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Short Communication

# Evaluation of rice hybrids in saline soils of *Pokkali*

Nikhil Narayanan*, S. Biju, and Jiji Joseph

*College of Horticulture, Kerala Agricultural University, Thrissur 680 656, Kerala, India*

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**Abstract**

Field evaluation of rice hybrids in *Pokkali* tract was carried out during *Kharif* season of 2016-17, adopting a randomised block design. Days to fifty per cent flowering and maturity showed that all hybrids came to flowering early under saline conditions. Tall plants were observed in saline tolerant varieties Vyttila-6 and Ezhome-2 and short plants in IR-29. A high number of productive tillers was observed in CORH-3, while it was low in Sahyadri-2. Ezhome-2, IR-29 and Vyttila-6 had high number of spikelets per panicle. High seed setting percentage and long panicles were observed in Ezhome-2. Spikelet sterility was high in Sahyadri-2 and low in Ezhome-2. High 1000 grain weight was observed in Ezhome-2, but it was low in IR-29. Based on visual scoring, Vyttila-6 was classified as highly tolerant and IR-29 as highly susceptible. Correlation studies indicated that grain yield per plant was positively correlated with productive tillers per plant and seed setting per cent, while it was found to be negatively correlated with sterility per cent. The hybrid CORH-3 was found to be moderately tolerant to salinity based on visual scoring and it produced the highest yield per plant indicating that this hybrid had high yield potential under saline condition and produced higher yield than saline tolerant traditional varieties

**Keywords:** Hybrid rice, *Pokkali,* Salinity tolerance.

Rice (*Oryza sativa* L.) is one of the most widely consumed cereal grains in the world. The various constraints causing a decline in global rice production are insect pests, weeds, pathogens, drought, salinity and chillness. Among these, salinity is one of the major abiotic stresses that affect crop productivity and quality and has been described as one of the most serious threats to agriculture and the natural status of the environment (Chinnusamy et al., 2005). Increased salinization of arable land is expected to have devastating global effects, resulting in a 30 per cent land loss within the next 25 years and up to 50 per cent by the year 2050 (Jamil et al., 2011).

The strategies for mitigating salinity problems in crop production include both the development of management options (Shannon, 1998) and genetic improvement of salinity tolerance in current cultivars (Epstein et al., 1980). In Kerala, saline soils are usually seen within the coastal tracts of the districts of Ernakulam, Alappuzha, Thrissur and Kannur. Rice is the major crop which can be cultivated in these areas. Most of the varieties grown in these areas are either traditional varieties or their selections with less yield potential. Under saline situations of Ernakulam and Alappuzha, there is a unique traditional system of rice cultivation called *Pokkali.* The traditional rice varieties grown in this area show remarkable tolerance to salinity and floods which makes them unique. However, the yield potential of these varieties is low. Hybrids are the first generation crosses of diverse parents with high yield potential compared to varieties and land races. From 1994 to 2017 a total of ninety three hybrid rice varieties have been developed in India (Directorate of Rice Development, 2017). Out of these, a few hybrids such as DRRH 28, PSD 3, KRH

*Author for Correspondence: Phone: +919961625356, Email: nikhilnarayanan20@gmail.com

4 etc. were reported to have tolerance towards salinity. Considering the facts about salinity and keeping in view the present alarming scenario of saline water intrusion on the one hand and high yield potential of hybrid varieties on the other, identification and development of salt tolerant hybrids suitable for *Pokkali* tract of Kerala is definitely an urgent need of the hour. Hence, this study was designed to explore the adaptability of promising saline tolerant rice hybrids to the unique tract of *Pokkali*.

The study on identification of saline tolerant rice hybrids was conducted in saline-prone areas of *Pokkali* tract of Kadamakudy Grama Panchayath of Ernakulam district during *Kharif* 2016. The materials consisted of 11 rice genotypes (eight rice hybrids along with three check varieties) which included improved saline tolerant variety of Kaipad (Ezhome-2), improved saline tolerant Pokkali variety (Vytilla-6) and international saline susceptible variety (IR-29), as well as rice hybrids from Regional Agricultural Research Station, Karjat (Sahyadri-1, Sahyadri-2, Sahyadri-3, Sahyadri-4), RH-4 and CORH-3 hybrids from Tamil Nadu Agricultural University, KRH-4, a hybrid developed by University of Agricultural Sciences, Bengaluru, and MRP-5401 a rice hybrid developed by Mahyco. The experiment was conducted in plots of $4m^2$ in randomised block design with 11 genotypes including eight hybrids and three check varieties with three replications each. Observations on plant height, uppermost internodal length, days to 50 per cent flowering, days to maturity, number of productive tillers per plant, number of spikelets per panicle, seed setting per cent, length of panicle, sterility per cent, 1000 grain weight, grain yield per plant and salinity symptoms on the plants were observed from 25 plants per replication in each treatment. Visual scoring for salinity symptoms was carried out as per evaluation system of IRRI (2002). The data on various parameters studied during the course of the investigation were subjected to statistical analysis.

The observations recorded from the check varieties and hybrids evaluated are presented in Table 1. The plant height ranged from 87.5 cm to 117.35 cm at flowering stage. Significantly greater plant height was recorded in saline tolerant check variety, Vytilla 6, followed by Ezhome 2. Low plant height of 87.5 cm was recorded in saline susceptible check variety IR-29 which was on par with that of Sahyadri 2. Roy et al. (2002) observed reduction of root length, shoot length and dry weight of root and shoot with increase in salinity. According to Ramoliya et al. (2004), soil salinity suppresses shoot growth more than the root growth. Islam and Mia (2007) also observed differences in plant height of rice varieties with different salinity levels. Adverse effects of salinity stress on shoot and root growth was reported by Sagi et al. (1997). As per the reports of Ramoliya

*Table 1.* Mean performances of rice hybrids and check varieties for biometrical traits

| Genotypes | Plant height (cm) | Uppermost internodal length (cm) | Days to 50 per cent flowering | Days to maturity | Productive tillers per plant | Number of Spikelets per panicle | Seed setting percentage | Length of panicle (cm) | Sterility percentage | 1000 grain weight (g) | Grain yield per plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CORH 3 | 97.95$^{c*}$ | 11.03$^{de}$ | 82$^{bc}$ | 112$^{bc}$ | 9.30$^{a}$ | 150.50$^{c}$ | 47.97$^{cd}$ | 20.7$^{cd}$ | 12.09$^{d}$ | 19.82$^{c}$ | 15.19$^{a}$ |
| TNAU RH-4 | 94.97$^{d}$ | 11.00$^{de}$ | 83$^{bc}$ | 112$^{bc}$ | 4.60$^{de}$ | 148.20$^{cd}$ | 48.38$^{c}$ | 20.28$^{d}$ | 13.45$^{c}$ | 19.62$^{c}$ | 10.62$^{c}$ |
| KRH-4 | 96.96$^{cd}$ | 11.40$^{c}$ | 84$^{abc}$ | 117$^{a}$ | 5.10$^{cd}$ | 150.10$^{c}$ | 47.53$^{cde}$ | 20.29$^{d}$ | 13.75$^{c}$ | 19.65$^{c}$ | 13.34$^{b}$ |
| Sahyadri 1 | 90.66$^{e}$ | 10.67$^{f}$ | 83$^{bc}$ | 106$^{de}$ | 4.40$^{e}$ | 145.40$^{ef}$ | 46.84$^{cde}$ | 19.29$^{ef}$ | 14.51$^{b}$ | 19.27$^{c}$ | 8.57$^{f}$ |
| Sahyadri 2 | 87.88$^{f}$ | 10.41$^{g}$ | 81$^{bc}$ | 108$^{cde}$ | 3.80$^{f}$ | 141.60$^{g}$ | 42.94$^{gh}$ | 18.70$^{g}$ | 14.97$^{a}$ | 19.13$^{c}$ | 8.48$^{f}$ |
| Sahyadri 3 | 91.36$^{e}$ | 10.83$^{ef}$ | 80$^{c}$ | 108$^{cde}$ | 4.70$^{de}$ | 145.50$^{def}$ | 45.57$^{def}$ | 19.52$^{e}$ | 14.43$^{b}$ | 19.25$^{c}$ | 8.72$^{f}$ |
| Sahyadri 4 | 90.48$^{e}$ | 10.68$^{f}$ | 80$^{c}$ | 108$^{cde}$ | 3.70$^{f}$ | 144.20$^{fg}$ | 43.70$^{fgh}$ | 18.98$^{fg}$ | 14.68$^{ab}$ | 19.17$^{c}$ | 8.79$^{f}$ |
| MRP-5401 | 96.27$^{cd}$ | 11.15$^{d}$ | 80$^{c}$ | 110$^{cd}$ | 5.10$^{cd}$ | 148.00$^{cde}$ | 45.07$^{efg}$ | 18.92$^{fg}$ | 14.66$^{ab}$ | 19.40$^{c}$ | 8.64$^{f}$ |
| IR-29 | 87.50$^{f}$ | 10.39$^{g}$ | 88$^{a}$ | 105$^{e}$ | 5.50$^{c}$ | 196.25$^{a}$ | 42.45$^{h}$ | 21.08$^{c}$ | 11.48$^{e}$ | 19.10$^{c}$ | 9.58$^{e}$ |
| Ezhome 2 | 101.29$^{b}$ | 14.92$^{b}$ | 85$^{ab}$ | 115$^{ab}$ | 4.70$^{de}$ | 196.30$^{a}$ | 72.69$^{a}$ | 27.15$^{a}$ | 7.89$^{g}$ | 34.25$^{a}$ | 10.30$^{d}$ |
| Vytilla 6 | 117.35$^{a}$ | 15.45$^{a}$ | 88$^{a}$ | 117$^{a}$ | 6.20$^{b}$ | 158.00$^{b}$ | 68.73$^{b}$ | 22.25$^{b}$ | 8.80$^{f}$ | 33.46$^{b}$ | 10.47$^{cd}$ |
| CD (0.05) | 2.451 | 0.227 | 4.077 | 4.614 | 0.51 | 2.72 | 2.56 | 0.48 | 0.39 | 0.82 | 0.31 |

*Values with same superscripts do not differ significantly in DMRT et al. (2004), plant height progressively decreased with increase in salinity levels due to the high concentration of soluble salts in the soil, and consequent osmotic pressure created disturbance in the uptake of water and other nutrients leading to a reduction in the growth of plants. Rajendran et al. (2009) reported that salinity affects stomatal closure which in turn causes an increase in leaf temperature and inhibition of shoot elongation. Hence, it can be assumed that the genotypes may produce taller plants if grown under non saline condition.

The uppermost internodal length varied from 15.45 to 10.39 cm. Vytilla 6 recorded the highest uppermost internodal length and Sahyadri had the lowest. Uppermost internodal length has direct contribution towards plant height.

Days to 50 per cent flowering varied from 80 to 88 days. MRP 5401, Sahyadri 3 and 4 were early to flower while IR 29 was the late flowering genotype among the tested entries. Khatun et al. (1995) reported that salinity resulted in delayed flowering. However, the study by Moud and Maghsoud (2008) showed that plants under saline condition were early in flowering. CORH 3 is reported to be a medium duration hybrid with 120 to 140 days duration. In the present study, fifty per cent flowering in CORH 3 occurred at 82 days making its duration 112 days, which was earlier than its normal duration. TNAU RH 4 also showed reduction in duration, from 130 -145days, to 112 days. Hence, it can be concluded that the salinity caused hybrids to enter into reproductive phase earlier compared to the non-saline condition.

Days to maturity comprised the number of days from sowing to harvest (when 85 per cent of grains on the panicle were matured). Rice hybrids Sahyadri 1, Sahyadri 2, Sahyadri 3, Sahyadri 4, MRP-5401and variety IR-29 recorded a duration of 105 - 110 days, the other two rice hybrids CORH3, and TNAU RH-4 recorded a duration of 112 days, variety Vytilla 6 and hybrid KRH-4 recorded a duration of 117 days, and rice variety Ezhome 2 recorded a duration of 115 days. As seen in the case of days to fifty per cent flowering the genotypes were early to flower and mature under saline condition. Ezhome 2, which had a total duration of 125-130 days under Kaipad condition reached maturity in 115 days. Hence it can be suggested that salinity induced early flowering and maturity in the tested genotypes. This along with other factors reduced the vegetative phase of the plant, thereby reducing the duration, leading to reduction in grain yield under saline condition.

The numbers of tillers per plant varied from 3.7 to 9.3 among the tested genotypes. CORH3 exhibited the highest number of tillers per plant at flowering stages and Sahyadri 4 recorded the lowest number of tillers per plant. Many researchers have reported that number of productive tillers per plant is an important trait contributing to yield in rice under

*Table 2.* Correlation among 12 characters recorded for the field

| | V- 1 | V- 2 | V- 3 | V- 4 | V- 5 | V- 6 | V- 7 | V- 8 | V- 9 | V- 10 | V- 11 | V- 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V-1 | | | | | | | | | | | | |
| V- 2 | $0.66^{*}$ | | | | | | | | | | | |
| V- 3 | $-0.84^{**}$ | $-0.87^{**}$ | | | | | | | | | | |
| V- 4 | $-0.81^{**}$ | $-0.81^{**}$ | $0.87^{**}$ | | | | | | | | | |
| V- 5 | $-0.85^{**}$ | $-0.77^{**}$ | $0.95^{**}$ | $0.89^{**}$ | | | | | | | | |
| V- 6 | $-0.24^{NS}$ | $-0.79^{**}$ | $0.43^{NS}$ | $0.35^{NS}$ | $0.54^{NS}$ | | | | | | | |
| V- 7 | $-0.82^{**}$ | $-0.59^{*}$ | $0.65^{*}$ | $0.85^{**}$ | $0.79^{**}$ | $0.35^{NS}$ | | | | | | |
| V- 8 | $-0.49^{NS}$ | $-0.26^{NS}$ | $0.16^{NS}$ | $0.22^{NS}$ | $0.19^{NS}$ | $0.26^{NS}$ | $0.35^{NS}$ | | | | | |
| V- 9 | $-0.25^{NS}$ | $-0.78^{**}$ | $0.49^{NS}$ | $0.19^{NS}$ | $0.47^{NS}$ | $0.74^{**}$ | $0.02^{NS}$ | $0.09^{NS}$ | | | | |
| V- 10 | $-0.85^{**}$ | $-0.89^{**}$ | $0.98^{**}$ | $0.85^{**}$ | $0.92^{**}$ | $0.43^{NS}$ | $0.71^{**}$ | $0.10^{NS}$ | $0.41^{NS}$ | | | |
| V- 11 | $-0.62^{*}$ | $-0.97^{**}$ | $0.87^{**}$ | $0.40^{NS}$ | $0.77^{**}$ | $0.59^{*}$ | $0.49^{NS}$ | $0.14^{NS}$ | $0.81^{**}$ | $0.97^{**}$ | | |
| V- 12 | $-0.20^{NS}$ | $-0.77^{**}$ | $0.03^{NS}$ | $0.39^{NS}$ | $0.17^{NS}$ | $0.22^{NS}$ | $0.54^{*}$ | $0.80^{**}$ | $0.02^{NS}$ | $0.81^{**}$ | $0.20^{NS}$ | |

V-1-Visual score; V-2-Sterility per cent; V-3-1000 grain weight; V-4-Plant height; V-5-Internodal length; V-6-Days to 50 per cent flowering; V-7-Days to maturity; V-8-Productive tillers/panicle; V-9-Spiklets/panicle; V-10-Seed setting/cent; V-11-Panicle length; V-12-Grain yield/plant all the situations of cultivation (Thippani et al., 2017; Sadimantara et al., 2018).

Mean values for number of spikelets per panicle of rice hybrids along with the check varieties varied from 141.6 to 196.3. The highest number of spikelets per panicle was recorded in Ezhome 2 which was on par with IR-29 followed by Vytilla 6, and the lowest spikelet number per panicle was recorded for Sahyadri 2. Shannon et al. (1998) reported that salinity had a negative impact on a number of yield components of rice. The decrease in a number of spikelets per panicle is one of the major factors for yield reduction in rice due to salinity. During the reproductive stage, salts adversely affect the number of spikelets per panicle (IRRI, 1978).

Seed setting percentage of rice hybrids along with the check varieties was recorded after harvest and it varied from 42.45 to 72.69 per cent. Ezhome 2 recorded the highest seed setting percentage. The saline susceptible check variety IR-29 recorded the minimum seed setting per cent which indicated that salinity decreased the seed setting percentage. According to Abdullah et al. (2001), sterility and reduction in seed set were primarily due to reduced translocation of soluble carbohydrates to primary and secondary spikelets, accumulation of more sodium and less potassium in all floral parts and inhibition of the specific activity of starch synthesis in developing rice grains.

Mean length of the panicle of rice hybrids along with the check varieties recorded varied from 18.70 to 27.15 cm. Ezhome 2 recorded the highest panicle length followed by Vytilla 6 and IR-29. According to Kranto et al. (2016), in the soil culture method, injury score was related to plant height, proline content and panicle length. Saline tolerant varieties with a low salt injury score were associated with greater plant height and panicle length.

Sterility percentage of rice hybrids and check varieties was recorded after harvest. It varied from 7.89 to 14.97 per cent. Sahyadri 2 recorded the highest sterility percentage followed by Sahyadri 4, and MRP-5401. Ezhome-2 showed minimum sterility per cent.

1000 grain weight of the rice hybrids and check varieties varied from 19.10 to 34.25 g. Ezhome-2 recorded the highest 1000 grain weight followed by Vytilla 6. IR-29 recorded lowest 1000 grain weight which was on par with all rice hybrids. In saline condition, the saline susceptible check variety IR-29 recorded minimum 1000 grain weight, indicating that high salinity level reduced the weight of grains.

Grain yield per plant of the tested genotypes varied from 8.48 to 15.19 g. Rice hybrid CORH3 recorded the highest yield per plant. Sahyadri 2 recorded the lowest yield per plant which was on par with that of MRP-5401, Sahyadri 3, Sahyadri 1 and Sahyadri 4.

According to Marschner (1995) and Ashraf and Harris (2004), the differential response of the plants to salinity depended on the concentration and composition of ions in the solution and the genotype of the plant. Many physiological processes in the plants were affected by salinity. The deleterious effects of salinity in plants were associated with low osmotic potential of soil solution which was equal to water stress, nutritional imbalance, specific ion effects and the combination of all these. Winicov (1998), Munns (2002) and Tester and Davenport (2003) suggested that all of these caused adverse pleiotropic effects on plant growth and development at physiological, biochemical and at the molecular level.

Chinnusamy et al. (2005) suggested that salt tolerance was generally known as a complex quantitative trait which was controlled by multiple genes. According to Lutts et al. (1996), rice had been grouped as the salt susceptible cereal, especially at its young stage. Todaka et al. (2012) reported that salinity confined the efficiency of production at the mature stage. Singh et al. (2009) reported that rice, being a transplanted crop, could alleviate salinity at the seedling stage by management, *i.e.*, transplanting of aged seedlings, but could not avoid stress at the flowering stage. Apart from seedling stage, flowering stage was another highly sensitive growth stage which was affected by salinity stress, although salt tolerance at seedling stage was independent to that at flowering/reproductive stage.

Correlation among 11 characteristics recorded in the field experiment was worked out. Grain yield showed highly significant positive correlation with productive tillers/ plant and seed setting percentage as well as with days to maturity whereas highly significant negative correlation was noted with sterility percentage.

Panicle length showed highly significant positive correlation with 1000 grain weight, internodal length, number of spikelets/panicle and seed setting percentage; and significant positive correlation with days to 50 per cent flowering.

High significant negative correlation of sterility percentage, which is another indicator of salinity tolerance, was observed with the characters 1000 grain weight, plant height, internodal length, days to fifty per cent flowering, number of spikelets/ panicle, seed setting percentage, panicle length and grain yield, pointing out the fact that improvement in sterility per cent could be achieved by exercising selection simultaneously for decreased value of these traits. The above results are in agreement with the reports of Vanaja (1998), Ramakrishnan et al. (2006), Akhtar et al. (2011), Idris et al. (2012), Nagaraju et al. (2013) and Kumar and Nilanjaya (2014) for seed setting percentage, and Reddy et al. (2013) and Allam et al. (2015) for number of spikelets per panicle.

Based on the study it can be concluded that even though the traditional varieties were found to have a better establishment under saline conditions, the hybrids CORH3, KRH4 and TNAURH4 performed better with respect to grain yield per plant indicating their suitability to *Pokkali* condition.

Correlation studies suggested that higher grain yield could be achieved by exercising indirect selection simultaneously for increased values of dependent biometric traits namely, productive tillers/plant and seed setting percentage along with days to maturity, and for decreased value of sterility percentage.

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