Original Research Article

EVALUATION OF RICE VARIETIESFOR GROWTH AND YIELD PERFORMANCE IN AEROBIC CULTIVATION

ABSTRACT

A field experiment was carried out to identify the best suitable rice variety for aerobic cultivation in the Cauvery delta region. Ten ruling varieties were sown for two consecutive Kharif seasons, with regular nutrient and weed management practices under aerobic condition. Growth parameters viz.,plant height, leaf area index, root length and dry root weight were studied. Similarly yield parameters viz., panicles m^{-2}, Dry matter production at flowering and grain yield were studied. The study revealed that the rice variety ANNA 4, proved to be the best in terms of production (ie) 3.9 tonnesha^{-1} in the first season and 3.8 tonnesha^{-1} in the second season respectively. Pant height at different stages viz., maximum tillering, panicle initiation, flowering and harvest was highest in ANNA 4 followed by PMK 3.Similar was the case with root length,dry root weight, panicles m^{-2} and dry matter production at flowering stage. Leaf area index was highest for ADT 45 followed by IR50. The above results reveal that ANNA 4 is the most suitable rice variety for aerobic cultivation in the Cauvery delta region.

Key words:Aerobic rice, ANNA4, plant population, grain yield

1. INTRODUCTION

Rice (*Oryzasativa* L.) is the widely cultivated and popular crop in the world. It is the major source of energyfor more than two billion people in the world. Approximately 60-70% of their energy requirement is met from rice and its derived products. It plays an important role economically and in terms of food security. Globally rice is grown over an area of about 149 million ha with an annual production of 600 million tonnes (Bernier et al 2008). In India, rice is cultivated round the year in one or the other part of the country, in diverse ecologies spread over 44.6 M ha with a production of 132 MT of rice and average productivity of 2.96 t ha-1 (Rai, 2006).Traditional rice cultivation is labour-intensive which is well- suited to regions with low labour cost and high rainfall (Jayasree*et al.* 2021). Irrigated rice is typically transplanted into puddled paddy fields, which includes land preparation with 4-6 inches of standing water (Singh et al. 2021).Rice cultivation is a water intensive enterprise which requires about 4000-5000 litres of water for production of one kg rice (Jana, 2018).

By 2050, the worldwide water requirement is expected to increase by 55% (Connor, 2015; WWAP, 2016).According to Jana (2018), water scarcity will be severe and managing the available water resources will be a challenge by 2025. In India, population explosion and rapid urbanisation are gradually depleting the availability of water for agriculture. Groundwater tables have dropped down on an average of 0.5 - 0.7 meter per year in Indian states like Karnataka, Maharashtra, Rajasthan, Punjab, Haryana, northern Gujarat and Tamil Nadu. Scarcity of water necessitated the development of several water saving technologies to decrease seepage, percolation, andevaporation. Thus, the newly upcoming approach of rice cultivation called aerobic rice cultivation is a sustainable rice production methodology that reduces the water consumption in rice production and increases the water use efficiency.

The term "aerobic rice" was coined by the International Rice Research Institute and refers to a water-saving method in which high-yielding rice varieties are grown as an upland crop with adequate input and supplementary irrigation, when rainfall is insufficient, by direct seeding in un-puddled conditions without water logging in unsaturated conditions.(Rajkumar*et al*., 2009).With a moderate application of fertiliser, aerobic rice types may maintain rapid development in soil with moisture content at or below field capacity and achieve yields of 4-6 t/ha (Parthasarathi*et al.,* 2012). The concept of aerobic rice holds promise for farmers in water-short irrigated rice environments where water availability at the farm level is too low or where water is too expensive to grow flooded lowland rice. (Lal *et* al., 2014).The higher efficiency and better income from aerobic rice plays vital role in advertising the technology for further wide spread adoption of this technology and shifting from conventional to aerobic in water distress rice growing regions. (Thejaswikumar*et.al*., 2021). In the words of Jana (2018), aerobic rice is the rice of the future.

Production practices for rice cultivation are shifting from lowland rice to aerobic rice to make more efficient use of irrigation. The water use from sowing to harvest for transplanted rice is 1200 - 1300 mm whereas for aerobic rice it varied from 470 to 650 mm, which is less by 60 per cent. In comparison to low land rice, total water productivity was 1.6 to 1.9 times higher.Higher water productivity and water savings up to 37 to 45% over flooded method was observed for aerobic rice. (Kadiyala*et al*.,2012).About 92 percent, 42 percent, and 40.6 percent of water (including rainfall) was used for evapotranspiration or consumptive purposes for aerobic, wet seeding, and transplanted rice, respectively, while the remaining 8.0 percent, 58.0 percent, and 59.4 percent of water left the root zone as seepage and deep percolation flows.(Martin *et al.,*2007).

Most of the varieties that farmers currently cultivate are not suitable for cultivation in aerobic conditions and to make aerobic rice successful, suitable site-specific varieties should be developed (Pradhan *et.al*., 2016). Selection of good aerobic rice variety with desired physiological attributes along with good cultural practices and weed free environment would give better performance.(Lal *et al*., 2014). Under this context, the present study was conducted to identify an appropriate rice variety for aerobic condition.

2. MATERIALS AND METHODS

Site description

A field experiment was conducted over two consecutive kharif seasons (June to September) during the year 2017 and 2018. The experiment was carried out in Semmangudi village, Sirkazhi block of Nagapattinam district of Tamil Nadu. The texture of the soil in the experimental field was clay loam in nature.

Experiment

The field was thoroughly prepared using tractor drawn disc plough, cultivator and rotavator. Ten rice varieties, viz.,ADT36, ADT37, ADT43, ADT45, ADT48, IR50, CO47, ASD16, PMK 3, and ANNA4, were sown under dry condition. Each variety was considered a treatment and a randomised complete block design with ten treatments in three replications were carried out. The seeds were soaked in water for 12 hours and incubated for 10 hours. Sprouted seeds were line sown with a spacing of 20 x 15 cm. A fertilizer dose of 150:50:50 kg N, P, K per ha was adopted. The entire dose of P was applied as a basal, whereas Nitrogen and K fertilizers were split and applied in four equal doses after 15th day of sowing, tillering stage, panicle initiation stage and heading stage. Initial irrigation was done immediately after sowing and frequent irrigations were done followed by alternate wetting and drying. Two hand weeding were taken up on 15 and 30 DAS. The recommended package of practices for individual crop was followed for the rest of the management practices.

Measurement

Growth parameters like plant height were measured in different growth stages like maximum tillering, panicle initiation, flowering and harvest. Similarly, leaf area index (LAI), root length and dry root weight were measured during flowering stage. Yield parameters like Panicles m^{-2}, dry matter production at flowering stage and grain yield were recorded.

Statistical Analysis

The experimental results were statistically analysed by analysis of variance method and the Critical Difference was worked out at 5% probability level.

3. RESULTS AND DISCUSSION

3.1 Growth parameters of rice varieties under aerobic cultivation.

Plant height recorded during different growth stages viz., maximum tillering, panicle initiation, flowering and harvest are furnished in table 1. The highest plant height was recorded in ANNA4 (37.86, 59.91, 78.83, 85.58) at growth stages viz., maximum tillering, panicle initiation, flowering, harvest respectively, which was followed by PMK 3. Similar study was carried out by Sandhu et.al., (2019), who reported that the mean plant height of aerobic rice breeding lines at different experimental locations were 97 to 129 cms (IRRI), 93 to 112 cms (Bangladesh), 95 to 120 cms (Nepal) and 93 to 112 cms (India). Similar results were reported by Chandrika *et.al.,* (2017) who stated that the plant height of aerobic rice ranged from 18.9 to 28.7 cm, 38.5 to 53.1 cm, 56.5 to 78.1 cm and 76.6 cm to 103.8 cm in 30, 60, 90 DAS and at harvest respectively.The lowest plant height was recorded in ADT37.

Leaf area index (LAI) was observed at flowering stage. ADT 45 had the highest LAI of 4.70 and was significantly superior to other rice varieties. This was followed by IR50 (4.51) and ADT48 (4.42). Chandrika *et al.,* (2017) reported that the leaf area index (LAI) ranged from 0.57 to 0.82, 2.07 to 3.89, 3.79 to 4.23 and 3.69 to 4.11 at 30, 60, 90 DAS and at harvest respectively. The lowest LAI was recorded in ADT 37(2.71). A larger leaf area in relation to the mass of the leaves means a higher specific leaf area, and to support this relative increase in leaf area it requires a greater investment in the stem (De Groot et al., 2002).

According to Sunil and Sankaraligappa, (2014), in aerobic rice cultivation well developed root system plays a vital role in uptake of nutrients and water. Variation in root characters by different genotypes was reported by Uphoff and RandriAmiharisoa (2007). Patil*et.al*.,(2013 reported that development of root traits is dependent on gene factor and also in which environment crop is grown. The study revealed that at flowering stage, the longest root was observed in ANNA4 (20.59 cm), which was followed by PMK3 (19.58 cm) and ADT37 (19.34cm).Higher root volume and longer root length help to absorb the moisture and nutrient from soil to reduce drought stress (Sridhara, 2008). The lowest root length was observed in ADT36 (16.40cm). The rice variety ANNA4 recorded the maximum root dry weight at flowering stage (5.99 $gm.plant^{-1}$) followed by PMK 3 (5.73 gm. $plant^{-1}$). The minimum root dry weight was observed in ADT43 (3.82gm $plant^{-1}$).

Table - 1. Growth attributes of different rice varieties under aerobic cultivation.

Treatments	Plant Height (cms)				Leaf area index at flowering	Root length at flowering (cm)	Root dry weight at flowering (g)
	Maximum Tillering	Panicle initiation	Flowering	Harvest			
ADT37	28.75	48.17	67.31	71.22	2.71	19.34	4.92
ADT43	27.85	50.50	58.91	68.17	3.37	15.73	3.82
ADT45	32.65	51.11	71.22	71.22	4.71	16.43	5.31
ADT48	33.48	52.33	71.45	71.45	4.42	17.44	4.42
IR50	30.61	48.68	68.79	76.02	4.51	16.73	5.46
CO47	31.30	48.82	67.17	72.64	2.41	14.45	4.83
ASD16	31.40	54.86	71.19	80.70	3.23	18.73	5.61
PMK3	36.59	56.83	76.20	84.00	4.26	19.58	5.73
ANNA4	37.86	59.91	78.83	85.58	4.30	20.59	5.99
ADT36	30.14	49.84	71.51	71.51	2.84	16.40	4.48

CD(0.05)	**1.10**	**1.60**	**1.71**	**1.40**	**0.10**	**0.23**	**0.032**

3.2 Yield parameters of rice varieties under aerobic condition

The yield parameters like panicles m^{-2}, DMP at flowering stage and grain yield were recorded and analysed (Table -2). The results indicated a significant difference in panicles per unit area for different rice varieties. It was found that rice variety ANNA4 was significantly superior to other rice varieties with a higher root length (20.59), root dry matter (5.99) and number of panicles (362m^{-2}), followed by PMK3 (346 m^{-2}). ASD16 (314 m^{-2}) was found to be on par with ADT45 (312 m^{-2}). The lowest number of panicles per unit area was recorded in ADT 36 (226 m-2). The total DMP also differed significantly among the rice varieties. ANNA4 recorded the highest DMP of 9.86 t/ha. This was followed by PMK3 (9.31t/ha) and was on par with ADT45 (9.21 t/ha). The next best treatment variety was ASD16 (8.32 t/ha) and the lowest DMP was recorded in ADT43 (6.35t/ha). The total grain yield was also significantly different among the rice varieties.

Table-2 .Yield attributes of different rice varieties under aerobic cultivation.

Treatments	Panicles m^{-2}	DMP at flowering (t ha-1)	Grain yield (kg ha-1)
ADT37	253	7.55	1744
ADT43	293	6.35	1244
ADT45	312	9.21	3125
ADT48	264	6.58	1333
IR50	271	7.92	2424
CO47	261	7.34	2307
ASD16	314	8.32	3133
PMK3	346	9.31	3695
ANNA4	362	9.86	3869
ADT36	226	6.68	1384
CD(0.05)	**6.343**	**0.12**	**15.05**

ANNA4 recorded the highest grain yield (3869 kg/ha) followed by PMK 3 (3695 kg/ha), ASD16 (3133 kg/ha) and ADT45 (3125 kg/ha) (Fig-1). Pradhan *et.al.,* (2016) reported that yield obtained with aerobic rice varieties varied from 3.5 to 6.0 t ha −1 , which is almost double that obtained with upland rainfed varieties, and 25% to 30% less than that obtained with irrigated lowland varieties grown under flooded conditions. Aerobic rice varieties have the ability to maintain rapid growth in soils with moisture content at or below field capacity, and can produce yields of 4-6 t/ha with a moderate application of fertilizers under such soil water conditions (Parthasarathi et al. 2012).

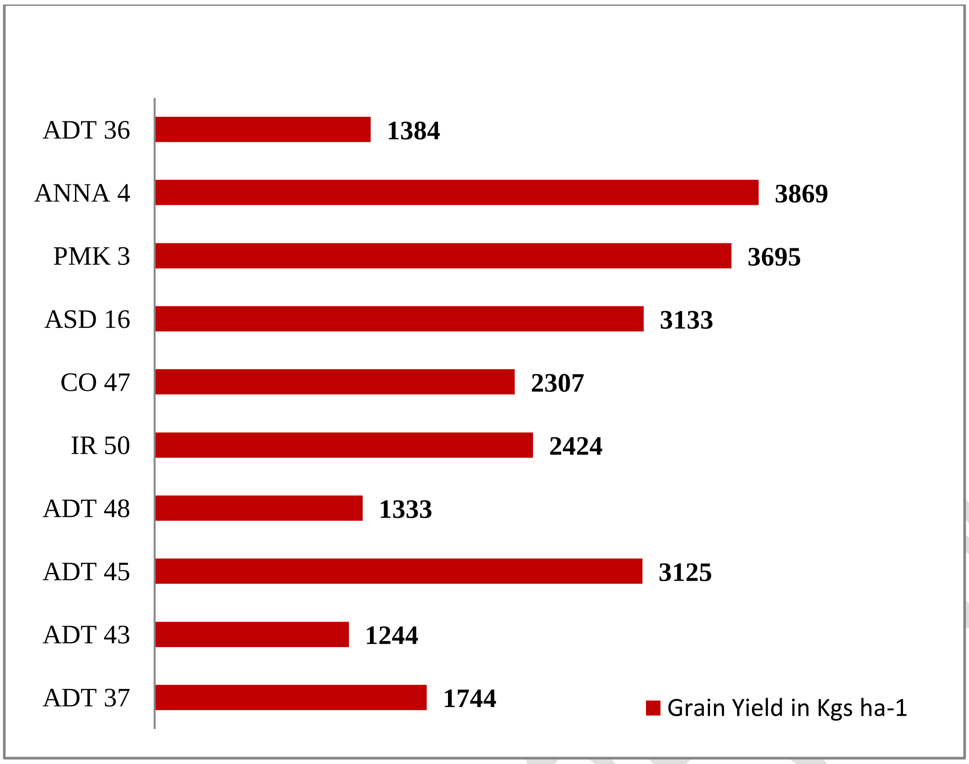

Figure-1 Grain Yield of rice varieties under aerobic cultivation

4. CONCLUSION

The present study after analysing the growth and yield parameters of ten different cultivars under aerobic condition concludes that rice varieties ANNA4 and PMK 3 were the suitable rice varieties for aerobic cultivation. The study revealed that ANNA4 performed better than PMK 3 in terms of grain yield and DMP. Growing rice with water-saving techniques such as aerobic rice has greatpotential in India. Considering the scope of aerobic rice, more research need to be done in terms of breeding suitable rice varieties and develop systems which are sustainable and viable for aerobic rice and also disseminate this technology to areas with high yield potential.

REFERENCE:

1. Bernier J. et al. Review, Breeding upland rice for drought resistance. Journal of Science, Food and Agriculture 88,927-939, (2008).
2. Chandrika, M. Uma Devi, V. Ramulu and VenkataRamana, M. 2017. Evaluation of Different Varieties of Aerobic Rice (Oryzasativa L.) under Different Fertigation Levels on Growth and Yield Parameters. Int.J.Curr.Microbiol.App.Sci. 6(5): 2793-2801. doi: https://doi.org/10.20546/ijcmas.2017.605.314
3. Connor, R. (2015). The United Nations World Water Development Report 2015: Water for a Sustainable World, Vol. 1. UNESCO Publishing
4. De groot, C., Marcellis, L.F.M., Van den Boogoard, R., Lambres, H. 2002. Interactive effects of nitrogen and irradiance on growth and partitioning of dry mass and nitrogen in young tomato plants.Functional Plant Biology 29: 1319-1328.
5. James Martin.G, Padmanathan .P. K. and Subramanian.E. (2007). Identification on Suitable Rice Variety Adaptability to Aerobic Irrigation. Journal of Agricultural and Biological Science. 2(2) mar. 2007. ISSN 1990-6145.
6. Jana K. (2018). Aerobic Rice Cultivation System: Eco-Friendly and Water Saving Technology under Changed Climate. Agri Res & Tech: Open Access J. 13(2): 555878. DOI: 10.19080/ARTOAJ.2018.13.555878
7. Jayasree, K., Michael, B., Rajesh, K.R. and Kadambot, H.M.S. (2021). Sustainability of Traditional Rice Cultivation in Kerala, India—A Socio-Economic Analysis, Sustainability, 13(980): 1-16.

8. Kadiyala, M.D.M., R. S. Mylavarapu, Y. C. Li, G. B. Reddy, and M. D. Reddy (2012) Impact of Aerobic Rice Cultivation on Growth, Yield, and Water Productivity of Rice–Maize Rotation in Semiarid Tropics, Agronomy Journal, 104(6): 1757- 1765.
9. Lal, Dr. B. &Nayak, A.K. &Gautam, Priyanka &Tripathi, Rahul & Singh, Teekam&Katara, Jawahar. (2014). Aerobic Rice: A Water Saving Approach for Rice Production. Popular Kheti. 1. 1-4.
10. Parthasarathi, T., Vanitha, K., Lakshamanakumar, P. and Kalaiyarasi, D. 2012. Aerobic rice mitigating water stress for the future climate change. International J. Agronomy and Plant Production. 3(7): 241- 254.
11. Patil A.S.P., Nanjappa H.V and B.K. Ramachandrappa. (2013). Root and tillering behaviour study of aerobic rice (Oryzasativa L.) genotypes for targeted yield under site specific nutrient management (SSNM) approach, Res. on Crops 14 (3) : 654-660.
12. Pradhan, S.K., Mall, A.K., Ghosh, A., Singh, S., Samal, P., Dash, S.K., Singh, O.N. and Kumar, Arvind (2016). Aerobic Rice Perspective in India: Progress and Challenges. Technical Assistance Consultant's Report prepared by International Rice Research Institute and partner organizations in Bangladesh, India, Nepal, Pakistan, and Philippines. pp. 45-66
13. Rai, M. (2006). In, Abstracts of 26th International Rice Research Conference, 2nd International Rice Congress, New Delhi. 2.
14. Rajkumar, D., Subramanian, E., Ramesh, T., Martin, G.H. and G. Thiyagarajan. (2009). Striding towards aerobic rice cultivation- a review. Agricultural Reviews. 30(3): 213-18.
15. Sandhu N, Yadaw RB, Chaudhary B, Prasai H, Iftekharuddaula K, Venkateshwarlu C, Annamalai A, Xangsayasane P, Battan KR, Ram M, Cruz MTS, Pablico P, Maturan PC, Raman KA, Catolos M and Kumar A (2019) Evaluating the Performance of Rice Genotypes for Improving Yield and Adaptability Under Direct Seeded Aerobic Cultivation Conditions. Front. Plant Sci. 10:159. doi: 10.3389/fpls.2019.00159
16. Singh, B., Shefali, M., Deepak, S. and Joshi, B. (2021). Growing Rice with Less Water: Improving Productivity by Decreasing Water Demand, Rice improvement, pp. 147-170.
17. Sridhara, C. J. (2008). Effect of genotypes, planting geometry, methods of establishment and micronutrient application on growth and yield of aerobic rice. Ph. D. thesis, Univ. Agric. Sci., Bengaluru, Karnataka, India.
18. Sunil C.M and B.C. Shankaralingappa, 2014. Rooting Behaviour of Aerobic Rice under Integrated Package of Agrotechniques. Asian Journal of Agricultural Research, 8: 105-113. DOI: 10.3923/ajar.2014.105.113.
19. Thejaswi Kumar, J., Lokesha, H. and Thapa, S. (2021). Resource Use Efficiency Among Aerobic and Conventional Rice Farms in Eastern Dry Zone of Karnataka: A Comparative Analysis. Economic Affairs, 66(3): 439-446.
20. Uphoff, N. and RandriAmiharisoa (2007). Root studies in aerobic rice genotypes. In Water-Wise Rice Production. Int. Rice Res Inst., Manila, Philippines. pp. 71-78.
21. WWAP (2016). The United Nations World Water Development Report 2016: Water and Jobs. United Nations World Water Assessment Programme. Paris: UNESCO.