Planting Geometry of Wet Spot Seeded Rice (*Oryza sativa* L.)

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ABSTRACT *Field experiments were conducted at Annamalai University Experimental Farm, Department of Agronomy, Annamalai University, Annamalai Nagar, Tamilnadu, India during Thaladi (Sep. to Jan.) and Navarai (Jan. to Apr.) seasons of 2013-14, to standardize the planting geometry for augmenting the growth traits and physiological dynamics of wet spot seeded rice. The experiment was laid out in a randomized block design and replicated four times. The medium duration rice variety CO 43 was used as test variety. The experiment consisted of different planting geometry as T_1: 25 × 25 cm, T_2: 30 × 30 cm, and T_3: 35 × 35 cm and T_4: 40 × 40 cm, which were replicated four times. Two years experimental data revealed that planting at 30 × 30 cm spacing recorded the maximum growth parameters during Thaladi season. Whereas, in Navarai season planting at 25 × 25 cm registered the maximum growth characters viz., plant height, number of tillers, dry matter production, root length, root volume and physiological characters viz., leaf area index and crop growth rate.*

Keywords: *coastal agroecosystem, crop geometry, crop growth rate, leaf area index.*

1. Introduction

Rice is a staple food for more than half of the world's population. Worldwide, rice is grown on 161 million hectares, with an annual production of about 678.7 million tonnes (FAO, 2016). To meet the global rice demand, it is estimated that about 114 million tonnes of additional milled rice need to be produced by 2035, which is equivalent to an overall increase of 26 per cent in the next 17 years.

Among the rice growing countries, India has the largest area (43.39 million hectares) and is the second largest producer (104.32 million tonnes) next to China (207 million tonnes). The rice productivity in India is 2.39 t ha^{-1}, while the world average is 4.25 t ha^{-1}. Tamil Nadu alone contributes eight per cent of the national rice production from an area of 2.04 million hectares, with a production of 7.98 million tonnes and productivity of 3.92 t ha^{-1} (MAFW, 2016). The possibility of expanding the area under rice in the near future is not possible. Therefore, extra rice production using agronomical technologies needed has to come from a productivity gain.

Degraded soils especially saline and poorly drained together with climatic adversities causes acute shortage of good quality irrigation water for rice cultivation in low land rice productivity in the coastal tracts of Northern Tamil Nadu. Uncertainties of rainfall together with long dry spell, seasonality of labour demand are increasingly becoming a severe alarm for the timely transplanting of rice (Rex Immanuel *et al*., 2018).

In rice growing tail end coastal regions of Tamilnadu, there is an acute shortage of water for raising nursery and in many cases this delayed transplanting, leading to reduced crop yield. As a result, conventional transplanting is becoming difficult in terms of economics. To overcome these difficulties wet spot seeded rice in puddled soils can be a substitute for sustaining the small and marginal farmers livelihood.

Wet spot seeded rice starts tillering earlier than transplanted rice because its growth proceeds without the set back caused by uprooting injury to the root of seedlings. Kumar *et al*., (2008) observed that direct seeding of sprouted seeds under puddled condition favourably influenced the growth parameters of rice due to favourable soil moisture regime than direct seeding of sprouted and dry seeds under unpuddled condition.

Appropriate agronomic management is a pre-requisite to make use of the full potential of rice cultivar. Among the available no-cost technology suitable planting geometry play a crucial role in boosting production of direct seeded rice. Wider spacing improves the canopy's photosynthesis which leads to greater root growth and accompanying more tillering percentage, provided that other favourable conditions for growth such as soil aeration are provided

Spot seeding methods have found that their crops mature 10 to 20 days sooner compared with the same variety grown conventionally. Harvesting sooner reduces crop's total amount of irrigation water needed and possible to include one more crop to enhance the resource use efficiency under resource constraint situation.

Proper planting geometry have more advantages such as, to maximize solar utilization efficiency, improves aeration within crop canopy, enhances soil respiration and provides better weed control thereby led higher crop growth (Gautam *et al*., 2008; Ranjita *et al*., 2011). Closer spacing hampers intercultural operations and as such more competition arises among the plants for nutrients, air and light as a result, plant becomes weaker and thinner producing lower growth. The planting geometry exploits the initial vigor of the genotypes with enhanced soil aeration creating congenial condition for better establishment (Shukla *et al*., 2014).

It is also observed that plant to plant and row to row spacing had a significant effect on yield and yield attributing characters of direct seeded rice (Sultana *et al*., 2012). Potential of a cultivar varies with effective utilization of solar radiation, soil moisture and nutritional uptake from the soil and all these depends on selection of appropriate plant spacing. At higher plant population these factors may be deficient while at lower plant population these factors are not well utilized. Increasing plant spacing between and within row increases light penetration in to the crop canopy, which enhance weed growth.

Planting practices have been shifting from closer planting geometry to wider planting geometry in high yielding cultivation. This improves the canopy's photosynthesis, at the same time, in combination with less irrigation water, pests may be better controlled and lodging can be prevented (Basha *et al*., 2017). Early intra-row competition in the plant's life cycle limits the supply of water and nutrients to the plant, thereby suppressing vegetative growth, and delaying access to inter-row reserves of water and nutrients until reproductive growth. High tillering crops have a more complicated response to both inter and intra-row spacing changes due to their strong tillering ability. However, at present, the information of appropriate crop geometry is not well known for wet spot seeded rice. With this background, field experiments were conducted in coastal agroecosystem of Northern Tamil Nadu to evaluate the suitable planting geometry for wet spot seeded rice.

2. Materials and Methods

The field experiments were conducted at Annamalai University Experimental Farm, situated at 11°24′ North latitude, 79°44′ East longitude and at an altitude of +5.79 m above the mean sea level and 10 km away from the Bay of Bengal Sea.

2.1. Weather

The mean annual rainfall of the experimental farm is 1,500 mm distributed over 60 rainy days. Out of the total rainfall, 400 mm during South-West monsoon (June – September), 1,000 mm is received during North-East monsoon (October – December) and 100 mm during hot weather period as summer showers. The potential evapotranspiration varies from 1,700 to 1,900 mm resulting in an annual water deficit of 200 – 400 mm year^{-1}. The maximum temperature ranged from 28 to 43° C with a mean of 33° C while the minimum temperature ranged from 18 to 28° C with a mean of 23° C. The mean highest and lowest relative humidity is 96 (Sep. – Jan.) and 76 per cent (Feb. - Aug.), respectively. The Thaladi season (Sep. to Jan.) received a rainfall of 1121.95 mm distributed over 43 rainy days and Navarai season (Jan. to Apr.) received 127.0 mm distributed over 6 rainy days.

2.2. Soil

The soil is deep clay, moderately saline, low in organic carbon (0.23 and 0.47 %) and available nitrogen (227 and 212 kg ha^{-1}), medium in available phosphorus (17 and 18.5 kg ha^{-1}) and high in available potassium (346 and 298.3 kg ha^{-1}).

2.3. Experimental detail

The experiments were laid out in RBD with four replications by adopting four different spacing's *viz*.,T_1: 25 x 25 cm, T_2: 30 x 30 cm, T: 35 x 35 cm and T_1: 40 x 40 cm.

2.4. Crop management

Rice variety CO 43 was used as test variety. Sprouted seeds were carefully spot seeded @ 2 seeds per hole in the field by maintaining thin film of standing water by adopting desired spacing. The seed rate used for treatments T_1, T_2, T_3 and T_4 were 12, 9, 6 and
5 kg ha^{-1}, respectively.

During Thaladi season 12.5 t ha^{-1} of FYM was added. Variety specific recommended dose of fertilizer for medium duration crop – 150: 50: 50 and short duration crop N, P_2O_5 and K_2O kg ha^{-1}, respectively was applied for the proper growth of the crop in all the treatments. Full dose of phosphorous, potash and half dose of nitrogen were applied as basal dose while the remaining half dose of nitrogen was applied in two equal splits at tillering and panicle initiation stage of the crop.

Depending on weather conditions plots were kept under a saturated condition from sowing to the vegetative phase. The plots were then kept under alternate wetting and drying method - application of 2 cm depth of water after the formation of hairline crack was followed. Irrigation was withheld 15 days before harvest.

Three series of weeding were done with a mechanical rotary weeder (cono weeder) with the first one done at 15 DAS followed by 15 days interval. Need based plant protection measures were carried out based on the economic threshold level of insect pests and diseases.

2.5. Biometric observations

Biometric observations on growth parameters *viz.,* plant height at harvesting stage, LAI at flowering stage, CGR between the appearance of 1st tiller and 50 per cent flowering stage, number of tillers m^{-2}, root length and volume at maximum tillering stage and DMP were recorded. The plant height was measured from the color region to the tip of the top most leaf at harvesting stage and expressed as cm. Five hills selected at random in sampling area was drawn in each plot at harvest stage of the crop, air dried, then oven dried at 80°C ± 5°C for 48 hours to constant weight and weighed in a electronic balance.

The length of the root was measured from collar region down to the tip of the longest root at flowering stage of the crop and the average was expressed in cm. Root volume was found out by placing the roots into a measuring cylinder containing a known volume of water. By measuring the increase in the water column, root volume was assessed at flowering stage of the crop and expressed in cc.

The Leaf Area Index (LAI) was worked out by the method lined by Palaniswamy and Gomez (1974) and Crop Growth Rate (CGR) during the growth period *viz*., appearance of 1st tiller to 50 per cent flowering were calculated the method as suggested by Watson (1958) and expressed in mg m^{-2} day^{-1}. The data on various parameters studied during the investigation was statistically analyzed as per the procedures suggested by Gomez and Gomez (1984) at 5 per cent probability level.

3. Results

3.1. Growth parameters

The plant height varied significantly due to different planting geometry adopted. The treatment T_2 (30 × 30 cm spacing) recorded a higher plant height of 99.11 cm for Thaladi season. Whereas in Navarai, the treatment T_1 (25 × 25 cm spacing) registered maximum plant height of 97.73 cm.

The number of tillers m^{-2} varied significantly due to different planting geometry adopted. The treatment T_2 (30 × 30 cm spacing) recorded the maximum tiller number of 403.83 m^{-2} at maximum tillering stage during Thaladi season, while the treatment T_1 (25 × 25 cm spacing) registered the highest tiller number of 370 m^{-2} at maximum tillering during Navarai season.

Among the different planting geometry adopted, the treatment T_2 (30 × 30 cm spacing) registered the higher DMP of 10435 kg ha^{-1} during Thaladi and the treatment T_1 (25 × 25 cm spacing) recorded the maximum DMP of 8981 kg ha^{-1} during Navarai season. The lowest DMP was observed in 40 × 40 cm spacing (T_4) during Thaladi and Navarai seasons.

Table 1 Effect of planting geometry on growth parameters of *rice* during Thaladi season

Treatments	Plant height (cm)	Number of tillers (m^{-2})	Dry mater production (kg ha^{-2})	Root length (cm)	Root volume (cc)	Leaf area index (LAI)	Crop growth rate (mg m^{-2} day^{-1})
T_1: 25 x 25 cm	95.76	391.48	9917	23.32	19.85	5.03	11.15
T_2: 30 x 30cm	99.11	403.83	10435	24.81	21.09	5.26	12.10
T_3: 35 x 35cm	87.00	335.32	7958	18.16	16.93	4.45	9.60
T_4: 40 x 40 cm	84.47	310.98	7463	16.60	16.24	4.21	8.94
S.Ed	1.64	6.04	248	0.74	0.51	0.10	0.18
C.D (0.05)	3.28	12.09	496	1.48	1.03	0.21	0.37

3.2. Root growth

The different planting geometry adopted exerts significant influence on the root length of rice crop at 50 per cent flowering stage. Lengthier root of 24.81 cm was recorded in the treatment T_2 (30 × 30 cm spacing) during Thaladi season. In Navarai, the treatment T_1 (25 × 25 cm spacing) registered the maximum root length of 23.60 cm.

Among the different spacing's adopted, adoption of 30 × 30 cm spacing (T_2) recorded a maximum root volume of 21.09 cc during Thaladi season, while adoption of 25 × 25 cm spacing (T_1) registered a maximum root volume of 19.97cc during for Navarai season. Crop raised with 40×40 cm spacing (T_4) registered least root volume in both the seasons.

3.3. Physiological parameters

The planting geometry caused considerable variations in LAI at maximum tillering stage. The treatment M_2 (30×30 cm spacing) recorded the maximum LAI of 5.26 during Thaladi season, while the treatment T_1 (25×25 cm spacing) registered the maximum LAI of 4.37 during Navarai season.

The CGR was markedly influenced by the different planting geometry adopted. The treatment T_2 (30×30 cm spacing) recorded higher CGR of 12.10 mg m^{-2} day^{-1} during Thaladi season and the treatment T_1 (25×25 cm spacing) registered maximum CGR of 11.13 mg m^{-2} day^{-1} during Navarai season. The least CGR was observed in T_4 treatment (40×40 cm spacing).

Table 2 Effect of planting geometry on growth parameters of *rice* during Navarai season

Treatments	Plant height (cm)	Number of tillers (m^{-2})	Dry mater production (kg ha^{-2})	Root length (cm)	Root volume (cc)	Leaf area index (LAI)	Crop growth rate (mg m^{-2} day^{-1})
T_1: 25 x 25 cm	97.73	370.00	8981	23.60	19.97	4.37	11.13
T_2: 30 x 30cm	94.39	359.26	8692	22.29	18.72	4.16	10.69
T_3: 35 x 35cm	85.26	307.33	6815	17.62	15.92	3.61	8.39
T_4: 40 x 40 cm	82.62	284.41	6083	16.00	14.94	3.42	7.63
S.Ed	1.25	4.00	138	0.60	0.41	0.09	0.20
C.D (0.05)	2.52	8.01	276	1.21	0.82	0.18	0.41

4. Discussion

4.1. Growth characters

There is a felt need to evaluate a suitable agronomic strategy which emphasis on eco-friendliness to accomplish the objectives of achieving the sustained production over a long period. Observations recorded from the field experiments revealed that the crop geometry treatments significantly exhibited a constructive effect, which was evident in terms of growth characters *viz*., plant height, number of tillers and DMP.

Spot seeding of rice at 30 x 30 cm (T_2) for Thaladi and 25 x 25 cm (T_1) spacing for Navarai season excelled all other spatial arrangements by registering higher values of plant height and tillers m^{-2} over the other treatments. The crop geometry provided to rice plants in favourable ecological conditions exhibits more vigorous growth *i.e.* tillers spread out more widely and produce maximum tillers with healthy internodes and more erect leaves that avoid mutual shading of leaves. This expressed visually in the way of higher tiller numbers with maximum plant height. Favourable ecological conditions determine the degree of elongation of the healthy internodes and its summation decides the maximum height and tillers were reported by Baloch *et al*. (2003) and Ogbodo *et al*. (2010).

In fertile environments, narrow row spacing will cause mutual shading earlier than wide row spacing, thus restricting excess tillering. This progress involves a shortage of carbohydrates, morphogenetic shade-avoidance response, and blue, red, and far-red radiation intensity variations (Luquet et al., 2006).

4.2. Root growth

The different spacing's adopted exercise significant influence on the root length and root volume of rice crop at maximum tillering stage. The optimum nutrient feeding area provided by spot seeding of rice at 30 x 30 cm (T_2) for Thaladi rice and 25 x 25 cm (T_1) spacing for Navarai season endowed with greater root growth in terms of root length and root volume. In general, increase in number of tillers produce higher root length and root volume. This was due to the plants grown with higher tiller numbers have greater accessibility of nutrients if optimum spacing provided, which precisely utilized the available nutrients from the rhizosphere soil. The result agrees with the findings of Sharma *et al.* (2004), Gill (2008) and Gangwar *et al.* (2008).

4.3. Physiological characters

Adoption of 30×30 cm spacing for Thaladi and 25×25 cm for Navarai season significantly registered the higher LAI, CGR values. This is because of the fact that accommodation of 11 hills m^{-2} and 16 hills m^{-2} for Thaladi and Navarai rice respectively had a solid open architecture which helped in even distribution of light, moisture, space and nutrient, that debilitated whole physiological mechanisms and machinery of plant and its efficient in mating use of the resources per unit area leading to manifestation of higher LAI and CGR. The increased plant height, tiller number, LAI and CGR under optimum population ensure the plant parts both of the observation are in concomitance with the findings of Mirza *et al*. (2009), Awan *et al*. (2011) and Roshan *et al*. (2011).

5. Conclusion

In view of the above results, it could be concluded that adoption of 30 × 30 cm spacing during Thaladi season and 25 × 25 cm during Navarai season pave way for recording higher growth attributes on wet spot seeding of rice in the coastal agroecosystem of Northern Tamil Nadu.

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Plate 1. Wet spot seeding of sprouted rice seeds

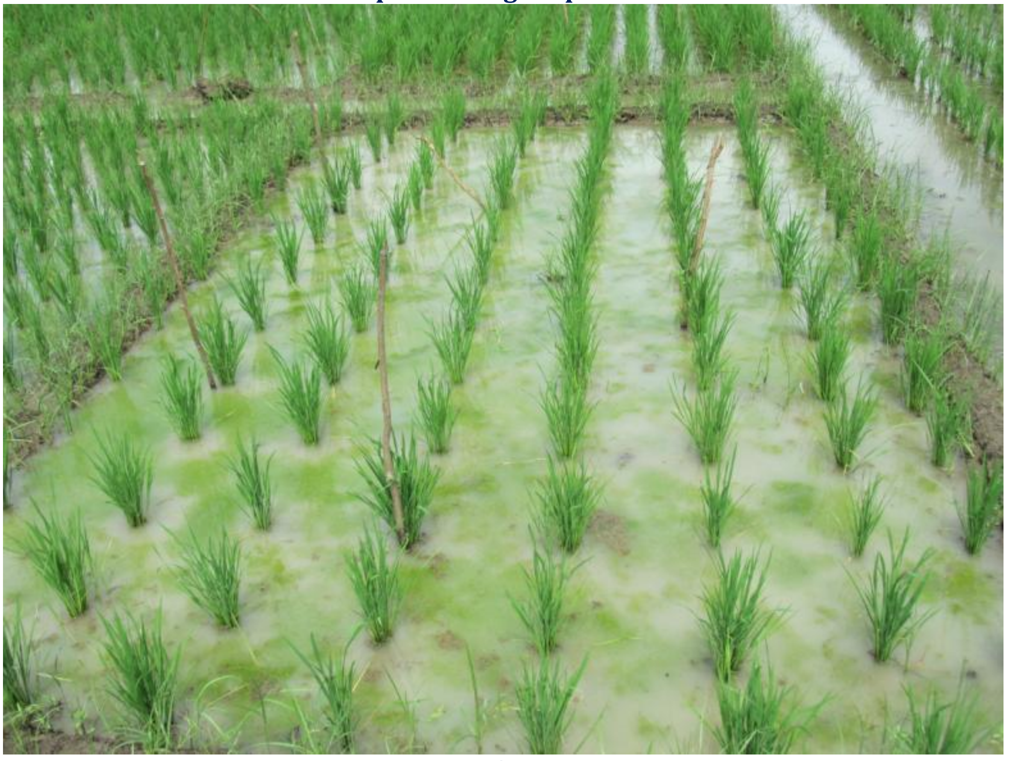

Plate 2. Vigour's growth of wet spot seeded seedlings