Dwarfing of a local tomato, *Lycopersicum esculentum* Mill., variety susceptible to logging for improving its' of market value

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ABSTRACT
Gibberellic acid stimulated the elongation of plant internodes in tomato plants. Plants treated with gibberellic acid (GA_3), as the sole plant growth regulator, were at least two (2) folds greater in height in comparison to the control and at least four (4) folds higher than other treatments after 8 weeks of acclimatization. Treatment with gibberellic acid gave a mean plant height of 202 cm, while the Control plants were 96 cm tall. All applied plant growth retardants (Ancymidol, Chlormequat chloride, Paclobutrazol, Uniconazole) inhibited the activity of endogenous giberrellic acid in the plant, thereby giving rise to plants with shorter internodes and plant height. Gibberellic acid promoted leaf growth and apical dominance in tomato plants. Gibberellic acid lengthened the fruit internodes which resulted in wider spaces between the tomato fruits in bunches; this gave rise to better air circulation between the fruits and reduced their susceptibility to fungal diseases. In this study, the plants treated with gibberellic acid inhibitors (i.e. plant growth retardants) had greener leaves which were smaller than those of both the Control plants and the ones treated with gibberellic acid. Observations under a microscope revealed that their cells were smaller and had higher concentration of chlorophyll in comparison to both the control and those treated with gibberellic acid. These results suggest that the increased level of chlorophyll production might have been as a result of some metabolic energy being channeled from gibberellic acid synthesis into chlorophyll production. These same plants (i.e. plants treated with growth retardants) showed less water stress which could be because of their smaller leaf size in comparison to the control.

KEYWORDS: Tomato; Gibberellic acid; Plant growth retardants; Logging; Plant height

1.0 INTRODUCTION

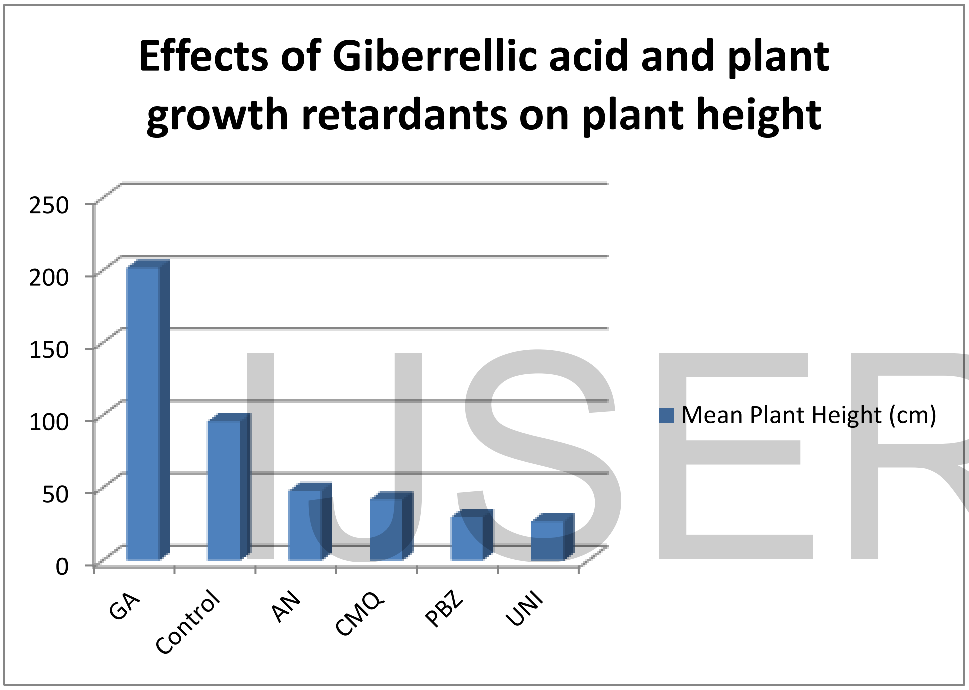
The tomato plant, *Lycopersicum esculentum* Mill (syn. *Solanum lycopersicum*), is a native of South America. It is an herbaceous annual plant growing to a height of between 60 and 190 cm. It is mainly cultivated for its edible fleshy fruit (berry) and belongs to the botanical family of *Solanaceae*. There are basically two types of tomato plant based on the manner of growth exhibited by the stem, the determinate or “bush” type, and the indeterminate or the “vine” type. The “bush” type tomatoes, with short stems, grow vertically and the plant will stop growing at the time fruit starts developing on the terminal shoot and all the fruits ripen at around the same time. The “vine” type tomato varieties spread laterally and will continue to grow and produce fruit all seasons and fruits will develop and ripen at different times. The “vine’ type tomato grows indefinitely and requires a support system to prevent them trailing along the ground. The stems are covered in coarse hairs and the leaves are arranged spirally. The tomato plant produces yellow flowers, which can develop into a cyme of 5–8. Tomato berry has a smooth skin which can be red, yellow, brown, orange or pink in color.

2.0 MATERIALS AND METHOD

Two hundred and forty (240) young tomato plants were used for this investigation. The following plant growth retardants (Ancymidol, Chlormequat chloride, Paclobutrazol, Uniconazole) were applied to 40 plants each, 14 days after transplanting, in order to reduce unwanted longitudinal shoot growth without lowering plant productivity of the tomato plants. Gibberellic acid (GA_3) was applied to 40 other plants to prove the effect of gibberellic acid in stem elongation, and the remaining 40 plants acted as Control plants. Plants were sprayed to run off (i.e. each plant was sprayed until spray visibly just began to drip off of the foliage) with 15 ml of 100ppm of either gibberellic acid or one of the inhibitors (growth retardants). Subsequent foliar sprays were repeated at 14 days interval until 2 weeks before fruit harvest. Measurements were conducted at the blooming period in order to ascertain the effects of applications.

3.0 RESULTS AND DISCUSSION

The determinate "bush" type of tomato variety which is susceptible to logging was used for this investigation. Gibberellic acid stimulated the elongation of plant internodes in tomato plants. Plants treated with gibberellic acid (GA_3), as the sole plant growth regulator, were at least two (2) folds greater in height in comparison to the control and at least four (4) folds higher than other treatments after 10 weeks of acclimatization. Treatment with gibberellic acid gave a mean plant height of 202 cm, while the Control plants were 96 cm tall. The results of this study agree with the one reported by Gaba (2005) where gibberellic acid was used to enhance shoot elongation before rooting. Gibberellin stimulated elongation of internodes and proved to be necessary for meristem growth. Other treatments had the following mean plant heights: Paclobutrazol (PBZ) - 30 cm; Chlormequat chloride (CMQ) – 42 cm; Uniconazole (UNI) - 27 cm, and Ancymidol (AN) yielded a mean plant height of 48 cm. The control plants, without any applied growth regulator or inhibitor of gibberellic acid biosynthesis, grew taller than the plants treated with a either GA_3 and Ancymidol or GA_3 and Paclobutrazol. This result indicates that all applied plant growth retardants (Ancymidol, Chlormequat chloride, Paclobutrazol, Uniconazole) inhibited the activity of endogenous giberrellic acid in the plant, thereby giving rise to plants with shorter internodes and plant height. Gibberellic acid promoted leaf growth and apical dominance in tomato plants. However, the exogenously applied inhibitors of gibberellic acid biosynthesis such as Paclobutrazol, Ancymidol, Chlormequat chloride, Uniconazole inhibited or blocked the synthesis of gibberellic acid which resulted in stunted growth or reduced stem elongation in plants treated with either of them. In this study, gibberellic acid lengthened the fruit internodes which resulted in wider spaces between the tomato fruits in bunches; this gave rise to better air circulation between the fruits and reduced their susceptibility to fungal diseases. Furthermore, in this study, the plants treated with gibberellic acid inhibitors (i.e. plant growth retardants) had greener leaves which were smaller than those of both the Control plants and the ones treated with gibberellic acid. Observations under a microscope revealed that their cells were smaller and had higher concentration of chlorophyll in comparison to both the control and those treated with gibberellic acid. These results suggest that the increased level of chlorophyll production might have been as a result of some metabolic energy being channeled from gibberellic acid synthesis into chlorophyll production. These same plants (i.e. plants treated with growth retardants) showed less water stress which could be because of their smaller leaf size in comparison to the control. The results of this experiment also showed that differences in plant height, nodium number, internodium length, leaf and flower area was at significance level of 0.05.



The results of this study show that exogenously applied gibberellic acid promoted plant higher height; this is in agreement with the work reported by many authors. The work of Huang et al. (1989) and Li et al. (1989) reported that the application of the plant growth retardant, paclobutrazol, caused a significant reduction on the stem length of Asian pears and peach trees respectively. Similarly uniconazole application reduced the plant height in maize, tulips, hyacinths and caladium (Schluttenhofer et al., 2011), Krug et al. (2005a), Krug et al. (2005b), Krug et al. (2007). Uniconazole also reduced plant height of *Ligustrum* by inducing shorter internodes with smaller diameters and by reducing secondary branching relative to the controls (Steinberg et al. 1991). Wang and Gregg (1989) reported a reduction in stem diameter in *hibiscus* treated with uniconazole. In contrast to paclobutrazol, chlormequat chloride is a weaker inhibitor of stem elongation when applied as a media drench, requiring 400 mg a.i. vs. 0.12 mg a.i. Chlormequat chloride is highly water soluble (Cathey and Stuart, 1961) and xylem and phloem mobile. It can be applied as a spray or drench, with drenches having greater uptake and efficacy (Belzile and Vonk, 1972). Chlormequat chloride is rapidly absorbed by plants in experiments when it is added to the nutrient solution. In one study, wheat plants were exposed to nutrient solution plus chlormequat chloride for 6 hours and then returned to normal nutrient solution. After two weeks, 20% growth inhibition was reported (Dekhuijzen and Vonk, 1974). Because of its complete water solubility (MSDS label, 2008), chlormequat chloride should remain in solution and not readily partition to media components, allowing it to be taken up by mass flow with the transpiration stream. Further, the investigations conducted by Aloni and Paskkar (1987) and Quinlan and Richardson (1984) support the findings of this work as paclobutrazol not only decreased vegetative growth but also reduced the length of shoots. In the same vein, Graebe (1985) reported that paclobutrazol is an effective GA_3 biosynthesis inhibitor; it inhibits the oxidation of kaurene to kaurenoic acid. Its mode of inhibition rests in its interaction with kaurene oxidase, a cytochrome P-450 oxidase, and inhibits the microsomal oxidation of kaurene, kaurenal and kaurenol. On the basis of comparison of molecular changes in transcript and metabolite levels, low gibberellic acid (GA_3) levels affect plant growth by uncoupling growth from carbon availability (Ribeiro et al., 2012).

4.0 CONCLUSION

All the plant growth retardants (Paclobutrazol, Ancymidol, Chlormequat chloride, Uniconazole) used in this study inhibited or blocked the biosynthesis of gibberellic acid in the tomato plants which resulted in stunted growth or reduced stem elongation in plants treated with any of the inhibitors. The short tomato plants, produced in this study, were not susceptible to logging, premature fruit drop and fruit loss during harvest.

REFERENCES

1. Aloni, B., Paskkar, T. (1987). Antagonistic effects of paclobutrazol and gibberellic acid on growth and some biochemical characteristics of pepper (*Capsicum annum*) transplants. Scientia Hortic., 33: 167-178.
2. Bailey, D., and Whipker, B. (1998). Best management practices for plant growth regulators used in horticulture. Horticulture information leaflet 529.
3. Belzile, L., Paquin, R. and Willemot, C. (1972). Absorption, translocation et métabolisme du chlorure de (2-chloroéthyl) triméthylammonium-1,2-14C chez l'orge d'hiver (Hordeum vulgare. Can. J. of Bot. 50: 2665-2672.
4. Cathey, H.M., and N.W. Stuart. (1961). Comparative plant growth-retarding activity of amo-1618, phosfon, and CCC. Botanical Gazette 123(1):51-57.
5. Dekhuijzen, H.M., and Vonk, C. R. (1974). The distribution and degradation of chlormequat in wheat plants. Pesticide Biochem. Physiol. 4:346-355.
6. Krug, B. A., Whipker, B. E., McCall, I., Dole, J. M. (2005a). Comparison of Flurprimidol to Ancymidol, Paclobutrazol and Uniconazole for Tulip Height Control. HortTechnology, 15(2): 370-373.

7. Krug, B. A., Whipker, B. E., McCall, I., Dole, J. M. (2005b). Comparison of Flurprimidol to Etephon, Paclobutrazol and Uniconazole for Hyacinth Height Control. Horticulture Technology, 15(4): 872-874.
8. Krug, B. A., Whipker, B. E., McCall, I., Dole, J. M. (2007). Caladium Height Control with Flurprimidol, Paclobutrazol and Uniconazole. Horticulture Technology, 17(3): 368-370.
9. Latimer, J. and Whipker, B. (2012). Selecting and using plant growth regulators on floricultural crops. Virginia Coorperative Extension, Publication 430-102.
10. Pieterse, C. M. J., Van Der Does, D., Zamioudis, C., Leon-Reyes, A., and Van Wees, S. C. M. (2012). Hormonal modulation of plant immunity. Annu. Rev. Cell Dev. Biol. 28. doi: 10.1146/ annurev-cellbio-092910-154055
11. Ribeiro, D. M., Araújo, W. L., Fernie, A. R., Schippers, J. H. M., and Mueller-Roeber, B. (2012). Translatome and metabolome effects triggered by gibberellins during rosette growth in Arabidopsis. J. Exp. Bot. 63, 2769–2786.
12. Schluttenhofer, C. M., Massa, G. D., Mitchell, C. A. (2011). Use of Uniconazole to Control Plant Height for an Industrial/Pharmaceutical Maize Platform. Industrial Crops and Products, 33 (3): 720-726.
13. Steinberg, S. L., Zajicek, J. M., and McFarland, M. J. (1991). Short-Term Effect of Uniconazole on the Water Relations and Growth of Ligustrum. J. Amer. Soc. Hort. Sci., 116 (3): 460-464.
14. Huang, H., Cao, S. Y., Qiao, X. S., Lu, R. (1989. The effect of paclobutrazol on growth of some Asian pears. Scientia Hortic., 38: 43-47.
15. Li, S.H., Bussi, C., Clanet, H., Regnard, J.L. (1989). Reponse dupcher au paclobutrazol: effets du produit sur la croissance vegetative et la fructification. Fruits, 44: 99-108. Lockhard
16. Quinlan, J.D., Richardson, P.J. (1984). Effect of paclobutrazol (PP333) on apple shoot growth. Acta Hortic., 146: 105-111.
17. Wang, Y., and Gregg, L. L. (1989). Uniconazole Affects Vegetative Growth, Flowering, and Stem Anatomy of Hibiscus. J. Amer. Soc. Hort. Sci. 1989. 114: 927-932.
18. Wolters, H., and Jurgens, G. (2009). Survival of the flexible: hormonal growth control and adaptation in plant development. Nat. Rev. Genet. 10, 305–317.