Effects of salinity levels in *Oryza sativa* in different phenological stages under greenhouse conditions

Efectos de niveles de salinidad en *Oryza sativa* en diferentes estados fenológicos en condiciones de invernadero

Efeitos dos níveis de salinidade em *Oryza sativa* em diferentes estágios fenológicos em casa de vegetação

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Abstract

In this research, the agronomic and yield components of rice were evaluated, subjected to different levels of salinity at different phenological stages. It was made on the greenhouse of the Faculty of Agricultural Sciences of the Technical University of Babahoyo, Ecuador. It was established an internally casualized delineation with an 8 X 3 factorial start with four repetitions, corresponding to only phenological phases of growth in three doses of salinity ($dS.m^{-1}$). According to the results obtained, it is concluded that some agronomic characteristics are affected by high levels of salinity (7.0 $dS.m^{-1}$), showing significant differences less than 0.05 between the treatments, as in the case of vigor whose level was 7.0 $dS.\ m^{-1}$. In the same way, chlorophyll levels are significantly reduced between treatments, being a level of 7.0 $dS.m^{-1}$ or more severe. It is evident that high levels of salinity are detrimental to yield variations, once at 7.0 $dS.m^{-1}$, or weight of 1000 grains decreased by 54 %, in quantity or panicle compression by 68 %. Furthermore, it affects other phenophases such as flowering, development and pickling of its vegetative cycle, mainly in the phases of germination, molting, profile and growth of caule.

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Resumen

En esta investigación se evaluó los componentes agronómicos y de rendimiento en arroz, sometido a diferentes niveles de salinidad en diferentes etapas fenológicas. Se llevó a cabo en el invernadero de la Facultad de Ciencias Agrarias de la Universidad Técnica de Babahoyo en Ecuador. Se estableció un diseño completamente aleatorio con arreglo factorial 8 X 3 con cuatro repeticiones, correspondiente a ocho fases fenológicas de crecimiento a tres dosis de salinidad ($dS.m^{-1}$). De acuerdo con los resultados obtenidos, se concluye que algunas características agronómicas se ven afectadas por altos niveles de salinidad (7,0 $dS.m^{-1}$), mostrando diferencias significativas menor a 0,05 entre tratamientos, como el caso de vigor cuyo nivel fue de 7,0 $dS.\ m^{-1}$. De manera similar, los niveles de clorofila se reducen significativamente entre tratamientos, siendo el nivel 7,0 $dS.m^{-1}$ el más severo. Es evidente, como los altos niveles de salinidad son perjudiciales para las variables de rendimiento, ya que a 7,0 $dS.m^{-1}$, el peso de 1000 granos disminuyó en un 54 %, mientras que la longitud de la panícula en un 68 %. Además, afecta a otras fenofases como la floración, el desarrollo y acorta su ciclo vegetativo, especialmente en las fases de germinación, plántula, macollamiento y crecimiento del tallo.

Palabras clave: Arroz, etapas fenológicas, niveles de salinidad, invernadero, rendimiento.

Resumo

Nesta pesquisa foram avaliados os componentes agronômicos e de rendimento do arroz, submetido a diferentes níveis de salinidade em diferentes estádios fenológicos. Foi realizado na estufa da Faculdade de Ciências Agrárias da Universidade Técnica de Babahoyo, no Equador. Estabeleceu-se um delineamento inteiramente casualizado com arranjo fatorial 8 X 3 com quatro repetições, correspondendo a oito fases fenológicas de crescimento em três doses de salinidade (dS.m-1). De acordo com os resultados obtidos, conclui-se que algumas características agronômicas são afetadas por altos níveis de salinidade (7,0 $dS.m^{-1}$), apresentando diferenças significativas menores que 0,05 entre os tratamentos, como no caso do vigor cujo nível foi de 7,0 $dS.\ m^{-1}$. Da mesma forma, os níveis de clorofila são significativamente reduzidos entre os tratamentos, sendo o nível de 7,0 $dS.m^{-1}$ o mais severo. É evidente o quão altos níveis de salinidade são prejudiciais às variáveis de rendimento, uma vez que a 7,0 $dS.m^{-1}$, o peso de 1000 grãos diminuiu em 54 %, enquanto o comprimento da panícula em 68 %. Além disso, afeta outras fenofases como floração, desenvolvimento e encurta seu ciclo vegetativo, principalmente nas fases de germinação, muda, perfilhamento e crescimento do caule.

Palavras-chave: Arroz, estádios fenológicos, níveis de salinidade, fotossíntese, produtividade.

Introduction

Rice (*Oryza sativa* L.) is one of the most important crops in the world, is produced in 113 countries and is the main food of more than half of the world's population, providing 27 % of food energy and 20 % of proteins (FAO, 2018). Not only it is important at the level of food security, but it represents a substantial source of income for farmers in Ecuador. In this regard, numerous researches in different areas including agronomy, pest management and rice genetic improvement have been developed to increase yields, so that domestic demand can be met and producers' profitability increased.

In Ecuador the main rice growing provinces are: Guayas with 63.85 % of the growing area, followed by Los Ríos with 28.19 %, and Manabí with 4.63 %. In some of this area three growing cycles of rice can be cultivated because favorable environment conditions (Castro, 2016).

All living organisms are exposed to different types of stress, which can be caused by man's activity or natural causes such as air pollution, drought, temperature, luminous intensity and nutritional limitations (Rodríguez *et al.*, 2019). Soil salinity is one of the oldest known problems for agriculture, this problem increases year after year in arid and semi-arid regions of the world, as a result of low rainfall and poor management of irrigation water and fertilizers. The accumulation of soil soluble salts affects the growth, production, yield and sustainability of many crops (Ramírez *et al.,* 2017). The main characteristic of saline soils is the presence of high concentrations of soluble salts, which increases the osmotic potential of the soil solution, causing physiological stress in the crop, in this type of soil few plant species can grow and some of them can be unproductive (Terrazas, 2018).

The salinization of the soils could originate difficulties of plant water absorption, toxicity of specific ions and interference in physiological processes (indirect effects), reducing the growth and development of plants (Xiu-wei *et al.,* 2016).

The saline stress can cause slow vegetative development and subsequently, effects on reproductive development. The primary consequence of salinity is the reduction in the formation of new leaves and growth points, this phase is known as the accumulation of salt at growth points or osmotic phase; the second phase consists of a slow inhibition of growth, which can take from days to weeks, due to the accumulation of salts over time, especially in older leaves causing a premature senescence, this phase is known as the ion phase or salt toxicity (Roy *et al.,* 2014).

In rice crops with salinization problems, patches of undeveloped plants are observed in the farmer fields. The plants with salinity stress can stop growing and have leaves with white tips and chlorosis, and in turn reduction in stems formation. The symptoms are observed in the first leaves then in the second and finally in the developing leaves. Rice is more tolerant at the germination stage, but they can be affected during the transplanting period, in the flowering stage with sterility peaks which number can be increased reducing the weight and grains, affecting the yields (Dobermann and Fairhurst, 2012).

In Ecuador, the Guayas River Basin, which accounts for 40.4 % of the country's irrigable area, has abundant water with a flow of 8,847 $m^3.year^{-1}$; however, in the soils of the basin there is accumulation of salts. The salinity conditions are due to the saline intrusion in this area of the Babahoyo River, which enters through the estuaries and irrigation channels. The problems of salt in the soils are increased by poor drainage (Pozo *et al.,* 2010).

This work aims to identifying the phenological stage and the salinity level in which the rice crop is most affected by saline stress, measured in agronomic components and yield.

Materials and methods

This research was conducted in the greenhouse of the Faculty of Agricultural Sciences of the Technical University of Babahoyo, located in Babahoyo, Los Ríos province, Ecuador, geographically located at 79°32´ W longitude and 01°49´ S latitude, elevation of 8 m.a.s.l., temperature of 30.4 °C, relative humidity 65.5 % (greenhouse), evaporation 1012.4 mm, heliophany 830.4 hours

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(INAMHI, 2019). The rice variety used in this study was INIAP 14, with early life cycle and moderately susceptible to salinity. It is an indica type rice, with long-grained variety, growing in significant percentage of Ecuador's rice area.

Factor A corresponds to eigth phenological growth phases of rice, as mentioned below: germination (1), seedling (2), tillering (3), stem growth (4), floral primordia (5), booting (6), flowering (7) and milky grain stage (8); factor B corresponds to saline treatments,: normal water or control 0.2 dS.m^{-1} (1), mean salinity level of 3.5 dS.m^{-1} (2) and high salinity level of 7.0 dS/m^{-1} (3) measured through electrical conductivity (EC), expressed in deciSiemens per meter (dS.m^{-1}) (critical salinity levels referred by Cedeño, 2015). It should be noted that the water salinization with the doses of 3.5 and 7.0 dS.m^{-1} were made at the beginning of each phenological phase in study and maintained until harvesting of plants.

The experiment was established under a Completely Random Design (DCA) using a factorial arrangement 8 X 3 with four repetitions. The evaluated variables were subjected to the variance analysis and the Tukey test (p> 0.05), to determine statistical differences between treatment means.

In the greenhouse, a hydroponic system was conditioned using wooden boxes with the dimensions of 60 cm wide and 80 cm long, covered with black polyethylene for the establishment of rice plants. Pumice stone was used as an inert substrate, which was homogenized and washed. Two seeds were sown per site (6 sites/box) to allow the establishment of the experimental unit, after germination of the seeds, one of the seedlings was removed to finally leave six plants per box. Irrigations were applied twice a week during the first two months of cultivation and then watered weekly until the end of the experiment. In order to achieve salinity levels in the treatments described above, water was supplied with the salt content or electrical conductivity (EC) defined in the treatments, which was salinized with sodium chloride (NaCl), because this salt is predominantly in saline soils and has the highest toxicity. These values were measured with the Bluelab combined conductivity meter (Bluelab Corporation Limited, Tauranga 3110, New Zealand).

The following variables were measured: Vigor (scale of CIAT's standard evaluation system for rice (Jennings *et al.,* 1981), plant height (cm), tillers per plant, root length (cm), flowering (days), vegetative cycle (days), panicle length (cm), grains per panicle, panicles per plant, panicle sterility (%), weight of 1000 grains (g), grain weight per panicle (g), degree (%), length and width of the flag leaf (cm), length and width of the second leaf (cm), length and width of the husked grain (mm), length and width of shelled grain (mm), grain shape, fresh and dried root biomass (g), fresh and dry biomass of the aerial part (g), chlorophyll content (%) measured by an chlorophyll meter at Leaf® brand, model CHL PLUS.

Results and discussion

Regarding to the variable vigor, the phenological stages of floral primordia, booting, flowering and milky grain stage formation, presented the highest vigor with a mean of 3, being statistically superior (<0.0001) to the rest of treatments (figure 1). The salinity level of 0.2 dS.m^{-1} with a mean of 1, was statistically higher (<0.0001) than the other treatments, with the treatment 7.0 dS.m^{-1} being the most affected with a mean of 6.13, corresponding to less vigorous plants than normal, according on the used scale.

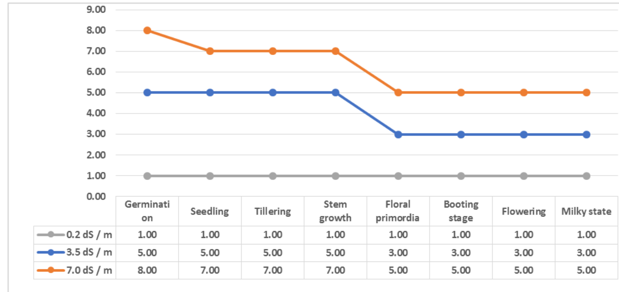


Figure 1. Variation in the vigor of rice plants through 8 phenological phases subject to different salinity levels.

The interactions of the phenological stages of germination, seedling, tillering, stem growth, floral primordia, booting, flowering and milky grain stage with the salinity level of 0.2 dS.m^{-1} (control); do not differ statistically (<0.0001) from each other and are superior to other interactions. The phenological stages of germination, seedling, tillering and stem growth with the salinity level of 7.0 dS.m^{-1}, had vigor's a mean of 7 and 8, corresponding to a very weak and small plants, according to the used scale. Figure 1 shows the variation in vigor presented by plants through the eight phenological phases subject to salinity levels of 3.5 and 7.0 dS.m^{-1}.

The phenological phases, such as the milky grain stage, flowering, booting and floral primordia, were those that exhibited less sterility; these are 10.32, 12.04, 12.82 and 14.15 %, respectively; and have similar statistical significance (<0.0001). The remaining phenological stages had higher mean values for this variable. The lowest sterility (<0.0001) was found at the 0.2 dS.m^{-1} level equal 10.06 %.

As for the interactions of the phenological phases of germination, seedling, tillering, stem growth, floral primordia, booting, flowering and milky grain stage with the salinity level of 0.2 dS.m^{-1} (control), presented statistically similarity (<0.0001); likewise, the floral primordia, booting and flowering phase with salinity of 3.5 dS.m^{-1} and floral primordia, booting and flowering with 7.0 dS.m^{-1}. The remaining interactions showed higher percentage of panicle sterility. Figure 2 shows the variation in panicle sterility obtained with salinity levels of 3.5 and 7.0 dS.m^{-1}.

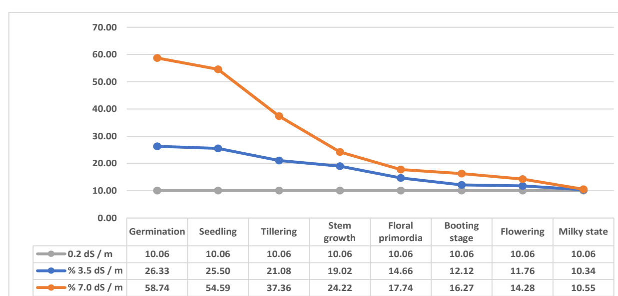
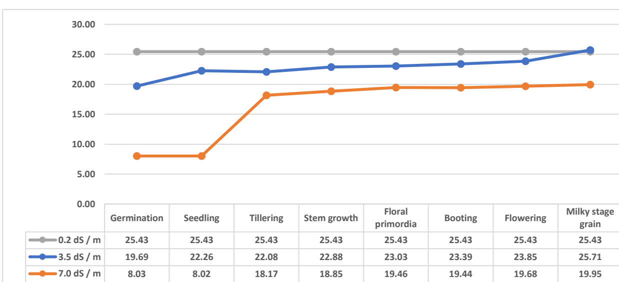


Figure 2. Variation of panicle sterility obtained with salinity levels of 0.2, 3.5 and 7.0 dS.m-1.

About plant height, the phenological stages of flowering, milky grain stage, booting and flowering, had the higher plant height with mean of 68.92, 69.15, 70 and 69.33 cm, respectively, statistically superior (<0.0001) to other treatments. The mean of 75.75 cm with the salinity level of 0.2 dS.m^{-1} (control) was statistically higher (<0.0001) to other treatments.

The interactions of the phenological stages of germination, seedling, tillering, stem growth, floral primordia, booting, flowering and milky grain stage, with the salinity level of 0.2 dS.m^{-1}; were statistically similar (<0.0001), but superior to the rest of the interactions. The phenological stages of germination, seedling, tillering and stem growth, with the salinity level of 7.0 dS.m^{-1}; they had the lower plant height mean equal to 23.1, 35.75, 37.55 and 48.39 cm, respectively. The fact that the height of the plant decreased as NaCl concentrations increased, is due to the fact that salts affect growth altering the absorption of water by the roots, a phenomenon that is called the osmotic component according to López *et al*., (2018). In saline environments, the reduction in the height of the seedlings due to the inhibitory effect of sodium, is a common phenomenon of several species, including rice (Abbas *et al*., 2013; Rajakumar, 2013). Similar results found Batista *et al*., (2017) in bail (*Ocimum basilicum* L) seedlings that decreased in height as NaCl levels increased.

Figure 3 shows negative values representing percentage values that were decreased by salinity at 3.5 and 7.0 dS.m^{-1} levels compared to the control with 0.2 dS.m^{-1}. For the variable number of tillers per plant, the phenological stages of milky grain stage, booting and flowering had the higher mean of tillers with values of 19.15, 18.87 and 18.72, respectively, statistically superior (<0.0001) to the other treatments. The salinity level of 0.2 dS.m^{-1} with a mean of 20.83, was statistically (<0.0001) higher than other treatments, while the lower value was achieved by the salinity level of 7.0 dS.m^{-1}, with 13.93 tillers.



	Germination	Seedling	Tillering	Stem growth	Floral primordia	Booting	Flowering	Milky stage grain
0.2 dS / m	25.43	25.43	25.43	25.43	25.43	25.43	25.43	25.43
3.5 dS / m	19.69	22.26	22.08	22.88	23.03	23.39	23.85	25.71
7.0 dS / m	8.03	8.02	18.17	18.85	19.46	19.44	19.68	19.95

Figure 3. Variation of the variable panicle length with salinity levels of 0.2, 3.5 and 7.0 dS.m^{-1}.

In relation to the interactions of the phenological stages of germination, seedling, tillering, stem growth, floral primordia, booting, flowering and milky grain stage with the salinity level of 0.2 dS.m^{-1} and floral primordia, booting, flowering, milky grain stage, with the salinity of 3.5 dS.m^{-1}; were statistically similar to each other (<0.0001), but superior to other interactions. The phenological stages of germination, seedling, tillering, stem growth and floral primordia, with the salinity level of 7.0 dS.m^{-1}; had the lowest means with 10.25, 11.25, 12.89, 13.31 and 13.65 tillers, respectively. Nawaz *et al*., (2010), indicate that damages are the result of disorders caused in the metabolism of plants, mainly due to changes in the osmotic potential of the soil, the nutritional imbalance due to interaction between toxic ions and nutrients essential for growth and development.

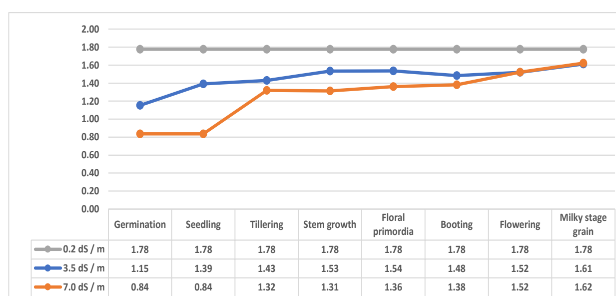
In the variable panicle length, the Tukey test (p> 0.05), determined that the phenological stages of the milky grain stage, flowering, booting, floral primordia, stem growth and tillering, had similar statistical significances (<0.0001), reaching the longer panicle length with 23.7, 22.99, 22.75, 22.64, 22.39 and 21.89 cm, respectively. The salinity level of 0.2 dS.m^{-1} with a mean of 25.43 cm was statistically higher (<0.0001) than other treatments.

Referring to the interactions of the phenological stages of germination, seedling, tillering, stem growth, floral primordia, booting, flowering and milky grain stage, with the salinity level of 0.2 dS.m^{-1} and the seedling stages, tillering, stem growth, floral primordia and booting with the salinity of 3.5 dS.m^{-1}; they do not differ statistically (<0.0001) and are superior to other interactions. The phenological stages of germination and seedling, with the salinity level of 7.0 dS.m^{-1}, had lower mean with values of 8.03 and 8.02 cm. The results of this study coincide with Martinez (2002), who mentions that salinity causes morphological damage in plants such as a decrease in leaf size to lower transpiration, reduction of the number of nerves and stomata. Finally, it affects the phenological level, causing a delay in flowering.

The phenological stages of the milky grain stage, flowering, booting, flowering primordia and stem growth had the highest amount of grains per panicle with means of 128.51, 126.93, 125.32, 123.28 and 120.24 grains, respectively; being statistically superior (<0.0001) to other treatments. The salinity level of 0.2 dS.m^{-1} with an average of 140.33 grains per panicle was higher (<0.0001) than other treatments, the treatment with 7.0 dS.m^{-1}, shown the lowest value with 89.89 grains.

With regard to the interactions of the phenological stages of germination, seedling, tillering, stem growth, floral primordia, booting, flowering and milky grain stage with the salinity level of 0.2 dS.m^{-1} and the stages of stem growth, floral primordia, flowering and milky grain stage with salinity of 3.5 dS.m^{-1}, were statistically similar (<0.0001), but superior to other interactions. The phenological stages of germination and seedling, at the salinity level of 7.0 dS.m^{-1}, obtained the lower values of 55.1 and 63.76 grains, respectively. The results presented support the observations of other authors that increasing salinity reduces development and affects rice yield in its different growth stages (Lutts *et al*., 1995).

For the variable grains weight per panicle (figure 4), the phenological stages of milky grain stage, flowering and floral primordia had the higher grain weight values, with means of 1.67, 1.61 and 1.56 g, respectively; statistically superior (<0.0001) to other treatments. The salinity level of 0.2 dS.m^{-1} with a mean of 1.78 g, was statistically higher (<0.0001) than other treatments. The salinity of 7.0 dS.m^{-1} shown the lowest value with 1.27g.



	Germination	Seedling	Tillering	Stem growth	Floral primordia	Booting	Flowering	Milky stage grain
0.2 dS / m	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78
3.5 dS / m	1.15	1.39	1.43	1.53	1.54	1.48	1.52	1.61
7.0 dS / m	0.84	0.84	1.32	1.31	1.36	1.38	1.52	1.62

Figure 4. Variation of the variable grain weight per panicle (g) with the effect of salinity levels of 0.2, 3.5 and 7.0 dS.m^{-1}.

The interaction of the phenological stages of germination, seedling, tillering, stem growth, floral primordia, booting, flowering and milky grain stage with salinity level of 0.2 dS.m^{-1}, the interaction of stem growth, floral primordia and milky grain stage with salinity level of 3.5 dS.m^{-1} and the interaction of milky grain stage with the salinity level of 7.0 dS.m^{-1}, were statistically similar (<0.0001), but superior to other interactions.

The phenological stages of germination and seedling at the salinity level of 7.0 dS.m^{-1}; presented the lowest average with 0.84

g. This result coincides with that described by Tavakkoli *et al*., (2011) who attribute the detrimental effect caused by salinity in crops in early stages. They also agree with Cha-um and Kirdmanee (2010), who state that rice with a salinity of 6.6 dS.m^{-1}; suffers a reduction in productivity of more than 50 %. Salt stress reduces rice yield by reducing the number of filled grains per panicle and the viability of pollen in plants. This study showed a significant decrease in grain weight in the evaluated phenological stages, as saline concentration increased.

For thousand grains weight, the Tukey test (p> 0.05) determined that the phenological stages of milky grain stage, flowering, booting and floral primordia had similar significances (<0.0001), reaching the higher weight values with 26.79, 26.68, 25.74, 25.44 g, respectively. The salinity level of 0.2 dS.m^{-1} with a mean of 29.8 g was statistically higher (<0.0001) than other treatments, while the lower weight was reached by the salinity level of 7.0 dS.m^{-1} with 20.25 g. This agrees with Torabi *et al* (2013), who mention that salinity is one of the main abiotic factors that affect the different stages of growth, yield and quality of agricultural crops through the stress they cause.

Regarding the interactions of the phenological stages of germination, seedling, tillering, stem growth, floral primordia, booting, flowering and milky grain stage with the salinity level of 0.2 dS.m^{-1}; they do not differ statistically (<0.0001), and they are superior to other interactions. The phenological stages germination, seedling and tillering, with the salinity level of 7.0 dS.m^{-1} showed the low results.

The variable chlorophyll content was recorded at 30, 45, 60 and 75 days. The phenological stage of germination had the lower means with values of 36.95, 29.71, 23.24 and 19.53 %, respectively. The salinity level 0.2 dS.m-1 with an average of 44.94, 38.23, 29.32 and 24.87 %, were statistically higher (<0.0001) than the other treatments. The salinity level of 7.0 dS.m-1 had the lowest values. In the interactions of the eight phenological stages x salinity levels, the damage to the mesophyll cells was evident when the chlorophyll content was or measured, and reduced as a result of increasing salts levels in the treatments. These results agree with Sandoval *et al*., (2010) who mention that the ionic salinity factor lies in toxicity, the ions that induce the most problems are chlorine and sodium, although others such as nitrate, sulfate or ammonia are also toxic. Its accumulation in the leaves produces marginal chlorosis and with it, a decrease in the photosynthetic area, which determines reductions in net photosynthesis. Ragab and Abd (2015) in their study in *Zea mays*, comment that plants under conditions of saline stress decrease the chlorophyll content and the rate of transpiration, negatively affecting the photosynthetic activity.

Figure 5 shows the sensitivity of rice plants expressed as significant decrease in yield when subjected to salinity levels applied at the beginning of each defined phenological phase (8 phases). Critical stages of high sensitivity were detected between seedling stage and tillering formation and even in the flowering phase. On the other hand, at milky grain phenological stage the salinity effect was relatively low. Zeng and Shannon, (2000), mention that during germination, rice is very tolerant to salinity, but it is very sensitive in the seedlings and in the reproductive stages. However, it is less sensitive during tillering and grain filling. Moreover, among the most sensitive stages is the seedling and flowering stage. These results agree with Singh *et al*., (2004), who indicate that flowering is another highly sensitive growth stage in the crop life cycle, which is affected by salinity stress.

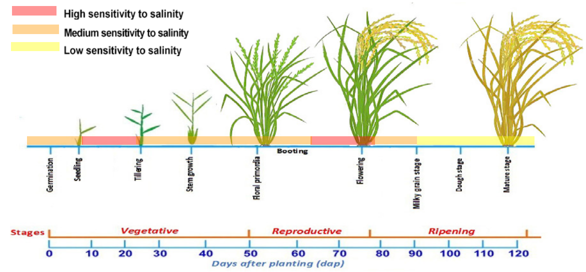


Figure 5. Phases of high, medium and low sensitivity to salinity during eight phenological stages of growth in rice plants.

The result of this cluster analysis allowed the grouping of phenological stages and salinity levels into four classes, which delimited their similarity between the characteristics (Figure 6).

Class I (yellow), groupings with similar characters were 2-3 (Seedling - 7. 0 dS.m^{-1}) and 1-3 (Germination - 7. 0 dS.m^{-1}). Class II (green) grouped to 8-2 (milky grain stage - 3.5 dS.m^{-1}), 7-2 (Flowering - 3.5 dS.m^{-1}), 6-2 (tillering - 3.5 dS.m^{-1}), 5-2 (Floral promordia - 3.5 dS.m^{-1}), 8-3 (milky grain stage - 7. 0 dS.m^{-1}), 7-3 (Flowering - 7. 0 dS.m^{-1}), 4-2 (Stem growth - 3.5 dS.m^{-1}) and 3-2 (Tillering- 3.5 dS.m^{-1}).

In Class III (blue) are 6-3 (Booting - 7. 0 dS.m^{-1}), 5-3 (Floral Primordia - 7. 0 dS.m^{-1}), 4-3 (Stem growth - 7. 0 dS.m^{-1}), 3-3 (Tillering - 7. 0 dS.m^{-1}), 2-2 (Seedling - 3.5 dS.m^{-1}), which very clearly grouped the phases in the salinity level of 7.0 dS.m^{-1}. Finally, Class IV (red) made up by the combination 8-1 (Milky grain stage - 0.2 dS.m^{-1}), 7-1 (Flowering - 0.1 2 dS.m^{-1}), 6-1 (Booting - 0.2 dS.m^{-1}), 2-1 (Seedling - 0.2 dS.m^{-1}), 5-1 (Floral Primordia - 0.2 dS.m^{-1}), 4-1 (Stem growth - 0.2 dS.m^{-1}), 3-1 (Tillering - 0.2 dS.m^{-1}), 1-1 (Germination - 0.2 dS.m^{-1}), which grouped the eight phenological phases with the control of 0.2 dS.m-1, clearly defining the low salinity effects in the phenological phases.

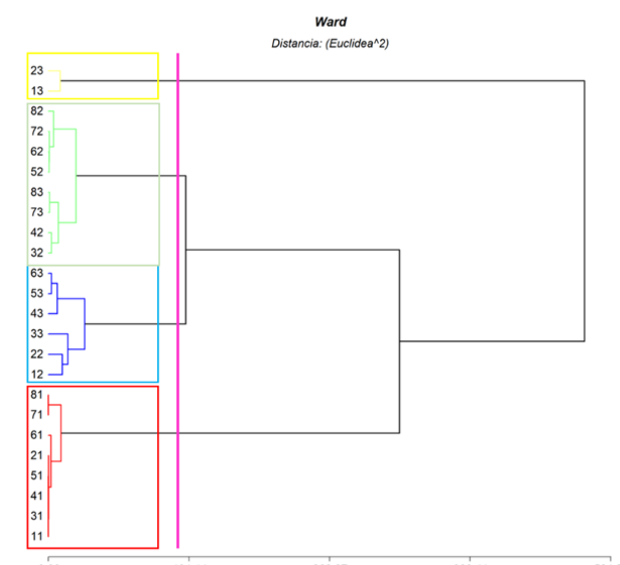


Figure 6. Grouping of phenological stages and salinity levels that shows similarity in characteristics, through the analysis of conglomerate (Euclidean-Ward Distance).

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Regarding Torabi *et al.* (2013) indicate that when there are high levels of salinity, the absorption of water by the roots is greatly reduced, the plants slow down their growth and come to present symptoms of drought, such as wilting or blue-green coloration dark, chlorosis and sometimes thicker waxy leaves. These symptoms vary according to the phenology stage of the crop, being more noticeable during the first stages of growth. They mention that, during germination, rice is very tolerant to salinity, but it is very sensitive in the seedlings and in the reproductive stages. The high levels of salinity in this stage affects the viability of the pollen, which results in poor pollination and the consequent reduction in the percentage of grains setting and, therefore, in the total yield of the plant. In a recent study led by Mohammadi *et al*., (2010), using various genotypes; it was found that most rice varieties show reduced pollen viability under salinity conditions.

Conclusions

In rice, under greenhouse conditions the critical stages of high sensitivity to salts were detected between seedling stage and tillers formation and even in the flowering phase, although at the stage of filling the grain or milky grain stage, this effect was low.

High levels of salinity (3.5 and 7.0 $dS.m^{-1}$) negatively influence many agronomic characters, components of flowering and plant growth, even shortening their vegetative cycle. This influence is most evident in the development of rice plants during germination, seedling, tillering and stem growth phenological phase.

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