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Rice cultivation in saline tracts of Kerala: An overview

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Abstract
Salinity is one of the most important abiotic constraints that limit plant growth. It also affects the development, productivity and yield of crop plants. Salinization is a wide spread phenomenon in irrigated agriculture in countries of almost all the continents. Large proportions of both rainfed and the irrigated land face the threat of an increase in concentration of dissolved salts in the soil profile to a level that impairs food production, environmental health and socio-economic wellbeing, due to either natural or human-induced causes. Over 15% of the world's cultivated land is affected by either salinity or sodicity and the problem is ever increasing. Rice is feeding more than half of the world's population.
One fifth area of Kerala state of India is wetland and there are about 217 wetland areas in Kerala which include the unique ecosystems like marshy and water logged areas, vast paddy cultivation areas associated with backwaters and lakes. The coastal saline soils of South India are highly underutilized because the use of ground water for normal crop production is not possible due to the poor water quality. At present, the entire coastal area is mostly monocropped during the monsoon period with rice as the only crop. The land remains fallow during the rest of the year due to lack of good quality irrigation water and high soil salinity. Thirty seven percent of rice production in the state is contributed by the lowland ecosystems. This paper is an effort to review the *Pokkali* and *Kaippad* systems of rice cultivation in Kerala which is significant presently since the wetlands under rice-fish farming have been facing severe threats due to a variety of factors including shift from the ecologically fragile rice-fish farming to semi intensive fish farming.

Keywords: *Pokkali*, *Kaipad*, rice, salt tolerance, salinity stress, saline rice tract

1. Introduction
Salinity is one of the major abiotic stress factor limiting plant growth and productivity in arid and semi-arid regions throughout the world. The detrimental effects of high salinity on plants can be observed at the whole plant level as the death of plants and/or decrease in productivity. Physiology, biochemistry and molecular biology of salinity stress in plant have been discussed over two decades [1, 2]. It occurs through natural or human induced processes that result in the accumulation of dissolved salts in the soil water to an extent that inhibits plant growth. Coastal salinity caused by seawater intrusion and shallow saline water tables is severe during the dry season; whereas flooding in the monsoon season limits rice cropping. Saline and sodic soils are widespread in inland areas and are progressively expanding because of improper water management. Salt stress limits rice production in vast areas worldwide, and the problem is ever increasing because of irrational human acts causing secondary salinization, as well as because of global warming, with the consequent rise in sea level and increase in storm incidences, particularly in coastal areas [3].
According to the FAO [4], over 6% of the world's land is affected by either salinity or sodicity; more than 1000 million hectare of land in more than 100 countries is affected by this menace. India is by far not different from others with 6.74 million hectare of salt affected lands suffering from huge economic losses [5]. The common cations associated with salinity are Na^+, Ca^{2+} and Mg^{2+}, while the common anions are Cl^-, SO_4^{2-} and HCO_3^-. Since Na^+ in particular causes deterioration of the physical structure of soil and Na^+ and Cl^- both are toxic to plants, these are considered the most important ions associated [1].

Causes of salinity
All soils contain some amount of salts, which is indeed essential for a healthy growth of the plants. If the quantity of salts in a soil exceeds a certain level, the growth and yield of most crop plants are adversely affected; such soils are called salt affected soils. Salts primarily

originate as a result of weathering of rocks. At the same time, climatic factors such as high temperature and low rainfall with high evaporation demand leave the salts at the soil surface.

Natural and manmade causes

Most of the saline sodic soils are developed due to natural geological, hydrological and pedological processes. Climatic factors and water management may accelerate salinization. In arid and semiarid lands evapotranspiration plays a very important role in the pedogenesis of saline and sodic soils. Secondary salt affected soils are those that have been salinized by human caused factors, mainly as a consequence of improper methods of irrigation and other activities such as deforestation, accumulation of air borne or water borne salts in soils, contamination with chemicals and overgrazing and are formed mainly in arid and semiarid regions [6].

The extent and distribution of salt affected soil

Salt affected soils are found in arid and semiarid climates in more than one hundred countries of the world and are the most common in aridic moisture regimes and they may be present at any latitude and altitude [7]. Salt affected soils cover a much larger surface in almost all the continents. Estimates of the extent of soil salinity and sodicity problems on the earth surface vary from 5% to 10% of the total land area [8]. Yield losses are particularly detrimental at a local scale because salt affected soils are not uniformly distributed and the condition threatens the continued existence of agriculture in some regions and countries. The total area of saline soils in the world, resulting from both primary and secondary salinization has been estimated at about 955 million ha. FAO [8] estimated 397 million ha of saline soils and 434 million ha of sodic soils globally. According to Oldeman *et al.* [9], more than 77 million ha of agricultural land is salt affected due to human interventions; the majority of it in Asia and Africa. Ghassemi *et al*. [10] have reported that approximately 76 million ha of agricultural land is affected by salinity, of which approximately 45 million ha are in irrigated areas and 30 million ha are in dry land farming areas.

Crop tolerance

All plants are sensitive to salts after some concentration and it changes with plant species, variety, and stage of development and duration of the salt stress. Although environmental factors other than high salt concentration may contribute to limit plant growth and yield, the choice of the crop must take into account the specific crop tolerance to salinity in order to avoid total crop failure. Growth can be inhibited at any stage of the biological cycle. Yield reductions can be caused by reduced vegetative growth and/or by perturbation of the reproductive phases [11].

Salinity and rice cultivation

Rice is one of the most important staple food crops in the world, feeding more than half of the world population and grown in more than 100 countries, predominantly in Asia [12]. It thrives best between latitude 45° N and 40° S of the equator. Optimum areas for getting higher yields are tropical and subtropical. With an increasing population and less water available for agricultural production, the food security for future generations is at stake. The agricultural sector faces the challenge to produce more food with less water by increasing Crop Water Productivity (CWP) [13]. Where irrigation is used for higher value crops, financial losses due to salinity or costs of salt management can seriously erode the small margins on agricultural crops. The impact of salinity is most serious in countries where all or most of agricultural production is based on irrigation and when agriculture is a substantial part of the national economy. The global income loss due to salinity was about $11.4 billion per year in irrigated and $1.2 billion per year in non-irrigated areas as reported in 1996 [14].

Rice appears even more sensitive during the early developmental stages after germination and at flowering, whereas at germination stage it is considered exceptionally tolerant. At germination and during maturation rice exhibits its highest tolerance. However, salt stress in all developmental stages of rice can contribute to yield losses [15]. Vegetative growth can be reduced in all parts (roots, leaves, stems, number of tillers, fresh and dry matter), as well as panicle length, number of branches per panicle and seed number and weight can be reduced. The salt sensitivity of rice limits the success of rice cropping during leaching of saline soils until enough reduction of salt concentration has been achieved. Yet, the practice of flooding paddy rice is beneficial for salt leaching. Paddy rice can be effectively cropped during reclamation of sodic soils probably because the water on the fields limits the negative effects of degraded soil structure on the plants. Soil salinity may interact with texture in affecting rice yield in rice fields. In that region moderate yields were obtained on soils with high salinity and high clay and minimum yields on sandy soils in coastal areas. Soil salinity and particle size distribution were linearly related to rice yield. Sea flooding can severely depress rice yield in coastal areas. Rice yield loss is caused to a great extent by reduced percentage of ripened grains under such conditions [16].

Paddy cultivation in water logged fields in Kerala - An outline

Kerala state the southern-most state of India has a coastline of about 580 km. This coastal belt has a unique popular system of rice cultivation in the saline soils [17]. But these areas are situated below the mean sea level and have serious problems of water logging. Rice forms the staple food of the people of Kerala and it is grown in a vast array of ecological niches ranging from regions situated 3 meters below MSL level as in *Kuttanadu* to an altitude of 1400 m in purely rainfed uplands with no standing water as in the high ranges like Wayanad. Probably nowhere else in the world, rice crop is cultivated under such a diversity of conditions [17, 18]. Unique salinity tolerant rice farming syetems have developed in the saline wetlands like *Pokkali, Kole* and *Kaipad* of Kerala. The farming system at *Kuttanadu* is also unique where rice is cultivated in wetlands at subsea level.

***Pokkali* fields**

Pokkali is a unique mode of saline rice production system in central Kerala using saline tolerant rice varieties that are cultivated exclusively in an organic way in the water logged acidic coastal regions of Ernakulam, Alappuzha and Thrissur districts of Kerala extending to a total area of 6,274 ha. It is rich in biodiversity and it has got amazing capacity to generate organic paddy and shrimp alternatively [19]. In this method, a single crop of rice is grown in the low saline phase of the production cycle (June to mid-October/early November) followed by prawn farming during the high saline phase (mid-November to mid-April).

Rice cultivation starts during the first cropping season taking advantage of the ability of the heavy south-west monsoon to

flush out salt from the land. The rice varieties used are highly salt tolerant and their resistance to salinity is remarkable. In order to survive in the water logged field, the rice plants grow even up to two metres but as they mature, they bend over and collapse with only the panicles standing upright. Presently, high yielding varieties such as *Vytilla*1, *Vytilla* 2, *Vytilla* 3, *Vytilla* 4, *Vytilla* 5, *Vytilla* 6, *Vytilla* 7, and *Vytilla* 8 are used for cultivation in this area [20].

Harvesting takes place by end of October. Only the panicles are cut and the rest of the stalks are left to decay in the water, which in time become feed for the prawns that start arriving in November–December- the second phase of the *Pokkali* farming. Juvenile prawns swim from the sea and the backwaters to the field when the rice harvest is over. They feed upon the leftovers of the harvested crop. The organically grown *Pokkali* is famed for its peculiar taste and its high protein content.

Kaipad farms

Kaipad is a saline-prone natural organic rice production tract of North Kerala, similar to the *Pokkali* tract of South Kerala. The *Kaipad* system of rice cultivation is an indigenous and integrated organic farming system in which rice cultivation and aquaculture are practiced together in coastal brackish-water marshes, which are rich in organic matter [21]. In this type of rice cultivation, a single crop of rice is grown in the low saline phase of the production cycle (June to mid-October) on soil mounds, to be followed by prawn farming during the high saline phase (November to April).

Rice farming is carried out in a purely natural way in *Kaipad* relying on the monsoon and the sea tides. Indigenous cultural methods coupled with local saline resistant paddy varieties have made rice cultivation peculiar to this area. In the *Kaipad* areas, the cultivation is done by soil mound method. Alternatively in some locations, saline resistant seedlings are raised in non-saline nurseries and transplanted in the months of June-July to the *Kaipad* fields [22]. Agricultural operations for cultivating rice begin by mid-April every year. The saline water is drained out completely and the fields are left to dry for about a month for the upcoming rice cultivation. Once the fields are dried, small mounds (*potta*) of 50 cm in diameter and 60 cm in height are formed. By the arrival of summer showers and the onset of South West monsoon the salinity and various toxic elements in the soil in the mounds are washed down by rainwater. As soon as there is adequate fresh water flow in the river, the water outlets of the bunds are opened. From this time onwards, tidal flows are not controlled all through the entire crop season. The fresh river water tides wash down the salinity of the soil. They are then ready for germinated paddy seeds to be sown. The germinated seeds of special varieties are sown on the mounds. After one and a half months of growth, the seedlings become mature enough for transplantation. The seedlings in the mounds are dug out together with the root soil by male workers and are planted uniformly by women workers in the field after removing the weeds. The crop is usually harvested by mid-September to mid-October.

Kuthiru, and *Orkayama* are the most important traditional land races widely grown in *Kaipad* rice tracts [23, 24]. *Mundon*, *Kandorkutty, Orpandy, Odiyan, Orissa, Punchakayama* and *Kuttadan* are the other land races cultivated in some pockets of *Kaipad*. Other varieties namely *Orthadian*, *Chovvarian* and *Kuttusan* are also cultivated in some areas of *Kaipad*. These landraces are tolerant to low and medium salinity. Traditional cultivars are susceptible to lodging because of the poor culm strength and excessive culm length and they show poor grain qualities like awn on grains, long, bold and heavy shattering nature which make harvest a tedious and laborious process especially in the present scenario of shortage of farm laborers. However, these cultivars are resistant to all pests and diseases in natural field conditions of *Kaipad* and cooked rice of local cultivars is very delicious. Recently, Kerala Agricultural University has developed some high yielding rice cultures for the area. Among those, *Ezhome*-1 and *Ezhome*-2 have been released for commercial cultivation. The average yield of *Ezhome*-1 and *Ezhome*-2 ranges from 3.2 -3.5 tones/ ha which is 60-70% higher than that of traditional native land races. They are awn less with non-shattering grains and favourable cooking qualities.

After the paddy harvest, the *Kaipad* fields are used for prawn filtration. With the withdrawal of North-East monsoon in November, the work of strengthening the bunds around the fields begins. Prawns and other fishes move into the fields through the tidal currents. The number of young prawns entering the fields depends largely on the force and duration of the current. During the tidal inflow, a conical shaped net with an opening at the end is fixed inside the sluice gate valves. After the tide, the net is removed and a filter is kept at the mouth of the sluice to prevent prawns and fishes from flowing out of the fields.

Now the *Kaipad* fields have got reduced to about 600 ha. A major reason for farmers from the *Kaipad* area to move away from rice cultivation has been unfavorable characters of locally available cultivars. Lack of realization of the potential of high yielding rice varieties for this rainfed, shallow lowland is the major reason for the low productivity and shrinkage of *Kaipad* fields.

Conclusion

Salinity effects and problems with regard to rice farming and crop productivity are discussed briefly here. It provides information on the impact of salinity on agriculture and global distribution of salinity. Salinity is the most serious threat to agriculture and to the environment in many parts of the world. Salinity management is required in most irrigated areas in the semi-arid regions of the world in order to sustain agricultural production. The wetlands of India, particularly of Kerala are currently subjected to acute pressure owing to rapid developmental activities and indiscriminate utilization of land and water. The major issues faced are mainly related to pollution, eutrophication, encroachment, reclamation, mining and biodiversity loss.

References

1. Hasegawa PM, Bressan RA, Zhu JK, Bohnert HJ. Plant cellular and molecular responses to high salinity. Annual Review on Plant Physiology and Plant Molecular Biology. 2000; 51:463-499.
2. Zhu JK. Salt and drought stress signal transduction in plants. Annual Review on Plant Biology. 2002; 53:247-273.
3. Wassmann R, Hien NX, Hoan CT, Tuong TP. Sea level rise affecting the Vietnamese Mekong Delta: water elevation in the flood season and implications for rice production. Climate Change. 2004; 66:89-107.
4. FAO. Land and plant nutrition management service. htpp://www.fao.org/ag/agl/agll/spush, 2008.
5. Biswas A, Biswas A. Comprehensive approaches in rehabilitating salt affected soils: A review on Indian perspective. Open transactions on geosciences. 2014;

1(1):13-24.
6. Ponnamperuma FN. Role of cultivar tolerance in increasing rice production on saline lands. In: 'Salinity Tolerance in Plants: Strategies for Crop Improvement (Ed. Staples RC, Toenniessen GA), Wiley International, New York'. 1984, 255-271.
7. Szabolcs I. Salt build up as a factor of soil degradation. In: Methods for Assessment of Soil Degradation. (Eds. Lal R, Blum WH, Valentine C, Stewart BA) CRC Press, Boca Raton, FL, USA, 1998, 253-264.
8. FAO: Fact sheets: World Food Summit-November 1996. Rome, Italy: FAO., 1996.
9. Oldeman LR, Hakkeling RTA, Sombroek WG. Second revised edition. World Map of the Status of Human-Induced Soil Degradation. An Explanatory Note. International Soil Reference and Information Center, Wageningen, the Netherlands, 1991, 35-45.
10. Ghassemi F, Jakeman AJ, Nix HA. Salinisation of land and water resources: Human causes, management and case studies. Sydney, Australia: University of New South Wales Press. 1995, 250.
11. El-Falaky AA, Rady AA. Salt tolerance of rice and cotton crops grown in salt affected soils. Tasks in Vegetable Science. 1993; 28:147-151.
12. Depar N, Rajpar I, Memon MY, Imtiaz M, Hassan Z. Mineral nutrient densities in some domestic and exotic rice genotypes. Pakistan Journal of Agriculture and Agricultural Engineering and Veterinary Science 2011; 27:134-142.
13. Kijne JW, Barker R, Molden D. Water Productivity in Agriculture: Limits and Opportunities for Improvement. CAB International, Wallingford, UK. 2003, 352.
14. Dregne HE, Xiong Z, Xiong S. Soil salinity in China. Desertification Control Bulletin. 1996; 28:28-33.
15. El-Saidi MT. Salinity and its effect on growth, yield and some physiological processes of crop plants. In: Strategies for Improving Salt Tolerance in Higher Plants. Eds. (Jaiwal PK, Singh RP, Gulati A) Science Publishers, Enfield, NH, USA., 1997, 111-127.
16. Kim S, Yang W, Choi W, Park H, Choi M, Back N *et al*. Effects of desalinization management on rice yield in sea water flooded field. Korean Journal of Crop Science. 1999; 44:38-43.
17. Gayatri RN, Raveendran K. Exploration of untapped potentiality of coastal paddy fields of Kerala (India) - A case study. Middle-East Journal of Scientific Research. 2009; 4(1):44-47.
18. Jayan PR, Nithya S. Overview of farming practices in the water-logged areas of Kerala, India. International Journal of Agriculture and Biological Engineering. 2010; 3(4):18.
19. Thomson KT. Economic and Social Issues of Biodiversity Loss in Cochin Backwaters-Technical Report. Cochin University of Science and Technology, Cochin, 2002.
20. Shylaraj KS, Sasidharan NK. VTL 5: A high yielding salinity tolerant rice variety for the coastal saline ecosystems of Kerala. Crop Science. 1998; 38:394-398.
21. Sreedharan TP. Study on the status of Valapattanam River with special reference to its ecology and socio-cultural aspects. Kerala Research Programme on Local Level Development, 2005. http://krpids.org/report/TPS.pdf.
22. Nair KN, Vineetha M, Mahesh R. The Lure of Prawn Culture and the Waning Culture of Rice-Fish farming: A Case Study from North Kerala Wetlands. Kerala Research Programme on Local Level Development, Centre for Developmental studies, Thiruvananthapuram, Discussion, 2002, 53.
23. Vanaja T, Mammootty KP. Kuthiru and 'Orkayama'– Newly identified genetic resources from Kerala, India for salinity tolerance in indica rice. Online publication in Nature proceedings, 2010.
24. Joseph EA, Mohanan KV. A Study on the Effect of Salinity Stress on the Growth and Yield of Some Native Rice Cultivars of Kerala State of India. Agriculture, Forestry and Fisheries. 2013; 2(3):141-150.