade, 1st planting, Black | | | | | E | F | G | H | I | J | K | | 31,083± 8652 |
| Mykonos, 1st planting, Black | | | | | | F | G | H | I | J | K | L | 28,050± 8476 |
| TAM-HOT-Ty, 1st planting, Black | | | | | | | G | | I | J | K | L | 21,864± 8532 |
| TAM-HOT-Ty, 1st planting, White | | | | | | | | H | I | J | K | L | 20,773± 8526 |
| Shourouq, 1st planting, Black | | | | | | | | | I | J | K | L | 20,532± 8590 |
| Tycoon, 2nd planting, Black | | | | | | | | | I | J | K | L | 17,678± 8666 |
| Mykonos, 2nd planting, Black | | | | | | | | | I | J | K | L | 16,559± 8567 |
| DRP-8551, 2nd planting, Black | | | | | | | | | | J | K | L | 15,214± 8546 |
| Everglade, 2nd planting, Black | | | | | | | | | | | K | L | 12,348± 8141 |
| TAM-HOT-Ty, 2nd planting, Black | | | | | | | | | | | K | L | 10,916± 8498 |
| Shourouq, 2nd planting, Black | | | | | | | | | | | | L | 69,63± 8498 |

± Represents the standard error. Combinations not connected by same letters are significantly different at P=0.05.

observed for the Tycoon-second planting date-white (97,632 kg/ha) and DRP8551-second planting date-white plastic with 79,332 kg/ha. No significant differences were observed between the DRP-8551-second planting date-white and the SV89TE-second planting-white, Tycoon-first planting date-black, SV8579TE-first planting date-black with 74,564, 68,565, and 65,723 kg/ha, respectively. The lowest yields (below 16,000 kg/ha) were observed for DRP-8551-second planting-black, Everglade-second planting date-black, TAM-HOT-Ty-second planting-black, and Shourouq-second planting, black (Table 8).

## DISCUSSION

Planting date is a crucial factor in specialty crop productions (Zhao et al., 2014), because it has exhibited marked influence on the yield of tomato fruits (Singh et al., 2015). The main objectives of the study were to evaluate the effect of different planting dates on the yield of the tomato varieties and study the tomatoes varieties grown under plastic mulch (white and black) and bare soil (open field). The results of the present study showed that the planting date and plastic mulch exhibit marked influence on the tomato varieties yield during both Spring and Fall season. In the Spring season, nine of the most common varieties grown in South Texas were selected, four round and five roma. The round varieties were the Torero, Mykonos, Shourouq, and TAM Hot-Ty, and the roma varieties were Prunus, Rio Grande, Seri, DRP-8551, and SV8579TE. These varieties were evaluated under three different planting dates during the Spring season (from late-February till late-March) and two different planting dates during the fall season (from early to mid-September). During the spring season, the second planting date resulted in an increase of 57.5 and 78.4% higher average yield than the first and third planting dates, respectively. This average yield increase could be attributed to the optimum temperature for optimum

tomato vegetative growth and yield. Maximum and minimum temperatures recorded during second planting cycle ranged from 20.9 to 31.1°C. Dhaliwal et al. (2017) reported that optimum growth and fruit setting tomato requires from 25 to 30°C day and 15 to 20°C night air temperature. They mentioned that below these optimal temperatures the tomato crop (*Solanum lycopersicum* L.) results in delayed fruiting and decreased fruit yield under field conditions. Equivalent results were observed by Hossain (2004) in Bangladesh, who obtained the highest tomato yield (86.40 t/ha) at early planting (October 25) where the temperatures were favorable for flower initiation and the lowest yields (16.8 t/ha) as planting was delayed possibly because of higher temperatures during the growing season when tomato was planted beyond February 24.

Hamma et al. (2012) in Nigeria observed that an earlier planting date (August, 1-20) performed better in terms of growth because the crop gets enough duration to complete the vegetative phase fully, indicating the importance of exploring the best planting dates in different climates and regions. For example, Ahammad et al. (2009) mentioned that in Bangladesh the tomato yields can be reduced from 48.7 t/ha if planted in Dec 1 to 7.2 t/ha if planted later than February 1. Although they mentioned that planting temperatures affect growth they did not mention what temperatures they observed during the growing season. However, this research points out the importance of determining the optimum window of opportunity for planting in different regions.

Significant difference of the yield among varieties were observed in each planting date. The best varieties during the spring season were DRP-8551, SV8597TE, Shourouq, and Seri first planting date with yields ranging from 68,630to 57,237 kg/ha; followed by SV8597TE, TAM-HOT-Ty, Shourouq, Prunus, and Mykonos-second planting date with yields ranging from 68,480 to 55,892kg/ha; and prunus-third planting with an average yield of 54,062 kg/ha. The variation of the yield of the same varieties in the three planting dates, could be attributed to the weather effects on early maturity.

The tomato yield obtained during the fall season planting dates (from September 6 to 19) resulted in significant lower tomato yields than the Spring season (planted from February 29 to March 31). The yield decrease could be explained by the infection with the white fly and some other common diseases such as early blight caused by *Phytophthora infestans* that strongly affects the late tomato plantations in the South Texas region. Therefore, many of the varieties require specific planting dates to avoid the diseases which probably results in low yield due to low disease resistance. Moreover, in the fall season a yield increase of 25.5% was observed in the first planting date compared to the second planting date. In the fall, the best varieties were DRP-8551, SV8597TE; and Tycoon in the first and second planting dates with yields ranging from 47,123 to 60,674 kg/ha.

Plastic mulches are used extensively in commercial vegetable production (Lamont, 1993). The benefits associated with the use of plastic mulches have been reported in several studies. The most popular plastic mulch worldwide is black, though white-on-black and clear, mulches are also used (Schales, 1990). In the present study, two plastic mulch (black and white) were tested. Plastic mulch affected significantly the tomato yield. The study results revealed that the performance of tomato varieties under black and white plastic mulch was considerably higher than the one grown in bare soil during the spring season. White plastic resulted in 25.3% higher yields than the black plastic, and 39.7% higher than the bare soil in the spring season. Whereas, during the fall season the white plastic resulted in 17.6% higher yield than the black plastic. White plastic can keep adequate temperature and soil moisture in the tomato varieties, as well as preventing the infection of common insects and viruses in the area. In addition, white plastic mulch usually gives cooler temperature than the black plastic because this mulch heats the soil less than the black mulch (Hatt et al., 1995; Schalk and Robbins, 1987). In this study, black plastic resulted in a significant increase of yields (approximately 14.4%) compared to bare soil planted tomatoes. Black plastic mulch is the standard plastic mulch used in vegetable production (Gordon et al., 2010). Moreover, researchers using black plastic instead of bare soil have recorded higher yields (Rajablarijani et al., 2012) and earliness in tomato production (Ibarra et al., 2001; Lamont, 1993). Black plastic also increased number of fruit in tomato by five fruits per plant compared to bare ground grown tomatoes (Díaz-Pérez and Batal, 2002). The low yield obtained in bare soil treatments with no mulch is attributed to the uncontrolled environmental conditions rather than plastic mulch. During the Spring season, there was no significant interaction between the plastic mulch and varieties under the three planting dates due to optimal temperatures for all varieties. However, during the fall season, a major influence of the plastic mulch was observed on the tomato varieties in the two planting dates that can be attributed to the low temperatures of the fall season and the importance of the plastic mulch to make a more suitable environment for tomato growth. The varieties that performed better during the fall season were (Tycoon-second planting) and (DRP-8551-second planting) under white plastic and under black plastic mulch were (Tycoon-first planting), (SV8579TE- first planting), and (DRP-8551-first planting) indicating that during the fall season some varieties performed better under the plastic mulch than the spring season. For example, the DRP-8551 increased yield in the fall season by approximately 50% compared to the spring.

## Conclusion

The present study has demonstrated the effect of

different planting dates and plastic mulch covers (black and white) on the tomato yield. Tomatoes grown under white plastic mulch resulted in approximately 40% increase in the tomato yields than the black plastic mulch and bare soil. Planting the TAM Hot-Ty, SV8597TE, and DRP-8551 in early Spring under white plastic mulch, resulted in higher tomato yields. Whereas, some other varieties resulted in higher yields during late planting dates such as Tycoon in the fall. The production yield depends on the varieties and its maturity type. Thus, the use of white plastic mulch to increase the yield as well as the proper selection of the variety was recommended. Information given by this study could be useful to growers striving to enhance marketable yields of tomato in south Texas and extend the market windows. During the fall farmers do not want to plant too early to avoid the high environmental temperatures which affect the affect tomato vegetative growth, but they do not want to plant too late to avoid the low temperatures that cause diseases. Farmers could select varieties that are more resistant to diseases, which can be planted earlier or select the plastic that helps the varieties to produce higher yields in late plantings.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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