IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 15, Issue 6 Ser. I (June 2022), PP 50-56
www.iosrjournals.org

Experimental study on impact of Salinity stress on plant growth and building Prediction Model for Stress responses

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Abstract
Plant abiotic stress has been a major problem for reduced crop yield and imposes the key challenges to farmers for dealing with abiotic stress. Salinity stress is one the abiotic stress, which causes huge loss in crop yield and needs immediate attention to reduce the salinity stress effect on plants growth. The general symptoms of damage caused by salt stress are growth inhibition, accelerated development, senescence and death during prolonged exposure. This paper showcases one such work towards determining the effects of salinity stress on plants growth and possible ways of predicting the salinity stress responses. The built prediction model for stress response is used for engaging the necessary actions in advance to minimize the stress effect. In this work, Wireless sensor Network technology is used to collect the real time data of plants under salinity stress and collected data is analyzed to build a prediction model for predicting the possible salinity stress responses. The results showcase the different effects of salinity stress on plants and evaluation of stress response prediction models by conducting repeated experiments.

Date of Submission: 12-06-2022 Date of Acceptance: 27-06-2022

I. Introduction

The plant abiotic has been a major problem around the worldwide for reduced crop yield. Plant abiotic stress deals with the effects of environmental factors or parameters on the normal growth of the plant. The abiotic stress causes the various changes in the physiological process in plants and affects the growth of plants. The different environmental factors as part of abiotic stress are varied temperature, moisture, humidity, atmospheric pressure, light intensities, elevated co2 and o2 levels etc. Each plant has its own abiotic stress tolerance by acclimating to the various abiotic stresses and maintains its physiological process. The variation of different plant species to abiotic stress tolerance and its adaptation to the different abiotic stress factors results in non unique responses of abiotic stress on plants. The non unique response of plant abiotic stresses imposes further challenges' for determining and predicting the abiotic stress responses on plants. Hence lots of research is underway to deal with the abiotic stress and minimize its effects on plant growth. Some of the research was carried out on the study of abiotic stress based on destructive methods, in which plants will be damaged to study the abiotic stress response. The advancement in technologies enables the researchers to carry out study of abiotic stress on plants using non destructive methods.

Soil Salinity level is one of the important properties of soil which has a direct effects on soil water accumulation level and plant growth. Salt stress causes huge loss of agricultural productivity worldwide. The general symptoms of damage caused by salt stress are growth inhibition, accelerated development, senescence and death during prolonged exposure. The high soil saline in the coastal region of agriculture land poses the greater threat to the crop yield. The saline soil causes the various changes in the physiological process of plant and effects the normal plant growth. The improper water management is one of the reasons for the increase in the soil salinity level. The high salinity in soil causes the reduction in plant water intake by root and reduces the water movement to different membranes of the plant. Salt tolerance level of plants differs with respect to different species and imposes difficulties in predicting and determining the salt stress response. Hence this paper showcases the work of non destructive methods on study of abiotic stress of salinity stress effect on plants using Wireless Sensor Technology and data analytics approach.

Wireless Sensor Technology is one of the popular technologies of the ear, in which sensor nodes are deployed to collect the real time data of different environmental factors. Data analytics is the phase, in which collected data undergo deeper analysis to identify the useful patterns among the data and end with useful information for determining the unknown knowledge.

II. Literature Survey:

Soil salinity is one of the abiotic factors affecting crop yield and approximately around 6% of world land is affected by soil salinity[1]. In paper [2], an experimental study was carried out by varying soil salinity stress levels using sea water on banana plants and observed the morpho-physiological responses. In paper [3] Effect of salinity stress on tomato cultivars is tested and determines the ROS parameters and phenotyping observation were noted for identifying the salinity stress tolerance parameter. In paper [4], salinity stress impact on kiwifruit genotypes were carried out and noted a highly considerable stress response in terms of plant root and leaf damages. In paper [5] different level salt stress is induced on eggplant cultivars and stress response in terms of physiological changes such as leaf number, shoot length, mean germination time were observed. In paper [6], salinit stress effect on basil plant is carried out and notable stress response on leaf surface area, leaf biomass and number of leafs were observed. In paper[7] salinity and water stress is applied on sweet basil and observed the effect of stress on root dry weight, aerial dry weight and shoot/root growth ratio and restulst showcased the decreased growth under high salinity even though basil plants tolerate salinity stress upto certain level. In Paper [8] 2 soybean cultivars were treated with different levels of salinity stress and decreased shoot length, leaf numbers were observed as a stress response. In paper [9], an experimental study was carried out to study the tolerance of salinity stress on pole beans. Different concentrations of salinity stress media are prepared and pole beans are grown in those media and impact of salinity stress and plant tolerance level is observed. In paper [10], plant growth bacteria is inoculated in salinity stressed plants and changes in the salinity stress tolerance is observed by comparing with the salinity stressed plants. In paper [11], an underground sensor network (WUSN) is utilized to get comprehensive real time data about soil temperature, salinity. In paper [12][13], discuss the incorporation of Internet of Things & WSN technology for monitoring the crop health and farm land parameters for achieving smart agriculture into reality. Paper [14][15] discuss the experimental study of building a machine learning based predcition model for stress response.

III. Materials and Methods

A pot experiment was conducted in the greenhouse for the study of salinity stress on chilli plants. Initially chilli plant seeds were sowed in a fertilized soil and waited for a week to get germinated. Once the chilli plants are germinated, 3 plants of equal growth size are taken for conducting salinity stress experiments. Three selected plants are transferred into 3 fertilized soil pots and correspondingly watered according to the water holding capacity of the pot soil for 2 weeks. Each of the pots is attached with the soil moisture, temperature sensors. Out of the three plants, one plant is considered as a controlled plant and the remaining two plants were chosen for inducing salinity stress. Two chosen plants for salinity stress are induced with 200ppm and 400ppm of salinity stress for alternative days respectively. Two NaCl concentrations of 200ppm, 400ppm are prepared and mixed with irrigating water to plants, which equals to the water holding capacity of the soil. Soil salinity level is computed per day using the drainage sample collected down at each pot using a vernier salinity sensor probe. The soil temperature, moisture level and soil salinity level is collected through National Instrument Wireless Sensor Node NI WSN 3202 Node. The NI WSN 9791 gateway collected sensor data to undergo deeper analysis and build prediction models.

NI WSN framework is used for collecting the real time data about the plant soil parameter. The architectural diagram for setup is shown in below fig, as shown in the fig each pot is attached with soil temperature, moisture and salinity sensor probe and connected to the NI WSN 3202 Node. NI WSN 3202 node in turn sends the collected data to the NI WSN 9791 Gateway though IEEE 802.15.44 Zigbee wireless channel.

The collected data undergo deeper analysis using R statistical language and WEKA tool for identifying association among data and building prediction models. The prediction model is useful in determining the plant growth status well in advance and engaging necessary actions to reduce the stress effect if any on the plant. The use of the proposed prediction model is described in detail by considering the following scenario of growing 5 plants as follows.

Plant A - No stress

Plant B & Plant D – 10 % Stress

Plant C & Plant E– 20 % Stress

Plant A, Plant B and Plant C data such as height of plant with respect to day wise are collected. The collected data undergo R statistical Language based analysis of building Regression Model based prediction model for predicting the possible height of a plant. The built prediction model is used for predicting the Plant height and if the plant height lies in the nearby range of Plant B and Plant C, then it is considered a stressed plant and shows abnormal growth of plant. In this study, Plant D and Plant E height is predicted and verified with the built prediction model.

IV. Results and Analysis.

Soil salinity stress induced the effects on plant height as shown in below figure 1. Plant A without stress grew to a larger height compared to the plant B and Plant C salinity stressed plant. Even highly stressed Plant C compared to Plant B shows the reduction in height with respect to Plant B. Both the stressed plant B and Plant C show the similar behavior for the first 20 days due to the Salt tolerance properties of the plant. After 20 days, variation in the height due to salinity stress is observed.

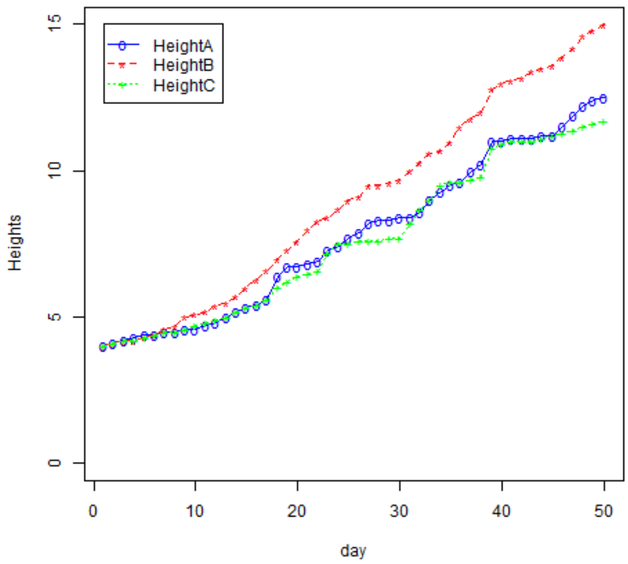

Figure 1 Salinity stress response on height of plant

Soil salinity stress induces the further effect on both the plant B and Plant C and correspondingly the stress response were noticed on plant B and plant C as shown in below figure 2. Sub-figure 2.1 shows Plant C leaf is observed with the dry leaf edge on 19th day of experiment and further stress response in terms of bottom up effect of leaf miner is noticed on day 38 in sub-figure 2.2. Similarly Plant B shows the stress response of bottom up effect of leaf miner on day 29 and overall plant B stress response of plant B leaf wilt on day 48.

Figure 2 Leaf burn at edge at plant C (day 19)

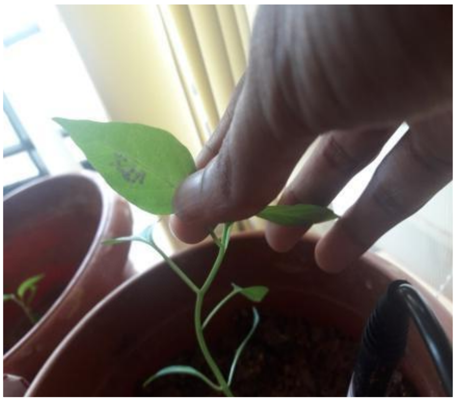

Figure 3 Leaf Miner Disease progression in plant C (day 38)

Figure 4 Leaf Miner Disease infection in plant B (day 29)

Figure 5 Moderate stage in plant B. Leaf falls (day 48)

Prediction Model: the collected data such as day wise height of each plant undergo the deeper analysis for building a prediction model. The prediction model is used to predict the height of the plant of stressed and unstressed plant shown in figure 7, figure 8 and figure 9. The predicted height of plant with respect to the day wise is useful the determining the plant growth status shown in figure 10 & figure 11. If the predicted height lies in the range of Plant B and Plant C observed height, it's the indication of stress on plant under observation. Even the height of plant is affected several other factors, in our study assumption is considered and plants are grown in the similar conditions. The below graph in figure 7, figure 8 and figure 9 shows the predicted height of Plant A and Plant B and Plant C and prediction model is verified by taking another test plant under 8% salinity stress and 15% salinity Stress. The predicted height of plant under 8% stress lies in range nearby by 10% stress induced plant height. And correspondingly the predicted height of plant under 16% stress lies in range nearby by 20% stress induced plant height.

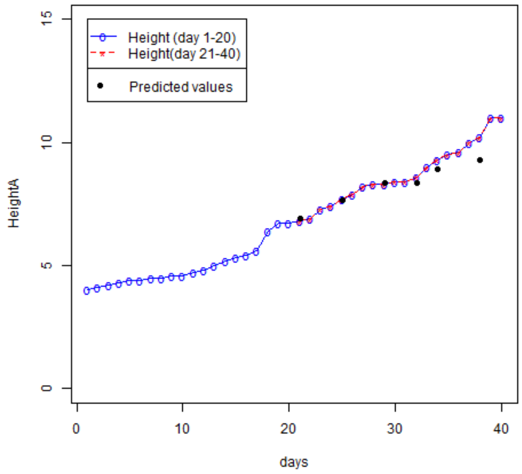

Figure 6 Plant A height predicted vs actual

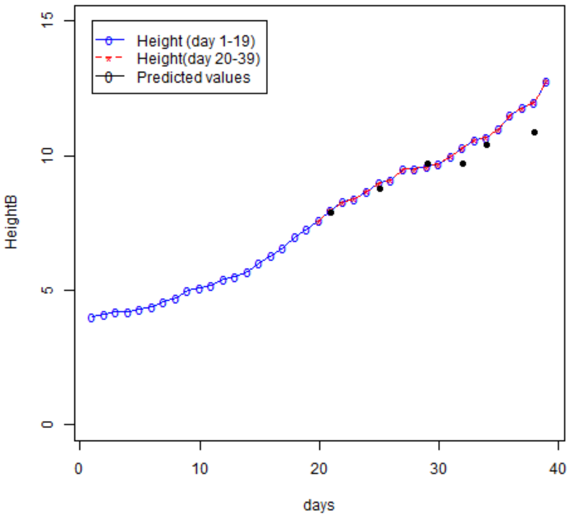

Figure 7 Plant B height predicted vs actual

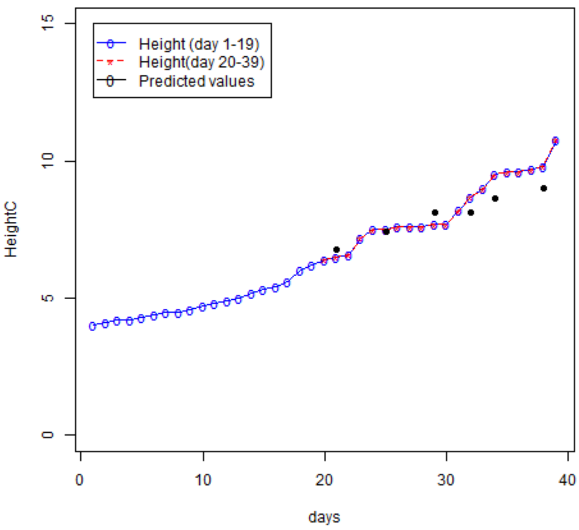

Figure 8 Plant C height predicted vs actual

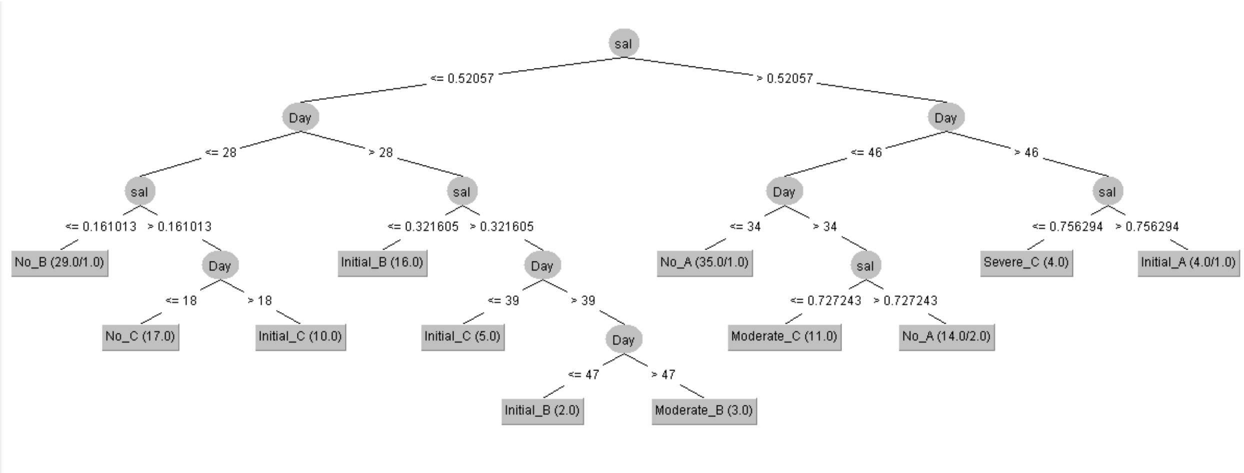

Figure 9 Decision Tree for predicting day wise stage of stress response

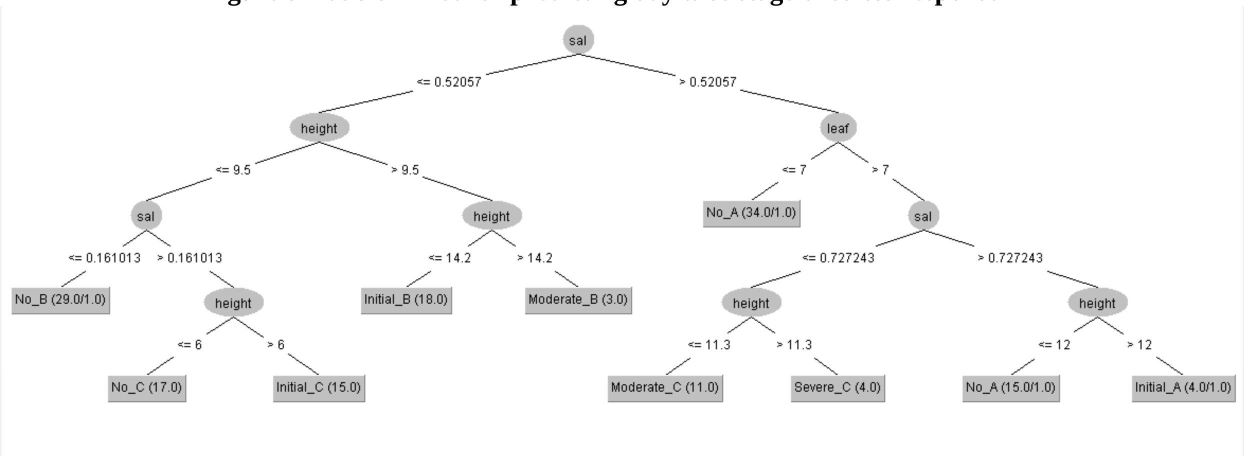

Figure 10 : Decision tree for predicting stage of stress response using height and leaf properties

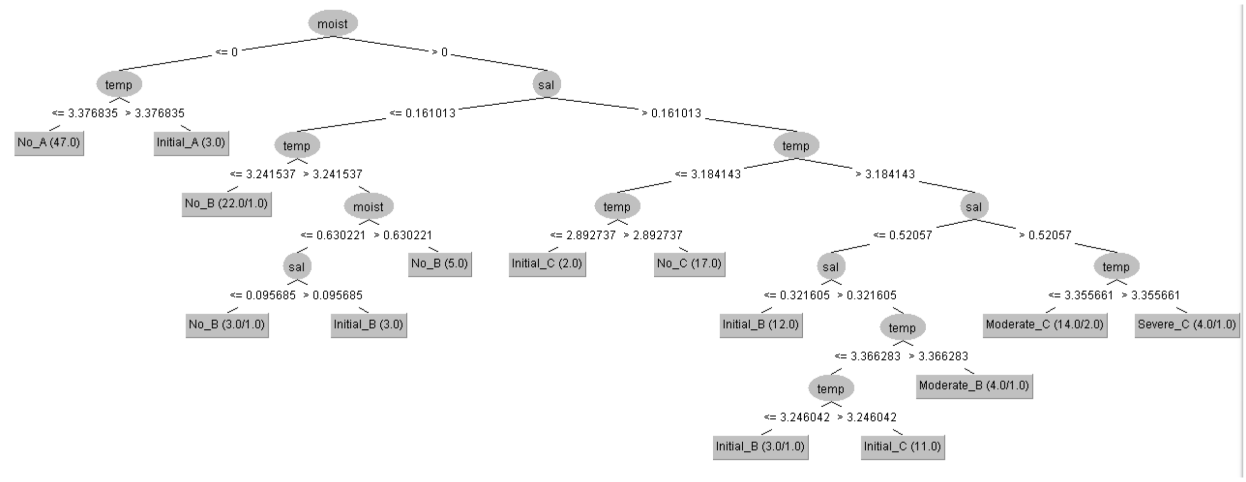

Figure 11: Stage of stress response associating between soil temperature and moisture

The figure 11 shows the decision tree for predicting the effect of salinity stress and its association among soil moisture and temperature parameters. As shown in the above figure soil moisture and temperature can be utilized to determine the effect of salinity to determine the stage of stress response.

V. Conclusion

The proposed work results clearly showcase the impact of salinity stress on plant growth and the roll of Wireless sensor network technology on the early detection of stress response. The prediction model for early detection of stress response would help the farmers to engage necessary actions to mitigate the escalation of stress conditions and in-turn increase the crop yield.

Acknowledgements

Authors like to sincerely acknowledge Vision Group on Science and Technology (VGST), Department. of IT, BT, and S&T, Government of Karnataka, Bangalore, for sanctioning research grant for the Department of Computer Science and Engineering, Mangalore Institute of Technology and Engineering, Moodabidri, under KFIST= L2 grant schema vide GRD No. 339 dated

References :

[1]. Parihar, P., Singh, S., Singh, R., Singh, V. P., Prasad, S. M., Ramanuj, G., & Singhdev, P. (2014). *Effect of salinity stress on plants and its tolerance strategies: a review - Springer Effect of salinity stress on plants and its tolerance strategies: a review Effect of salinity stress on plants and its tolerance strategies: a review - Springer*. https://doi.org/10.1007/s11356-014-3739-1/fulltext.html

[2]. Mazumdar, P., Lau, S. E., Singh, P., Takhtgahi, H. M., & Harikrishna, J. A. (2019). Impact of sea-salt on morpho-physiological and biochemical responses in banana (Musa acuminata cv. Berangan). *Physiology and Molecular Biology of Plants*, *25*(3), 713–726. https://doi.org/10.1007/s12298-019-00659-3

[3]. Gharsallah, C., Fakhfakh, H., Grubb, D., & Gorsane, F. (2016). Effect of salt stress on ion concentration, proline content, antioxidant enzyme activities and gene expression in tomato cultivars. *AoB PLANTS*, *8*. https://doi.org/10.1093/aobpla/plw055

[4]. Abid, M., Zhang, Y. J., Li, Z., Bai, D. F., Zhong, Y. P., & Fang, J. B. (2020). Effect of Salt stress on growth, physiological and biochemical characters of Four kiwifruit genotypes. *Scientia Horticulturae*, *271*. https://doi.org/10.1016/j.scienta.2020.109473

[5]. Hannachi, S., & van Labeke, M. C. (2018). Salt stress affects germination, seedling growth and physiological responses differentially in eggplant cultivars (Solanum melongena L.). *Scientia Horticulturae*, *228*, 56–65. https://doi.org/10.1016/j.scienta.2017.10.002

[6]. Attia, H., Ouhibi, C., Ellili, A., Msilini, N., Bouzaïen, G., Karray, N., & Lachaâl, M. (2011). Analysis of salinity effects on basil leaf surface area, photosynthetic activity, and growth. *Acta Physiologiae Plantarum*, *33*(3), 823–833. https://doi.org/10.1007/s11738-010-0607-6

[7]. Caliskan, O., Kurt, D., Temizel, K. E., & Odabas, M. S. (2017). Effect of salt stress and irrigation water on growth and development of sweet basil (Ocimum basilicum L.). *Open Agriculture*, *2*(1), 589–594. https://doi.org/10.1515/opag-2017-0062

[8]. El-Kholy, R. I., Sayed, A. I., El-Shaer, H. F., & Hanafy, M. S. (2021). Impact of sea salt stress on growth and some physiological attributes of two soybean (Glycine Max L.) cultivars. In *Journal of Agricultural Research V* (Vol. 46, Issue 2).

[9]. Al-huraby, A. I., & Bafeel, S. O. (2022). The effect of salinity stress on the Phaseolus vulgaris L. plant. *African Journal of Biological Sciences*, *4*(1), 94. https://doi.org/10.33472/afjbs.4.1.2022.94-107

[10]. Bisht, S., Singh, S., Singh, M., & Sharma, J. G. (2022). Augmentative role of Piriformospora indica fungus and plant growth promoting bacteria in mitigating salinity stress in Trigonella foenum-graecum. *Journal of Applied Biology and Biotechnology*, *10*(1), 85–94. https://doi.org/10.7324/JABB.2021.100111

[11]. Banaseka, F. K., Franklin, H., Katsriku, F. A., Abdulai, J. D., Ekpezu, A., & Wiafe, I. (2021). Soil Medium Electromagnetic Scattering Model for the Study of Wireless Underground Sensor Networks. *Wireless Communications and Mobile Computing*, *2021*. https://doi.org/10.1155/2021/8842508

[12]. Rehman, A., Saba, T., Kashif, M., Fati, S. M., Bahaj, S. A., & Chaudhry, H. (2022). A Revisit of Internet of Things Technologies for Monitoring and Control Strategies in Smart Agriculture. In *Agronomy* (Vol. 12, Issue 1). MDPI. https://doi.org/10.3390/agronomy12010127

[13]. Mehmood, M.Z. *et al.* (2022). Internet of Things (IoT) and Sensors Technologies in Smart Agriculture: Applications, Opportunities, and Current Trends. In: Jatoi, W.N., Mubeen, M., Ahmad, A., Cheema, M.A., Lin, Z., Hashmi, M.Z. (eds) Building Climate Resilience in Agriculture. Springer, Cham. https://doi.org/10.1007/978-3-030-79408-8_21

[14]. Rico-Chávez, A. K., Franco, J. A., Fernandez-Jaramillo, A. A., Contreras-Medina, L. M., Guevara-González, R. G., & Hernandez-Escobedo, Q. (2022). Machine Learning for Plant Stress Modeling: A Perspective towards Hormesis Management. *Plants*, *11*(7), 970. https://doi.org/10.3390/plants11070970

[15]. Wu, L., Zeng, W., Lei, G., Ma, T., Wu, J., Huang, J., Gaiser, T., & Kumar Srivastava, A. (2022). Simulating root length density dynamics of sunflower in saline soils based on machine learning. *Computers and Electronics in Agriculture*, *197*, 106918. https://doi.org/10.1016/j.compag.2022.106918

Sunil Kumar S, et. al. "Experimental study on impact of Salinity stress on plant growth and building Prediction Model for Stress responses." *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)*, 15(06), 2022, pp. 50-56.