Journal of Technology and Innovation June 2024 Vol.11 No.28 39-45
Article

Attenuation of the effect of salinity on redwood (*Caesalpinia platyloba*) by saline compost

Atenuación del efecto de la salinidad en palo colorado (*Caesalpinia platyloba*) por composta salina

Roblero-Roblero, Elier Rutilo[a], Ruelas-Ayala, Rey David[b], Sañudo-Torres, Rosario Raudel[c] and Félix-Herrán, Jaime Alberto[d]

[a] Universidad Autónoma Indígena de México • KCX-8954-2024 • 0009-0001-6893-6994
[b] Universidad Autónoma Indígena de México • 0000-0002-4953-0622 • 313030
[c] Universidad Autónoma Indígena de México • 0009-0009-7563-7317 • 1353280
[d] Universidad Autónoma Indígena de México • 0000-0002-9232-8163 • 261552

CONAHCYT classification:

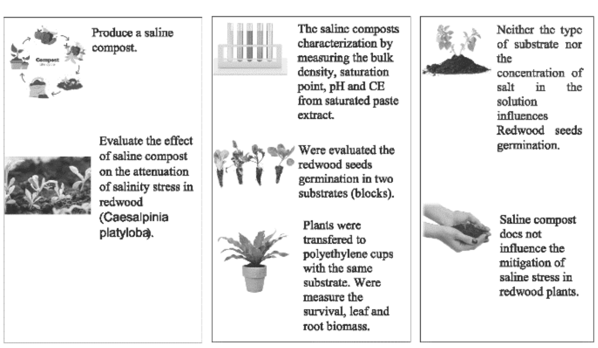
Area: Biotechnology and agricultural science
Field: Agricultural biotechnology
Discipline: Agricultural biotechnology
Subdiscipline: Others

https://doi.org/10.35429/JTI.2024.28.11.39.45
History of the article:
Received: January 30, 2024
Accepted: June 30, 2024

* [jfelixherran@yahoo.com.mx]

Abstract

The objective of this research is to evaluate the effect of saline compost on the attenuation of salinity stress in palo colorado (Caesalpinia platyloba). A representative sample of saline soil was taken at Ciudad Universitaria Intercultural, sieved (mesh < 5mm) and composted with cattle manure and Cynodon dactylon garden grass pruning, in a 3:1:1 ratio (stubble: manure: saline soil), for 120 days, the characterization consisted of measuring the bulk density (DA), saturation point, pH and EC of the saturated paste extract. The effect of different concentrations of NaCl on the in vitro germination of palo colorado seeds was evaluated in a randomized complete block design with two substrates (blocks), B1) sand-perlite; B2) sand-perlite-salt compost, five treatments 0 M, 0.3 M, 0.4 M, 0.5 M and 0.6 M of NaCl, eight replicates per treatment. The control irrigation was with distilled water. The plants transference to polyethylene cups was fifteen days after sowing; the cups had the same substrate mixture. The variables measured were survival, leaf biomass and dry root biomass. The EC decreased during composting, from 9.45 dS/m low to 2.4 dS/m; the pH of the samples did not show a significant difference. It is concluded that neither the substrate nor the NaCl concentration significantly influenced the germination of palo colorado seeds, and that the saline compost had no effect on the mitigation of salt stress in palo colorado plants.



Foliar and root biomass, soil bioremediation, saline stress, plant development

Resumen

La presente investigación tiene por objetivo evaluar el efecto de la composta salina en la atenuación del estrés por salinidad en palo colorado (Caesalpinia platyloba). Se tomó una muestra representativa del suelo salino en Ciudad Universitaria Intercultural, se tamizó (malla < 5mm) y composteo con estiércol de bovino y poda de pasto de jardín Cynodon dactylon, en relación 3:1:1 (rastrojo: estiércol: suelo salino), por 120 días, la caracterización consistió en medir la densidad aparente (DA), punto de saturación, el pH y la CE del extracto de pasta saturada. Se evaluó el efecto de diferentes concentraciones de NaCl en la germinación in vitro de semillas de palo colorado en un diseño de bloques completos al azar con dos sustratos (bloques), B1) arena-perlita; B2) arena-perlita-composta salina, cinco tratamientos 0 M, 0.3 M, 0.4 M, 0.5 M y 0.6 M de NaCl, ocho repeticiones por tratamiento. El riego del testigo fue con agua destilada. Las plantas se transfirieron a vasos de polietileno a los 15 días de la siembra; los vasos tenían la misma mezcla de sustrato. Las variables medidas fueron sobrevivencia, biomasa foliar y radicular seca. La CE disminuyó durante el compostaje, de 9.45 dS/m bajo a 2.4 dS/m; el pH de las muestras no presentó diferencia significativa. Se concluye que ni el sustrato ni la concentración de NaCl influyen significativamente en la germinación de las semillas de palo colorado, y que la composta salina no tuvo efecto en la mitigación del estrés salino en plantas de palo colorado.

Biomasa foliar y radicular, bioremediación de suelo, estrés salino, desarrollo de planta

Citation: Roblero-Roblero, Elier Rutilo, Ruelas-Ayala, Rey David, Sañudo-Torres, Rosario Raudel and Félix-Herrán, Jaime Alberto. Attenuation of the effect of salinity on redwood (*Caesalpinia platyloba*) by saline compost**.** Journal of Technology and Innovation. 2024. 11-28:39-45.

Introduction

Redwood Caesalpinia platyloba S. Watson is a tree species of the Fabaceae family, distributed from Mexico to tropical South America (Rendón-Sosa and Sagayo-Lorenzana, 2017). It is one of the most rustic and versatile legume species (Díaz-Gustavo et al. 2015). In Mexico, the Comisión Nacional Forestal (CONAFOR) has used it in its reforestation programs, as well as to produce pulp for the pulp industry (Prieto et al. 2016). In addition, in the State of Sinaloa there is a high demand for C. platyloba sticks, used it in vegetable crop production market (CONAFOR, 2018).

Globally, soil salinity affects the environmental services that the ecosystem provides, including decreasing soil productivity, water quality, soil biodiversity and increasing soil erosion, degrades soil structure and reduces soil fertility by affecting the availability of micronutrients (FAO, 2021).

In Mexico, by 2022, approximately 64% of soils showed some degree of physical degradation (soil compaction, water or wind erosion) or chemical degradation (salinity, misuse of fertilizers); however, biological degradation (carbon loss) is higher (SADER, 2022). As for salinity, this can reach up to 3.2% of the territory with the states of Sonora, Sinaloa, Tamaulipas, San Luis Potosí, Chiapas, Nuevo León, Oaxaca, Veracruz and Zacatecas being the most affected (Trejo-González, et al., 2019).

Salinity in soil affects seed germination and plant development, causes changes in enzyme activity, suppression of chlorophyll biosynthesis, decreases electron flow from photosystem II (PSII) to photosystem I (PSI), and reduces CO_2 flux due to stomata closure (Nikolić et al., 2023).

In Sinaloa there is enormous potential for reforestation projects, especially when are established in degraded soil conditions where vegetation is scarce (Camejo and Torres, 2000; Rojo et al., 2006; Martínez-Villavicencio et al., 2011). *C. platyloba* is a species that has emerged as a legume of great interest for reforestation in the state, and for the establishment of agroforestry systems (Castillo-Morales et al., 2010). An option to reduce soil salinity is land drainage that allows washing the soils (FAO, 2023).

Also phytoremediation using soil reconversion to a stable ecosystem by introducing native forest species with potential to bioremediate the soil, such as mesquite, catclaw, huizache, among others (Trejo-González et al., 2019). Through redox reactions during the saline soil composting process, to reduce Na^+ ions and other ions present in saline soil to non-toxic forms for plants, e.g. compost and vermicompost (Ait-El-Mokhtar et al., 2022).

Compost and vermicompost, besides favoring the reduction of Na^+ ions in saline soil, can contribute to plant development, favoring the development of stem and root tissue, that is, they contribute to plant vigor; in soils disturbed by salinity, compost could attenuate the impact of salt on redwood plants.

Materials and methods

The representative samples of soil were from four sites with different degrees of salinity disturbance within Ciudad Universitaria Intercultural: 1) soil behind the greenhouse; 2) soil next to the lagoon; 3) soil under mesquite canopy; and 4) soil under tabachín canopy. The sites selection depends on the visible signs of salinity. The variables considered for soil characterization, dried and sieved (> 5 mm), were bulk density, pH and electrical conductivity of saturated paste extract (Table 1).

Box

Table 1

Characterization of soil sampling sites with different degrees of salinity disturbance: 1) soil behind the greenhouse; 2) soil next to the lagoon; 3) soil under mesquite canopy; 4) soil under tabachin canopy. The variables measured were bulk density (DA), saturation point (PS), pH and electrical conductivity.

Sample	DA(g/mL)	PS(mL H_2O)	pH	CE(dS/m)
1	0.8258	82.5	10.4	9.45
2	0.9941	50.0	10.5	8.98
3	0.8083	80.0	10.7	7.15
4	0.814	37.0	10.0	7.75

Composting process

The composting process of the mixture of saline soil samples, cattle manure and garden grass *Cynodon dactylon* pruning stubble from CUI in a 3:1:1 ratio, lasted 120 days, according to the procedure described by Lal-Meena et al. (2021), the trial was developed in 1 L polyethylene cups, with four treatments and three replicates per treatment.

ISSN: 2410-3993
RENIECYT-CONAHCYT: 1702902

Roblero-Roblero, Elier Rutilo, Ruelas Ayala, Rey David, Sañudo Torres, Rosario Raudel and Félix-Herrán, Jaime Alberto. Attenuation of the effect of salinity on redwood (*Caesalpinia platyloba*) by saline compost. Journal of Technology and Innovation. 2024. 11-28:38-13.
https://doi.org/10.35429/JTI.2024.28.11.39.45

To prevent that the temperature of the mixtures exceeded 50 °C, were turned daily for the first 10 days, the measurement of the temperature and humidity was during the turning. The measurement of the EC and pH of the saturated paste extract was monthly, using an Orion Model 230A potentiometer calibrated at pH 4.0 and 7.0, and at 1.4118 dS/m for EC.

At the end of the process, the composts were harvested, stored at room temperature in sacks for maturation, and later sieved (> 5 mm) for later use.

In vitro germination essay

To evaluate the effect of different concentrations of NaCl on the *in vitro* germination of redwood seeds. The experiment consisted of a randomized complete block design with two substrates (blocks): B1) 50% sand – 50% perlite, B2) 25% sand – 25% perlite – 50% compost, and five treatments: 0, 0.3, 0.4, 0.5 and 0.6 M, with eight replicates per treatment. The reference was the substrate B2. The experimental unit was one plant.

The seeds were provided by the biotechnology laboratory of the UAIM Mochicahui Unit.

As pre-germinative treatment, the seeds were scarified with No. 400 waterproof sandpaper to abrade the seed coat sufficiently to allow water to penetrate the embryo (Sánchez-Soto *et al*. 2016).

The sand was washed with running water to remove the soil particles present; two substrates were used: T1 sand - perlite (1:1 ratio); T2 sand - perlite - compost (1:1:2 ratio). One seed per cavity was sown in the substrate, i.e. 400 seeds in total. Polystyrene trays of 200 cavities of 182 mL each were used, with dimensions of 58.8 x 33.5 x 4.5 cm (length, width, upper diameter of the cavity, respectively).

The trays were watered three times a week to favor germination; once the seedlings had the first true leaves, they were transplanted into 233 mL polyethylene cups with the aforementioned substrates.

Subsequently, irrigation was started with the saline solutions at different concentrations. The variables measured were: plant survival, root and aerial dry weight (g).

Sowing was carried out in 200-cavity polyethylene trays; eight seeds per treatment were considered. The trial started on October 15, 2019; seed emergence lasted 6 days.

Polyethylene cups test

When the seedlings had the first true leaves, were transplanted into 233 mL polyethylene cups with the aforementioned substrates. Subsequently, irrigation started with the saline solutions at different concentrations.

The variable to be measured was the accumulation of aerial and root biomass.

Statistical analysis

The data were checked for normality of residual errors with the Shapiro-Wilk test ($p > 0.05$), homoscedasticity with Bartlett's test ($p > 0.05$); and non-autocorrelation of the data by the Durbin-Watson Contrast test.

Statistical analysis and tests were performed with the statistical package R Software, version 4.1.1 (R Core Team, 2021). The experimental design was completely randomized.

For the one-way ANOVA, the "aov" function was used and for the comparison of means, Tukey's multiple range test was used with the "agricolae" package (from Mendiburu 2021). The significance level for all tests was $\alpha = 0.05$.

Results and discussion

Composting significantly influenced the pH and EC of the mixtures (Table 2). The EC of the four samples decreased. In pH, a trend was observed (Table 2), in all four samples the pH changed from alkaline to neutral in T1 and T2, and to moderately acidic in T3 and T4.

ISSN: 2410-3993
RENIECYT-CONAHCYT: 1702902

Roblero-Roblero, Elier Rutilo, Ruelas Ayala, Rey David, Sañudo Torres, Rosario Raudel and Félix-Herrán, Jaime Alberto. Attenuation of the effect of salinity on redwood (*Caesalpinia platyloba*) by saline compost. Journal of Technology and Innovation. 2024. 11-28:38-13.
https://doi.org/10.35429/JTI.2024.28.11.39.45

Box

Table 2

Mean initial and final electrical conductivity and pH measurements of compost samples at the end of the composting process: 1) soil behind the greenhouse; 2) soil next to the lagoon; 3) soil under mesquite canopy; 4) soil under tabachín canopy.

Treatment	CE (dS/m)		pH	
	Initial	Final	Initial	Final
T1	9.45	2.4 ±0.27 ab*	10.4	7.1 a
	8.98	2.79 ±0.30 a	10.5	7.0 a
T2	7.15	1.75 ±0.26 ab	10.7	6.6 a
T3	7.75	1.13 ±0.05 b	10.0	6.5 a
T4	9.45	2.4 ±0.27 ab*	10.4	7.1 a

* Different letters in columns indicate significant differences, according to Tukey's multiple range test ($p< 0.05$).
** Standard error of the mean

Karanja et al. (2019) mentioned that, at the end of the composting process of rice bran with chicken manure and donkey manure the pH of the humus was close to neutral, is consistent with the findings of the present study, the pH ranged between 6.5 – 7.1.

As for the electrical conductivity, the authors mentioned that the final EC of the compost ranged between 0.016 – 0.021dS/m, the EC reported by the authors are lower than the EC from our composts, which ranged from 1.13 to 2.78dS/m.

It is worth mentioning that the Karanja et al. (2019) trial lasted 64 days, and our trial lasted 120 days.

Gondek et al. (2020) mention that salinity in soil and compost is related to the presence of Na^{+}, K^{+}, Ca^{+2}, Mg^{+2}, Cl^{-}, SO_4^{+2}, CO_3^{-2}, HCO_3^{-}, NO_3^{-} ions. The authors mention that a saline compost is one with an EC >5 dS/m, and it could be thought that using this compost would affect the soil and plant development, but, on the contrary, the authors comment that a saline compost favors soil bioremediation, when mixed with substrate or zeolite, to reduce the EC of the compost.

The humification process of SOM helps to increase the cation exchange capacity, and the humic substances present favor the chelation of ions so that they are not toxic to plants (Tan, 2014).

The results obtained are in agreement with that reported by Barbaro et al. (2019) who report that the EC of a compost used for substrate should range between 0.09 - 5.55 dS/m, and that EC is an important factor in the formulation of substrates, and that it is necessary to know the tolerance to salt concentrations of the species to be grown.

The composts in the present study had an EC < 5 dS/m. In the nursery trial, nor the salt concentration of the solutions applied or the substrate didn´t affect significantly the plant development (stem and root weight) (Table 3).

Savy et al. (2022) report that compost application helps mitigate salt stress in tomato plants relative to mineral fertilization.

The authors attribute this beneficial effect to the induction of a more efficient metabolic response that increases the accumulation of metabolites involved in the modulation of salt stress.

Box

Table 3

Average of the variables stem weight and root weight of redwod plants.

Treatment	Substrate	Stem weight (μ ± ES)*	Root weight (μ ± ES)*
0 M	Sand-Perlite	0.49 ±0.03 a**	0.10 ±0.01 a
0.3 M	Sand-Perlite	0.28 ±0.06 a	0.10 ±0.05 a
0.4 M	Sand-Perlite	0.16 ±0.02 a	0.03 ±0.004 a
0.5 M	Sand-Perlite	0.19 ±0.014 a	0.03 ±0.003 a
0.6 M	Sand-Perlite	0.09 ±0.02 a	0.02 ±0.003 a
0 M	Sand-Perlite-Compost	0.53 ±0.14 a	0.13 ±0.04 a
0.3 M	Sand-Perlite-Compost	0.28 ±0.03 a	0.05 ±0.02 a
0.4 M	Sand-Perlite-Compost	0.21 ±0.03 a	0.02 ±0.005 a
0.5 M	Sand-Perlite-Compost t	0.20 ±0.02 a	0.03 ±0.006 a
0.6 M	Sand-Perlite-Compost	0.19 ±0.02 a	0.03 ±0.004 a

* Different letters in columns indicate significant differences, according to Tukey's multiple range test ($p< 0.05$).
** Standard error of the mean

ISSN: 2410-3993
RENIECYT-CONAHCYT: 1702902

Ait-El-Mokhtar et al. (2022) evaluated the effect of green waste compost to mitigate the effect of salt stress in date palms, reporting that compost helped to lower lipid peroxidation and hydrogen peroxide (H_2O_2) accumulation in stressed plants, which they attribute to the stimulation of antioxidant enzyme activity and increased soluble sugars and proline accumulation. The authors report that the use of compost favors the tolerance of date palms to salt stress.

According to Yusuf et al. (2024) there are plant hormones and signaling molecules that helps to mitigate abiotic stress in plants. They evaluate 24-Epibrassinolide (EBL) and Melatonin (ML) in enhancing plant tolerance to different abiotic stresses, like saline stress, they found that the joint application of both EBL and ML can improve plant tolerance to stress.

Ali et al. (2023) mentioned that the application of compost can improve the production of melatonin in stressed plants.

Humic substances produced during composting (Tan, 2014), help to reduce Na^+ ions so that they are not toxic to plants (Kumar Gautam et al., 2021). Jarukas et al. (2021) mention that humic substances present in compost form complexes with minerals through chelation, this improves the availability of nutrients, and form complexes with clay, improving soil structure and permeability, in the plant they favor plant resilience to withstand salinity stress.

In this sense, the biomass accumulation of the redwood plants produced in the substrate with saline compost was similar to the sand-perlite substrate, but the plants that grew in the saline compost, could present greater tolerance to saline stress, compared to the plants that grew in the sand-perlite-compost substrate, this would favor the survival to transplanting in a soil disturbed by salinity in projects for bioremediation of disturbed soils.

Conclusions

Composting favored a decrease in EC in soils with different degrees of disturbance; the pH of the composts tended to be neutral or slightly acid, which facilitates the availability of the nutrients present.

It is feasible to use the saline compost as a complement in a substrate to produce redwood plants, since the effect of the substrate with saline compost and the sand-perlite substrate was similar. These plants produced in a substrate with saline compost could be better adapted to a disturbed soil than a plant produced in sand-perlite substrate.

Declarations

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Author contribution

Roblero-Roblero, Elier Rutilo:Data collection.

Ruelas-Ayala, Rey David: Study conception and design.

Sañudo Torres, Rosario Raudel:Analysis and interpretation of results.

Félix-Herrán, Jaime Alberto: Manuscript preparation.

Availability of data and materials

The data of the article were obtained from the thesis work "Attenuation of the effect of salinity on red wood (*Caesalpinia platyloba*) by compost" of the forestry engineer Elier Rutilo Roblero-Roblero

Funding

The research didn´t received some financing, it was financed by the authors.

Abbreviations

Ca^{+2} Calcium ion
CE Electrical Conductivity
Cl^- Chlorine ion
cm centimeter
dS/m deciSiemmens per meter
ES Standard error
g grams
g/mL grams per milliliter
K^+ Potassium ion
Mg^{+2} Magnesium ion
μ Mean
M Molar

ISSN: 2410-3993
RENIECYT-CONAHCYT: 1702902

mL milliliter
mm millimeters
Na^+ Sodium ion
NaCl Sodium chloride
pH Hydrogen ion potential
SO_4^{+2} Sulfate ion
CO_3^{-2} Carbonate ion
HCO_3^- Bicarbonate ion
NO_3^- Nitrate ion

References

Antecedents

Camejo, D. & Torres, W. 2000. La salinidad y su efecto en los estadios iniciales del desarrollo de dos cultivares de tomate (*Lycopersicon esculentum* Mill). Cultivos Tropicales, 21(2), 23-26.

Castillo-Morales, V.M., Rojo-Martínez, G.E. & Armenta-López, C. 2010. Manejo y diseño de un sistema agroforestal de palo colorado (*Caesalpinia platyloba*) para suelos de temporal. En: *Estudios y Propuestas para el Medio Rural Tomo Vll*, Libro editado por la Universidad Autónoma Indígena de México y el Colegio de Postgraduados Campus Puebla, México. (195 – 222 pp.).

CONAFOR. 2018. Ficha técnica de unidades productoras de germoplasma forestal (UPGF). Red Mexicana de Germoplasma Forestal – CONAFOR – SEMARNAT. [en línea] 1260FT FI-rn 002 SIN

FAO. 2021. Global map of salt-affected soils.

FAO. 2023. El Manejo de Suelos Afectados por Salinidad.

Martínez-Villavicencio, N., López-Alonzo, C. A., Pérez-Leal, R. & Basurto-Sotelo, M. 2011. Efectos por salinidad en el desarrollo vegetativo. Tecnociencia Chihuahua, 5(3), 156-161.

Nikolić, N., Ghirardelli, A. & Schiavon, M. 2023. Effects of the salinity-temperature interaction on seed germination and early seedling development: a comparative study of crop and weed species. BMC Plant Biol, 23, 446.

Rojo, M. G. E., Jasso, M. J. & Velázquez, M. A. 2006. Political and economic instruments related to the climatic change and the environmental pollution. Ra Ximhai, 2(1), 173-185.

SADER (2022). Degradación física del suelo.

Trejo-González, N., Prieto-Méndez, J., Prieto-García, F., Acevedo-Sandoval, O.A., y Marmolejo-Santillán, Y. 2019. Tecnologías de remediación para suelos salinos. un caso de estudio: México. *Avances en Ciencias e Ingeniería*, *10*(1), 13-26.

Basics

Barbaro, L., Karlanian, M., Rizzo, P., & Riera, N. 2019. Caracterización de diferentes compost para su uso como componente de sustratos. Chilean J. Agric. Anim. Sci., ex Agro-Ciencia, 35(2), 126-136.

Díaz-Gustavo, N., Martínez-Salvador, M., García-Hernández, J.L., Norzagaray-Campos, M., Luna-González, A. & González-Ocampo, H.A. 2015. Carbon Sequestration of *Caesalpinia platyloba* S. Watt (Leguminosae) (Lott 1985) in the Tropical Deciduous. Forest. PLoS ONE, 10, e0125478.

Jarukas, L., Ivanauskas, L., Kasparaviciene, G., Baranauskaite, J., Marksa, M., Bernatoniene, J. 2021. Determination of Organic Compounds, Fulvic Acid, Humic Acid, and Humin in Peat and Sapropel Alkaline Extracts. Molecules, 26, 2995.

Karanja, A.W., Njeru, E.M. & Maingi, J.M. 2019. Assessment of physicochemical changes during composting rice straw with chicken and donkey manure. International Journal of Recycling of Organic Waste in Agriculture, 8(1), S65–S72.

Lal-Meena, A., Karwal, M., Dutta, D. & Mishra, R.P. 2021. Composting: Phases and factors responsible for efficient and improved composting. Agriculture & Food. E-newsletter, 3, 85–90.

Supports

Ali, M.A.A., Nasser, M.A. & Abdelhamid, A.N. 2023. Melatonin as a Key Factor for Regulating and Relieving Abiotic Stresses in Harmony with Phytohormones in Horticultural Plants — a Review. Journal of Soil Science and Plant Nutrition. 2023.

Kumar Gautam, R., Navaratna, D., Muthukumaran, S., Singh, A., More, I. & More, N. 2021. Humic Substances: Its Toxicology, Chemistry, and Biology Associated with Soil, Plants and Environment. In: InTech Open, India. Pp. 1 – 13.

ISSN: 2410-3993
RENIECYT-CONAHCYT: 1702902

Prieto-Ruíz, J.A., Aldrete, A., Hernández Díaz, J.C. & Goche-Télles, J.R. 2016. Causas de mortalidad de las reforestaciones y propuestas de mejora. En: Las reforestaciones en México: problemática y alternativas de solución. (J.A. Prieto Ruiz y J.R. Goche Télles, Eds.). Universidad Juárez del Estado de Durango, Dgo, México.

Tan, K.H. 2014. Humic matter in soil and the environment, Principles and Controversies. 2nd edition, Taylor and Francis group, Boca Raton, Florida, US. 495 p.

Differences

Rendón-Rosa, K. & Sayago-Lorenzana, R.C. 2017. Efecto de distintos sustratos en la germinación del Quebrache (*Caesalpinia platyloba*). Memorias del 4°Encuentro de Jóvenes en la Investigación de Bachillerato CONACYT Acapulco, Guerrero. Tlamati Sabiduría, 8 (2), 1 – 5.

Sánchez-Soto, B.H., Pacheco-Aispuro, E., Reyes-Olivas, A., Lugo-García, G. A., Casillas-Álvarez, P. & Sauceda-Acosta, C.P. 2016. Ruptura de latencia física en semillas de *Caesalpinia platyloba* S. Watson. Interciencia, 41, 691 – 695.

Discussions

Ait-El-Mokhtar, M., Fakhech, A., Ben-Laouane, R., Anli, M., Boutasknit, A., Ait-Rahou, Y., Wahbi, S. & Meddich, A. 2022. Compost as an eco-friendly alternative to mitigate salt-induced effects on growth, nutritional, physiological and biochemical responses of date palm. International Journal of Recycling of Organic Waste in Agriculture, 11, 85-100.

Savy, D., Cozzolino, V., Vinci, G., Verrillo, M., Aliberti, A., Maggio, A., Barone, A. & Piccolo, A. 2022. Fertilization with compost mitigates salt stress in tomato by affecting plant metabolomics and nutritional profiles. Chem. Biol. Technol. Agric., 9,104.

Yusuf, M., Saeed, T., Almenhali, H. A., Azzam, F., Hamzah, A. I. A. H., & Khan, T. A. 2024. Melatonin improved efficiency of 24-epibrassinolide to counter the collective stress of drought and salt through osmoprotectant and antioxidant system in pea plants. *Scientia Horticulturae*, *323*, Article 112453.

Gondek, M., Weindorf, D.C., Thiel, C. & Kleinheinz, G. 2020. Soluble Salts in Compost and Their Effects on Soil and Plants: A Review, Compost Science & Utilization, 28(2), 59-75.

ISSN: 2410-3993
RENIECYT-CONAHCYT: 1702902