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Research Article

Evaluation of recombinant inbred lines of IR20 and Nootripathu for root traits

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Abstract
Root length and rapid elongation of roots during early stages of growth determines drought tolerance in rice. Some of the traditional rice genotypes including Nootripathu, a drought tolerant upland rice genotype possesses the above drought adaptive traits but no attempts have been made to map them. In this study, a set of 100 advanced generation Recombinant Inbred Lines (RILs) developed between IR20 (shallow rooted) and Nootripathu (deep rooted) were carefully examined for their root growth behaviour. Parents, IR20 and Nootripathu exhibited significant differences in their radicle emergence, root elongation rate and root length on 3rd and 9th day after germination. RILs exhibited continuous genetic variation for root length and crown root number and revealed its suitability for genetic mapping of various root growth traits.

Keywords
Rice, Early rooting, Crown root, Recombinant Inbred Lines

Introduction

Achieving higher yields with less water is the most challenging factor in feeding two more billion people. Rice, a water loving crop consumes 24 – 30% of the world's freshwater resources and whose production is frequently affected by drought (Bouman *et al.,* 2007, Molden 2013). Drought avoidance is one of the important mechanisms which helps in minimizing yield losses by maintaining high internal water status facilitated by extensive root system. Roots also determine uptake of nutrients, providing support, synthesis of growth regulators and production of organic acids to solubilise minerals in the soil. Deep-rooted rice genotypes including landraces were shown to exhibit better tolerance against drought. Conventional breeding programs met with limited success in developing genotypes with altered root growth behaviour.

Therefore, improving the root system architecture will be a remarkable strategy in developing drought tolerant rice. Advancements in molecular genetics have identified several QTLs and genes controlling root architecture related traits in rice. Although more than 700 QTLs controlling root traits viz., root number, root length and root thickness have been mapped, only a few have been mapped using our native gene pool.Earlier reports suggest that Nootripathu, a drought tolerant upland rice genotype possess higher number of roots, deeper and thicker roots (Muthurajan *et al.,* 2018, Ramanathan *et al.,* 2018). A RIL population developed between IR 20 and Nootripathu has been utilized for mapping several drought tolerance traits such as canopy temperature, stress recovery, relative water content, leaf rolling, flowering time, grain yield etc., under drought conditions (Gomez *et al.,* 2010, Prince *et al.,* 2015, Salunkhe *et al.,* 2011). But, this has not been utilized for studying the inheritance pattern of root traits and mapping genetic loci controlling root growth behaviour in Nootripathu. Hence, this study was formulated to evaluate the recombinant inbred lines developed between IR20 (shallow rooted; drought susceptible) and Nootripathu (deep rooted; drought tolerant) for root growth traits and testing its suitability for mapping root traits.

Materials and Methods

A sub set of 100 RILs derived from a high yielding drought sensitive indica cultivar with shallow root system variety, IR20 and a drought tolerant upland indica rice genotype Nootripathu with thick deep root system and higher root penetration ability were used in this study. Freshly harvested seeds of RILs and the parents were sun dried and used in this study. A total of 15 seeds per RIL were germinated on petri dishes along with the parents and maintained under laboratory conditions at 25^{o}C. Data on root length and number of crown root was taken on nine randomly germinated seedlings. Root length of seedlings and number of crown roots were measured on 3rd, 5th and 9th days after germination. Length of roots was measured using the standard ruler and expressed in cm whereas the crown root number was counted visually and expressed in numbers. The statistical analysis was done using SPSS 16.0.

Results and Discussion

Drought stress is becoming a major challenge in negatively affecting the production of major agricultural crops including rice. Developing drought tolerant genotypes is the primary objective of rice breeding programs and marker assisted selection holds promising in achieving the task when compared to conventional plant breeding tools (Salekdeh *et al.,* 2009). Molecular breeding will be more effective if QTLs/markers linked to major component traits are available. With regard to drought tolerance, roots play a major role in determining avoidance from drought (Goss *et al.,* 1993). Root traits along with other physio-morphological traits contribute to early seedling vigour (Mahender *et al.,* 2015). Since plant needs to take up water from deeper layers of soil under drought, deep rooting will enable this.

IR20 and Nootripathu, exhibited significant variation in root length and number of crown roots as reported earlier (Ramanathan *et al.,* 2018). Nootripathu had longer roots and more number of crown roots than IR20 (Table 1 and 2, Fig. 1). Similar results of Nootripathu having better root traits viz., root length, root volume, root thickness, total number of roots have been reported in early studies (Chandra Babu *et al.,* 2001, Ramanathan *et al.,* 2018, Ganapathy *et al.,* 2010, Boopathi *et al.,* 2001).

Wide variation for root length and number of crown roots was observed among the RILs. The RILs derived from IR20 and Nootripathu showed transgressive segregation for root length (Fig. 2) and number of crown roots. Population mean root length at 3^{rd} day after sowing was 0.78cm and at 4^{th} day it was 2.39cm i.e., an average of 1.6cm root growth was observed in population from 3^{rd} to 4^{th} day.Longer the root grows, its ability to access deep-water increases thus improving drought resistance (Price *et al.,* 1997).Among parents, Nootripathu developed more number of crown roots than IR20. Crown root development started at 5^{th} day in Nootripathu while IR20 started on 6^{th} day. Average number of crown roots among the RILs was three on 5^{th} day and it was six on 9^{th} day. Crown root helps in absorbing water and nutrition as well as provide good anchor to the plants(Wang *et al.,* 2011). It plays vital role during plant growth (Cheng *et al.,* 2016). This study revealed significant variation for root length and number of crown roots among the RILs as that of their parents. Hence, this population can ideally be used to map root length and number of crown roots during the early stages of plant growth.

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Table 1. Phenotypic variation for root length among the parents IR20 and Nootripathu and their RILs

Traits	IR20	Nootripathu	Population Mean	Std. Error	Range
3DRL	0.32	0.87	0.78	0.028	0.30 – 1.66
5DRL	2.63	3.76	4.27	0.074	2.37 – 6.46
9DRL	4.43	6.01	6.01	0.12	3.62 – 8.87

3DRL, 5DRL and 9DRL – 3rd, 5th and 9th Day Root Length of seedlings respectively.

Table 2. Phenotypic variation for number of crown roots among the parents IR20 and Nootripathu and their RILs

Traits	IR20	Nootripathu	Population Mean	Std. Error	Range
5DCR	0	2	3.1	0.08	0.78 – 4.67
9DCR	4.4	7.1	6.4	0.09	4.25 – 8.44

5DCR and 9DCR – Crown root number on, 5 and 9 day old seedlings respectively.

Fig. 1. Genetic variation for root length in 3 days old seedling of IR20, Nootripathu and RILs. Scale bar = 1 cm

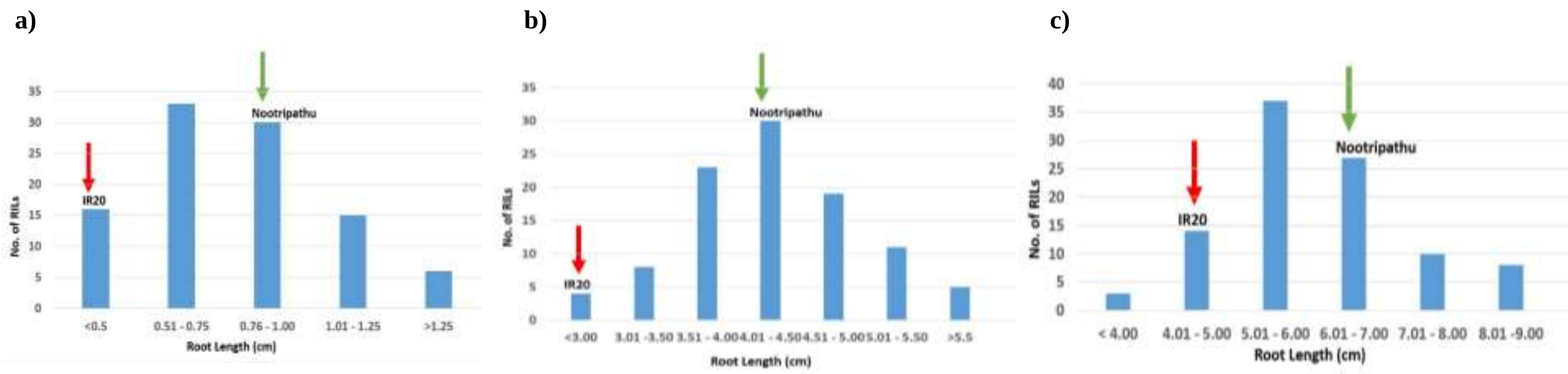

Fig. 2. Frequency distribution of root length at 3, 5 and 9 day old seedlings represented as a, b and c, respectively in the RIL population of IR20 and Nootripathu. The red and green arrow represents the root length of the parents IR20 and Nootripathu, respectively.