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# RESPONSE OF MOISTURE STRESSED TOMATO (*Solanum lycopersicum* L.) GROWTH CHARACTERS TO ANTITRANSPIRANTS AT KANO IN SUDAN SAVANA OF NORTHERN NIGERIA

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## ABSTRACT
Antitranpirants are foliar sprayed chemicals to plants in order to reduce the rate of moisture loss and increase productivity of irrigated crops. To test antitranspiracy of Salicylic and Benzoic acids, field experiment was conducted at the Teaching and Research Farm of the Faculty of Agriculture, Bayero University Kano (11° 97′ 98.6″ N, 8°42′ 03.7″ E) 475 m elevation) during 2011/2012 and 2012/2013 dry seasons to study the effects of antitranspirants and moisture stress on crop growth and development stages of tomato. The treatments consisted of two antitranspirants at four concentrations each (0, 200, 400 and 600 ppm) and three moisture stress stages (vegetative, flowering and fruit setting). Antitranspirants and moisture stresses were assigned to the main plot and concentrations were used as sub-plot treatment. These were replicated three times and laid out in a split-plot design. Data were taken on some growth attributes of tomato and subjected to analysis of variance data using Statistical Analysis Software (SAS). The results revealed that, application of Salicylic acid at 600 ppm significantly enhanced leaf area, total dry matter, crop growth rate, relative growth rate and net assimilation rate better than application of Benzoic acid. Interaction between and among different factors were significant on leaf area, total dry matter, crop growth rate and relative growth rate. Flowering and fruiting stages were found to be the critical growth stages for moisture stress of tomato. The study concluded that application Salicylic acid enhanced the growth characters of moisture stressed tomato better than Benzoic acid**.** It was recommended that 600 ppm of Salicylic acid should be foliar sprayed on moisture stressed tomato in the study area.

**Keywords:** Antitranspirant, Growth, Moisture, Stress, Tomato.

## INTRODUCTION
Besides chilling and freezing temperatures, drought is one of the most important limiting factor of crop production all around the world. The cultivated tomato reached its present status after a long period of domestication and it is now grown throughout the temperate and tropical climates (Harvey *et al.*, 2002).The area of major production is the Northern part of the country, between latitude $8^0 – 13^0$N, but the greatest market is mostly in the South and other neighboring countries (Amans *et al*., 1986). Cultivation of tomato is now widespread throughout the temperate and tropical climate (Harlan, 1984). It is among the most important vegetable crops in Nigeria. Large scale tomato production in Nigeria is mainly under irrigation during the dry season. Tomato is a rich source of vitamin A, B and C with acidic properties that bring out other flavour (Rakesh and Adarsh, 2010).

Cancers such as prostate cancers, cervical cancer, colon cancer, rectal cancer and the cancer of the stomach and mouth have all been proven to be reduced by high levels of lycopene (Inmaculada *et al*., 2011). Tomatoes require a high water potential for optimal vegetative and reproductive development. Therefore, irrigation is required for profitable production. There is a critical need to balance water availability, water requirement and water consumption in conserving water which has become a decisive consideration for agricultural expansion, particularly in arid and semi- arid regions. One way to achieve this goal is by reducing the transpiration rate using Antitranspirant materials to minimize the amount of irrigation water (Younis *et al.*, 2000). Foliar application of antitranspirant seams an attractive method for regulating transpiration and maintaining a favourable plant water status. The reduced transpiration enhances plant survival especially under hot climatic conditions with reduced soil water potential. Not much work has been done on the use of antitranspirants to reduce water lost into the atmosphere. This experiment was therefore conducted to determine the effects of antitranspirants, their concentrations and moisture stress on the growth characters of tomato.

## MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research Farm of the Faculty of Agriculture Bayero University Kano (11° 97′ 98.6″ N, 8° 42′ 03.7″ E) 475 m above sea level during dry seasons of 2011/2012 and 2012/2013 to study the response of moisture stressed tomato growth characters to antitranspirants. The treatments consisted of two antitranspirants (Benzoic and Salicylic acids) at four concentrations each (0, 200, 400 and 600 ppm) and three moisture stress stages (vegetative, flowering and fruit setting). These were factorially combined to give 12 treatments and laid out in a split-plot design replicated three times.

The land was ploughed, harrowed and prepared into plots of slightly sunken beds of 3.6 m x 3.0 m (10.8 $m^2$) sizes. Paired rows of beds were separated by 0.75 m wide irrigation channels between the plots. Before removing the seedlings from the nursery, the beds were thoroughly irrigated and seedlings were uprooted using a small hand hoe and then transplanted at a spacing of 60 cm x 60 cm. Salicylic and Benzoic acids were sprayed to the foliage using a hand sprayer at vegetative, flowering and fruit setting stages at the rate of 0, 200, 400 and 600 ppm equivalent to 0.2, 0.4 and 0.6 g $L^{-1}$ of water. Data were collected on some growth characters, subjected to analysis of variance using SAS and Duncan's Multiple Range Test (DMRT) was adopted in separating the means.

## RESULTS AND DISCUSSION

Table 1 shows the effect of antitranspirants and moisture stress on leaf area and total dry matter of tomato. The result revealed a significant difference between the two antitranspirants on the leaf area and dry matter of the moisture stressed tomato, where foliar sprayed plants with salicylic acid had wider leaf area (9.48 $cm^{-2}$) than those sprayed with benzoic acid (8.89 $cm^{-2}$).

The effect of stress was observed to be significant where plants that were stressed at fruiting stage had wide leaf area (9.27 $cm^{-2}$) while those stressed at flowering and vegetative stages had narrow leaf areas (7.42 $cm^{-2}$) and (7.42 $cm^{-2}$), respectively. Irrespective of the antitranspirant, application of 600 ppm resulted into plants with wider leaf area (9.85 $cm^{-2}$), although statistically at par with 200 ppm (9.53 $cm^{-2}$). There was significant interaction between stress stages and concentrations in 2012 and 2013 seasons while there was no significant interaction between the factors in the combined seasons.

Similarly, there was significant difference statistically between the two antitranspirants on total dry matter where foliar applied salicylic acid produced plants with higher dry matter (100.47g) than benzoic acid (98.22g). Plants stressed at fruiting stage had higher dry matter (103.45g) while those stressed at vegetative stage had lower dry matter (79.12g) and plants sprayed with 600ppm concentration had higher dry matter (110.66g) than the control 0ppm (80.22g). Interaction between antitranspirant and stress as well as between stress and concentration on the dry matter of moisture stressed tomato was significant in 2012 season. Similarly, interaction between antitranspirants and concentrations as well as interaction between stress and concentration on dry matter was significant in 2013 season Salicylic acid gave higher leaf area at 600 ppm in both seasons than Benzoic acid. Higher performance of Salicylic acid than Benzoic acid could be attributed to the differences of the active ingredient in the formulation of the antitranspirants.

**Table 1:** Effects of Antitranspirants on Leaf Area ($cm^{-2}$) and Dry Matter (g) of Moisture Stressed Tomato at Bayero University, Kano in 2012, 2013 Dry Seasons and Combined

| **Treatments** | **Bayero University, Kano** | | | | | |
|---|---|---|---|---|---|---|
| | **Leaf Area** | | | **Dry Matter** | | |
| | **2012** | **2013** | **Combined** | **2012** | **2013** | **Combined** |
| **Antitranspirants (A):** | | | | | | |
| Benzoic acid | 8.89b | 7.86b | 8.37 | 100.47b | 132.77b | 116.62b |
| Salicylic acid | 9.48a | 8.30a | 8.89 | 98.22a | 169.47a | 129.34a |
| Level of significance | * | * | NS | ** | ** | ** |
| SE± | 0.178 | 0.194 | 0.328 | 2.340 | 2.520 | 2.010 |
| **Stress (S):** | | | | | | |
| Vegetative | 8.86 | 7.42b | 8.20b | 79.12b | 127.45c | 103.29b |
| Flowering | 9.46 | 7.42b | 8.44b | 101.95a | 151.29b | 126.62a |
| Fruit setting | 9.24 | 9.27a | 9.25a | 103.45a | 174.62a | 139.04a |
| Level of significance | NS | * | * | ** | ** | ** |
| SE± | 0.178 | 0.194 | 0.328 | 2.340 | 2.520 | 2.010 |
| **Concentrations ppm (C):** | | | | | | |
| 0 | 8.38b | 7.86 | 8.12 | 80.22c | 117.77d | 99.00c |
| 200 | 9.53a | 8.20 | 8.87 | 93.88b | 152.88b | 123.38b |
| 400 | 8.98ab | 8.32 | 8.65 | 94.61b | 130.21c | 112.41bc |
| 600 | 9.85a | 7.92 | 8.88 | 110.66a | 203.61a | 157.13a |
| Level of significance | * | NS | * | ** | ** | ** |
| SE± | 0.205 | 0.158 | 0.151 | 2.700 | 2.060 | 1.5140 |
| **Interactions (I):** | | | | | | |
| A x S | NS | NS | NS | ** | ** | NS |
| A x C | NS | NS | NS | NS | ** | NS |
| S x C | ** | * | NS | ** | ** | NS |
| A x S x C | NS | NS | NS | NS | NS | NS |

Note: Means followed by the same letter (s) in a column are not statistically different at 5% level of probability using Student-Newman Keuls Test. *significant at 5%; **significant at 1%; NS = not significant

As revealed in Table 1, the active ingredient in Benzoic acid was 0.3 kg a.i while that of Salicylic acid was 0.95 kg a.i. similar result was observed by Latimer, 1992 who reported that, application of $GA_3$ increased leaf area. These findings are in contrast with the results of El-Kobbia and Ibrahim (1986) that did not observe any effect on leaf area of tomato plants sprayed with Epoxylin seed oil and vapour guard antitranspirants. Total dry matter increased with Salicylic acid than Benzoic acid in both seasons. This may probably be due to the fact that, Salicylic acid might have affected assimilate transportation to the various organs positively than the Benzoic acid. Irmak *et al.* (1999) found that, plant development and dry matter production for the vegetative parts of tomato plants were increased by antitranspirants. Application of Salicylic at fruit setting stage had higher dry mater possibly because of higher number of branches recorded by this antitranspirant at this stress stage. Gu *et al.*, (1996) had earlier reported that, water stress and antitranspirant GLK-8924 interacted on tomato to affect plant growth rate and hence dry matter (Table 1).

Table 2 shows the interaction between Antitranspirants and stress stages on dry matter of moisture stressed tomato. In 2012 season, looking at the Antitranspirants under different stress stages, application of Benzoic acid at all the stress stages significantly had plants with higher dry matter (107.41 g) even though at par with application of Salicylic acid at flowering (96.50 g) and fruiting stages (105.75 g). When the stress stages were considered, stressing the plant at vegetative stage with application of Salicylic acid had significantly lower dry matter (65.41 g) (Table 2).

**Table 2:** Interaction between Antitranspirant and Stress stages on Dry Matter (g) Plant$^{-1}$ of Tomato at Bayero University, Kano and Kadawa in 2012 and 2013 Dry Seasons

| **Antitranspirant** | **Stress stage** | | |
|---|---|---|---|
| | **Vegetative** | **Flowering** | **Fruit setting** |
| **BUK 2012:** | | | |
| Benzoic acid | 92.83a | 107.41a | 101.16a |
| Salicylic acid | 65.41b | 96.50a | 105.75a |
| SE+ | 2.485 | | |
| **BUK 2013:** | | | |
| Benzoic acid | 127.07c | 126.91c | 144.33c |
| Salicylic acid | 127.83c | 175.66b | 204.91a |
| SE+ | 2.52 | | |

Note: Means within and across column followed by the same letter (s) are not significantly different at 5% level of probability using Student-Newman-Keul.

Table 3 shows that there was significant difference between the antitranspirants on the crop growth rate and relative growth rate of moisture stressed tomato where application of salicylic acid resulted into plants with higher crop growth rate (3.47) than those sprayed with Benzoic acid (2.75) in both seasons and combined. Plants stressed at fruiting stage had higher crop growth rate (9.99) than those stressed at vegetative state (2.72). the result further indicated that, concentration of antitranspirant was observed to be significantly different, where plants sprayed with 600 ppm had higher crop growth rate (8.17) than the other concentrations, although statistically at par with 400 ppm (7.53); and the control 0 ppm resulted into plants with lower crop growth (3.35). Interaction between the treatments was significant.

Similarly plants sprayed with salicylic acid had statistically higher relative growth rate (0.49) while those sprayed with benzoic acid had lower relative growth rate (0.39) in both seasons and combined. Stress had significant effect where plants that were stressed at fruiting stage had higher relative growth rate (0.78) than those stressed at vegetative state (0.40) and application of 400 ppm concentration produced plants with higher relative growth rate (0.69), although at par with 600 ppm (0.63) while plants sprayed with 200 ppm had lower relative growth rate (0.47) which was at par with the control 0 ppm (0.53). Interaction between the factors on relative growth rate was significant (Table 3).

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**Table 3:** Effect of Antitranspirant and Moisture Stress on Crop Growth Rate (g $wk^{-1}$) and Relative Growth Rate ($gg^{-}wk^{-1}$) of Moisture Stressed Tomato at Bayero University, Kano in 2012, 2013 Dry Seasons and Combined

| Treatments | Bayero University, Kano | | | | | |
|---|---|---|---|---|---|---|
| | Crop Growth Rate (g $wk^{-1}$) | | | Relative Growth Rate ($gg^{-}wk^{-1}$) | | |
| | 2012 | 2013 | Combined | 2012 | 2013 | Combined |
| **Antitranspirants (A):** | | | | | | |
| Benzoic acid | 2.75b | 2.88b | 2.82b | 0.39b | 0.42b | 0.41b |
| Salicylic acid | 3.47a | 9.06a | 6.26a | 0.49a | 0.74a | 0.62a |
| Level of significance | * | ** | ** | * | ** | ** |
| SE+ | 0.325 | 0.361 | 0.194 | 0.042 | 0.033 | 0.024 |
| Stress (S) | | | | | | |
| Vegetative | 2.98 | 2.72c | 2.85b | 0.41 | 0.40c | 0.41c |
| Flowering | 3.27 | 5.20b | 4.23b | 0.46 | 0.55b | 0.51b |
| Fruit setting | 3.09 | 9.99a | 6.54a | 0.45 | 0.78a | 0.62a |
| Level of significance | NS | ** | ** | NS | ** | * |
| SE+ | 0.325 | 0.361 | 0.194 | 0.042 | 0.033 | 0.024 |
| **Concentrations ppm (C):** | | | | | | |
| 0 | 2.81 | 3.35c | 3.82 | 0.40 | 0.53b | 0.46 |
| 200 | 3.41 | 4.83b | 3.38 | 0.48 | 0.47b | 0.48 |
| 400 | 3.06 | 7.53a | 5.30 | 0.43 | 0.69a | 0.56 |
| 600 | 3.16 | 8.17a | 5.66 | 0.45 | 0.63a | 0.54 |
| Level of significance | NS | ** | NS | NS | * | NS |
| SE+ | 0.375 | 0.295 | 0.216 | 0.049 | 0.027 | 0.026 |
| **Interactions (I):** | | | | | | |
| A x S | NS | ** | NS | NS | ** | NS |
| A x C | NS | ** | NS | NS | * | NS |
| S x C | NS | ** | NS | NS | ** | NS |
| A x S x C | NS | NS | NS | NS | NS | NS |

Note: Means followed by the same letter (s) in a column are not significantly different at 5% level of probability using Student-Newman Keuls Test. *significant at 5%; **significant at 1%; NS = not significant.

Table 4 shows the effect of the antitranspirants on the net assimilation rate of moisture stressed tomato. There was significant difference between the two antitranspirants on the net assimilation rate of moisture stressed tomato where foliar applied salicylic acid had resulted into plants with higher net assimilation rate (0.12) than those sprayed with benzoic acid (0.09). There was no significant difference between the stress stages, concentrations as well as the interactions between the treatments on the net assimilation rate of the moisture stressed tomato.

**Table 4:** Effect of Antitranspirants on Net Assimilation Rate ($gcm^{-2}wk^{-1}$) of Moisture Stressed Tomato at Bayero University, Kano in 2012, 2013 Dry Seasons and Combined

| **Treatments** | **Net Assimilation Rate** | | |
|---|---|---|---|
| | **2012** | **2013** | **Combined** |
| **Antitranspirants (A):** | | | |
| Benzoic acid | 0.08 | 0.09b | 0.08 |
| Salicylic acid | 0.09 | 0.12a | 0.10 |
| Level of significance | NS | * | NS |
| SE+ | 0.007 | 0.012 | 0.019 |
| Stress (S) | | | |
| Vegetative | 0.09 | 0.09 | 0.09 |
| Flowering | 0.08 | 0.11 | 0.09 |
| Fruit setting | 0.08 | 0.12 | 0.10 |
| Level of significance | NS | NS | NS |
| SE+ | 0.007 | 0.012 | 0.019 |
| **Concentrations ppm (C):** | | | |
| 0 | 0.07 | 0.11 | 0.09 |
| 200 | 0.09 | 0.11 | 0.10 |
| 400 | 0.08 | 0.12 | 0.10 |
| 600 | 0.08 | 0.09 | 0.09 |
| Level of significance | NS | NS | NS |
| SE+ | 0.007 | 0.007 | 0.008 |
| **Interactions (I):** | | | |
| A x S | NS | NS | NS |
| A x C | NS | NS | NS |
| S x C | NS | NS | NS |
| A x S x C | NS | NS | NS |

Note: Means followed by the same letter (s) in a column are not significantly different at 5% level of probability using Student-Newman Keuls Test. *significant at 5%; **significant at 1%; NS = not significant.

## CONCLUSION AND RECOMMENDATIONS

It could be concluded that application of Salicylic acid significantly enhanced all the growth characters measured Benzoic acid. Flowering and fruiting stages were found to be the critical growth stages for moisture stress of tomato. Farmers in the study area were recommended to apply 600 ppm of Salicylic acid in order to mitigate the effect of moisture stress.

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