

**ADVENTITIOUS ROOT FORMATION OF DIFFERENT VARIETIES OF
TOMATO (*Solanum lycopersicum* L.) APPLIED WITH PLANT GROWTH
REGULATORS UNDER FLOODED CONDITION**

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(Crop Science-Horticulture)**

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ACCEPTANCE SHEET

This undergraduate thesis entitled “**ADVENTITIOUS ROOT FORMATION OF DIFFERENT VARIETIES OF TOMATO (*Solanum lycopersicum* L.) APPLIED WITH PLANT GROWTH REGULATORS UNDER FLOODED CONDITION**” prepared and submitted by **JOHN JERIC SORIANO LEAÑO**, in partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN AGRICULTURE (CROP SCIENCE HORTICULTURE)**, is hereby accepted:


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BIOGRAPHICAL SKETCH

The author, John Jeric S. Leano was born on February 2nd nineteen ninety seven at Brgy. Sta. Lucia, Guimba, Nueva Ecija. He was the oldest child of Mr. Jerry F. Leano and Mrs. Juliet S. Leano. He has two sister named Jessa Mae S. Leano and Janina Mae L.Asunsion.

He finished his elementary in the year 2009 at Guimba East Central in Guimba, Nueva Ecija while he completed his secondary education in year 2013 at Our Lady of the Sacred Heart College in Guimba, Nueva Ecija.

To reach his goal and fulfill his dream of being a successful agriculturist, he took up Bachelor of Science in Agriculture major in Crop Science with Horticulture as his skills and knowledge, he conducted an undergraduate thesis entitled “Adventitious root formation of different varieties of tomato (*Solanum lycopersicum* L.) applied with plant growth regulators under water logged condition”. His stay in the university enabled him to acquire knowledge and skills needed for a better future.

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ABSTRACT

LEAÑO, JOHN JERIC, S., Department of Crop Science, College of Agriculture, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines, January 2020, **ADVENTITIOUS ROOT FORMATION OF DIFFERENT VARIETIES OF TOMATO (*Solanum lycopersicum* L.) APPLIED WITH PLANT GROWTH REGULATORS UNDER FLOODED CONDITION.**

Adviser: Mr. ACE MUGSSY L. AGUSTIN

This study evaluated the effects of Auxin and Cytokinin on growth and survival of different varieties of tomato under flooded conditions. Specifically, it aimed to evaluate varietal difference in adventitious root formation of tomato under flooded condition and to determine the effects of Auxin and Cytokinin in adventitious root formation and elongation of flooded tomato. The treatment used were water regime as main plot WR1 - 0 day (non-waterlogged/control), WR2 - 2 days (waterlogged) (0r until wilting). Variety as sub plot V1 - Diamante Max, V2 – Rosanna, and V3 – Apollo. Combination of Auxin and Cytokinin as sub-sub plot C1 - Untreated Control, C2 – 0% Auxin + 5% Cytokinin, C3 – 0% Auxin + 10% Cytokinin, C4 – 0.125% Auxin + 0% Cytokinin, C5 – 0.125% Auxin + 5% Cytokinin, C6 – 0.125% Auxin + 10% Cytokinin, C7 – 0.25% Auxin + 0% Cytokinin, C8 – 0.25% Auxin + 5% Cytokinin, C9 – 0.25% Auxin + 10% Cytokinin. Treatments were arranged in split-split plot design in RCBD.

Based on the results, combination of auxin and cytokinin did not improve the growth (plant dry weight) of different tomato varieties subjected to flooded condition. No varietal difference was found in terms of adventitious root formation (number, length and dry weight) indicating that Diamante Max, Rosanna and Apollo have similar capacity in

adventitious root development under flooded condition. Furthermore, the combinations of auxin and cytokinin used in this study were not able to improve adventitious root formation of tomato. Thus, it is recommended that in studying adventitious root of tomato, any of the above varieties can be used and other PGRs and techniques should be explored to improve adventitious root formation of tomato for flooding adaptation.

Keywords: Tomato, Growth Regulators, Auxin and Cytokinin

LITERATURE CITED

- Allen, A. (2008). "A Passion for Tomatoes". Retrieved on July 5, 2017 from <http://www.smithsonianmag.com/sciencenature/fasionfortomatoes>
- Armstrong W., Drew MC. (2002). Root Growth and Metabolism, Under Oxygen Deficiency.
- Ashraf Muhammad Arslan. (2012). Waterlogging Stress in Plants: A Review. *African Journal of Agricultural Research* Vol. 7(13), pp. 1976-1981
- Apel K., Hirt H. (2004). Reactive Oxygen Species: Metabolism, Oxidative Stress, and Signal Transduction. *Plant Bio.* 55 (1): 379-399.
- Ashraf M., Arfan M. (2005). Gas exchange characteristics and water relations in two cultivars of *Hibiscus esculentus* under waterlogging. *Biology Plant*, 49: 459-462.
- Ashraf MA., Ahmad MSA., Ashraf M., Al-qurainy F., Ashraf MY. (2011). Alleviation of waterlogging stress in upland cotton (*Gossypium hirsutum* L.) by exogenous application of potassium in soil and as a foliar spray. *Crop Pasture Sci.*, 62(1): 2538.
- Ashraf M., Akram NM. (2009). Improving salinity tolerance of plants through conventional breeding and genetic engineering: An analytical comparison. *Biotech. Adv.*, 27: 84-93.
- Baloch, A., (1994). Vegetable crops. Horticulture National Book Foundation. Islamabad. Pp:489-509
- Bange M.P., Milroy S.P., & Thoinbai P. (2004). Growth and yield of cotton in response to waterlogging. *Field Crops Res.* 88: 129-142.
- Boem FHG., Lavado RS, Porcelli CA (1996). Note on the effects of winter and spring waterlogging on growth, chemical composition and yield of rapeseed. *Field Crops Res.*, 47: 175-179.
- Bradford KJ., Hsiao TC. (1982). Stomatal behaviour and water relations of waterlogged tomato plants. *Plant Physiology.* 70, 1508-1513.
- Bradford, K.J. (1983) Effects of Soil Flooding on Leaf Gas Exchange of Tomato Plants. *Plant Physiol.*, 73:475-479.

- Dat J., Folzer H., Parent C., Badot P-M., Cappeli N. (2006). Hypoxia stress. Current understanding and perspectives. In: *Teixeira da Silva JA (Ed) Floriculture, ornamental and plant biotechnology. Advances and tropical issues (Vol 3)*, Global Science books, Isleworth, United Kingdom, pp. 664-674.
- Dennis E.S., Dolferus R., Ellis M., Rahman M., Wu Y., Hoeren F. U., Grover A., Ismond K.P., Good A.G., & Peacock W.J. (2000). Molecular strategies for improving waterlogging tolerance in plants. *J. Exp. Bot.* 51: 89–97.
- Evans DE. (2004). Aerenchyma formation. *New phytol.*, 161: 35-49.
- Else MA., Coupland D., Dutton L., Jackson MB. (2001). Decreased root hydraulic conductivity reduces leaf water potential, initiates stomatal closure and slows leaf expansion in flooded plants of castor oil (*Ricinus communis*) despite diminished delivery of ABA from the roots to shoots in the xylemsap. *Physiol. Plant*, 111:46-54.
- Ezin, V., Pena, R.D.L. and Ahanchede, A., (2010). Flooding tolerance of tomato genotypes during vegetative and reproductive stages. *Brazilian Journal of Plant Physiology*, vol. 22, pp. 131-142.
- Fischer G., Shah M., Van Velthuisen H., and Nachtergaile F.O. (2001). Global Agro-ecological Assessment for Agriculture in the 21st Century. International Institute for Applied Systems Analysis, Laxenburg, Austria, 33 pp.
- Folzer H., Dat J., Capelli N., Rieffel D., Badot PM. (2006). Response to flooding of sessile oak: An integrative study. *Tree Physiol.*, 26: 759766.
- Fulton, J. M. & Erikson, A. E. (1964). Relation between soil aeration and ethyl alcohol accumulation in xylem exudate of tomatoes. *Proc. Soil Sci. Soc. Am.* 28:610-614.
- George, E. F, (2008). Plant Growth Regulators II: Cytokinins, their Analogues and Antagonists. *Plant Propagation by Tissue Culture 3rd Edition*, 205–226.
- Hemantaranjan A, Patel PK, Singh AK, Tripathi N, and Yadav D. Flooding: Abiotic Constraint Limiting Vegetable Productivity. (2014). *Adv Plants Agric Res* 1(3):00016
- Hirabayashi Y., Mahendran R., Koirala S., et al. (2013). Global flood risk under climate change. *Nature Climate Change* 3: 816–821.

- Hiron RWP., Wright STC. (1973). The role of endogenous abscisic acid in the response of plants to stress. *J. Exp. Bot.* 24:769-781.
- Horchani, F., Khayati, H., Raymond, P., Brouquisse, R. and Aschi-Smiti, S., (2009). Contrasted effects of prolonged root hypoxia on tomato root and fruit (*Solanum lycopersicum*) metabolism. *Journal Agronomy & Crop Science*, vol. 195, no. 4, pp. 313-318. <http://dx.doi.org/10.1111/j.1439-037X.2009.00363.x>.
- Islam MR, Hamid A, Khaliq QA, Haque MM, Ahmed JU, and Karim MA. (2010). Effects of Soil Flooding On Roots, Photosynthesis and Water Relations in Mungbean (*Vigna radiate* L.). *Bangladesh J. Bot.* 39(2):241-243
- Jackson, W. T. (1956). The relative importance of factors causing injury to shoots of flooded tomato plants. - *Am. J. Bot.* 43: 637-639.
- Jackson M. B. and Colmer T. D. (2005) Response and Adaptation by Plants to Flooding Stress.
- Justin, S.H.F.W. & Armstrong, W. (1987) The Anatomical Characteristics of Roots and Plant Response to Soil Flooding. *New Phytologist* 106, 465–495.
- Kieffer, M., Neve, J., Kepinski, S., (2010). Defining auxin response contexts in plant development. *Curr Opin Plant Biol* 13:12–20
- Kozlowski, T.T., (1997). Responses of woody plants to flooding and salinity. *Tree Physiology Monograph*, vol. 1, pp. 1-29.
- Kramer PJ. (1951). Causes of injury to plants resulting from flooding of the soil. *Plant Physiol.* 26: 722-736.
- Li H., Syvertsen JP., Stuart RJ., McCoy CW., Chumann AW., Castle WS. (2004). Soil and *Diaprepes abbreviatus* root weevil spatial variability in a poorly drained citrus grove. *Soil Sci.*, 169: 650-662.
- Lin K.R., Weng C., Lo H., Chen J. (2004). Study of the root antioxidant system of tomatoes and eggplants under waterlogged conditions. *Plant Sci.* 167: 355-365.
- Lindolph PE. (1985). *Weather and Climate* Rowman & Allenheld; editors. Littlefield Adams and Company. P. 2-66.
- Loach, K., (1988). Hormone applications and adventitious root formation in cuttings a critical review. *Acta Hort (ISHS)* 227:126–133

- Malik AL, Colmer TD., Lambers H., Schortomeyer M. (2001). Changes in physiological and morphological traits of roots and shoots of wheat in response to different depths of waterlogging. *Aus J. of Plant Physio.* 28 (11): 1121-1131.
- Mc Namara S., Mitchell C. (1991). Roles of Auxin and Ethylene in Adventitious Root Formation by a Flood- resistant Genotype. *Hort. Sci.* 20 (1): 57-58.
- Mommer L., Visser EJ. (2005). Underwater photosynthesis in flooded terrestrial plants: a matter of leaf plasticity. *Annals of Botany* 96: 581–589.
- Ngomuo, M., Mneyney, E., & Ndakimedi, P., (2013). The Effects of Auxins and Cytokinin on Growth and Development of (*Musa sp.*) *Var. "Yangambi" Explants in Tissue Culture. From American Journal of Plant Sciences*, 2013, 4, 2174-2180
Published Online November 2013 (<http://www.scirp.org/journal/ajps>)
<http://dx.doi.org/10.4236/ajps.2013.411269>
- Opena, R. T., (1985). Development of tomato and Chinese Cabbage cultivars adapted to hot humid tropics. *Acta Horticulture* 153: 421-436.
- PAGASA-DOST. (2016) Climate Change in the Philippines. Retrieved November 10, 2016. <http://pagasa.dost.gov.ph/>
- Parent C., Berger A., Folzer H., Dat J., Crevecoeur M., Badotp- M., Capelli N. (2008). A novel nonsymbiotic hemoglobin from oak: Cellular and tissue specificity of gene expression. *New phytol.*, 177: 142-154.
- Parelle J., Brendel O., Bodencs C., Berveiller D., Dizengremel P., Jolivet Y., Dreyer E. (2006). Differences in morphological and physiological responses to waterlogging between two sympatric oak species (*Quercus petraea* [Matt.] Liebl., *Quercus robur* L.). *Ann. Forest Sci.*, 63: 257-266.
- Perboni, A.T., Cassol, D., Silva, F.S.P., Silva, D.M. and Bacarin, M.A., (2012). *Chlorophyll a fluorescence study revealing effects of flooding in canola hybrids. Biologia*, vol. 67, no. 2, pp. 338-346. <http://dx.doi.org/10.2478/s11756-012-0006-0>.
- Preece, J. E., (2003). A century of progress with vegetative plant propagation. *Hortic Sci* 38:1015–1025
- Prosea, (1996). *Plant Resources of South-East Asia 8 Vegetables*. Retrieved on december 1, 2017 from <https://books.google.com.ph/books/about/>
- Rao R, LI Y, Bryan HH. (2002) Assessment of Foliar Sprays to Alleviate Flooding Injury in Corn (*Zea mays* L.). *Proc Fla State Hort Soc.* 115: 208-211.

- Richford, N., (2010). Growing Tomatoes Hardening Off Tomato Plants. Retrieved on July 2, 2017 from <http://www.associatedcontent.com/>.
- Rudich, J. & Artherton, J.G. (1986). Botany of Tomato Crop. 6th edition Mac Millan Publication Com., New York, pp:221-222
- Sand-Jensen K. (1989). Environmental variables and their effect on photosynthesis of aquatic plant communities. *Aquatic Botany*34: 5–25.
- Slabbert, R.M. and Kruger, G.H.J., (2011). Assessment of changes in photosystem II structure and function as affected by water deficit in *Amaranthus hypochondriacus* L. and *Amaranthus hybridus* L. *Plant Physiology and Biochemistry*, vol. 49, no. 9, pp. 978-984. <http://dx.doi.org/10.1016/j.plaphy.2011.05.001>. PMID:21696974.
- Sojka RE. (1992). Stomatal closure in oxygen-stressed plants. William and Wilkins. J of Soil Sci.
- Smethurst CF., Garnet T., Shabala S. (2005). Nutrition and chlorophyll fluorescence responses of lucerne (*Medicagosativa*) to waterlogging subsequent recovery. *Plant Soil*, 270(1–2): 31-45.
- Smith K. (2013). Hydrological hazards: floods. In: Environmental hazards: assessing risk and reducing disaster. London & New York: Routledge, 299–329.
- Steffens B., Wang J., Santer M. (2006). Interactions between ethylene, gibberellins and abscisic acid regulate emergence and growth rate of adventitious roots in deep water rice. *Planta*, 223: 604-612.
- Ta-liao C., Ho Lin C. (2001). Physiological Adaptation of Crop Plants to Flooding Stress. *Proc. Natl. Sci. Coun. ROC (B)*. 25: 148-157.
- Tarekegne A., Bennie ATP., Labuschagne MT. (2000). Effects of soil waterlogging on the concentration and uptake of selected nutrients in wheat genotypes differing in tolerance. In the eleventh regional wheat workshop for eastern, central and southern Africa, Addis Abeba, Ethiopia, Addis Ababa, pp. 253-263.
- Titanreko T. (2000) Test parameters of revealing the degree of fruit plants tolerance to the root hypoxia caused flooding of soil. *Plant Physiol. Biochem.*, 38(Suppl): s115.

- Trewavas, A. J., 1982. Growth substance sensitivity: the limiting factor in plant development. *Physiol Plant* 55:60–72
- Vanbodegom PM., Sorrel BK., Oosthoek A., Bakker C., Aerts R. (2008). Separating the effects of partial submergence and soil oxygen demand on plant physiology. *Ecology* 89: 193–204.
- Van Der Vossen, H. A. M., Nono-Womdim, R. & Messianen, C. M. 2004. *Lycopersicon esculentum* In: Grubben, G. J. H. & DENTON, O. A (Editors). PROTAB2. Vegetables/legumes. PROTA, Wageningen, Netherlands.
- Vervuren PJA., Blom CWPM., De Kroon H. (2003). Extreme flooding events on the Rhine and the survival and distribution of riparian plant species. *Journal of Ecology* 91: 135–146.
- Wright, H., DeLong, J., Lada, R. and Prange, R., 2009. The relationship between water status and chlorophyll a fluorescence in grapes (*Vitis* spp.). *Postharvest Biology and Technology*, vol. 51, no. 2, pp. 193-199. <http://dx.doi.org/10.1016/j.postharvbio.2008.07.004>.
- Yordanova RY., Popova LP. (2001). Photosynthetic response of barley plants to soil flooding. *Photosynthetica*, 39: 515-520.
- Zou, X., Xiaoyu, T., Chengwei, H., Liu, Z., Guangyuan, L., Guiping, F., Yong, C. and Xuekun, Z., 2013. The transcriptome of *Brassica napus* L. roots under waterlogging at the Seedling Stage. *International Journal of Molecular Sciences*, vol. 14, no. 2, pp. 2637-2651. <http://dx.doi.org/10.3390/ijms14022637>. PMID:23358252.