PLANT GROWTH AND PHYSIOLOGICAL DYNAMICS OF WET SPOT SEEDED RICE (*Oryza sativa* L.) AS INFLUENCED BY AGROFORESTRY BASED GREEN LEAF MANURES

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Abstract: Field experiments were conducted at Annamalai University Experimental Farm, Department of Agronomy, Annamalai University, Annamalai Nagar during Thaladi and Navarai seasons, to optimize the agronomic strategies for plant growth dynamics of wet spot seeded rice in the coastal agroecosystem of Northern Tamil Nadu. The treatments comprised of four agroforestry tree green leaf manure integrated with N management *viz*., T_1: control (RDN), T_2 - 50 per cent N *via*., *Pongamia pinnata* and 50 per cent N *via*., inorganic fertilizer, T_3: 50 per cent N *via*., *Albizia lebbeck* and 50 per cent N *via*., inorganic fertilizer and T_4: 50 per cent N *via*., *Azadirachta indica* and 50 per cent N *via*., inorganic fertilizer. Discernible variations in growth parameters of rice due to integrated N management were found in both the seasons over control. Integrated application of 50 per cent N *via*., *Albizia lebbeck* and remaining 50 per cent N *via*., inorganic fertilizer recorded significantly highest average plant height (98.78 cm), tiller number (391.19 m^{-2}), root length (24.10 cm), root volume (20.57 cc), LAI (4.8), CGR (11.58 mg m^{-2} day $^{-1}$) and DMP (9921 kg ha^{-1}).

Index terms: Agroforestry, coastal agriculture, green leaf manuring, multipurpose tree species

1. INTRODUCTION

Rice (*Oryza sativa* L.) being one of the staple food for more than half of the world's population which represents 27 per cent of the dietary energy supply and 20 per cent of the protein intake of developing nations. Asia accounts 90 per cent of world's rice growing area and production, which contributes about 70 per cent of the calorie supply and about 30 per cent of the total protein requirement of the people. Rice cultivation occupies a predominant position in Indian economy and sustainability of rural livelihoods for a long time. Among the rice growing countries in the world, India has the largest area under rice (44.5 m ha) and ranks second in rice production (165.3 mt) which contributing to more than 45 per cent of total food grains production in the country (Annon, 2017). In Tamil Nadu, rice is cultivated in an area of 1.84 m ha with a production of 5.66 m t. The average rice productivity in India and Tamil Nadu is 2.1 and 3.4 t ha^{-1}, respectively as against 6.1 and 3.7 t ha^{-1} in China and the world productivity, respectively.

The green revolution was successful for making our country to self-sufficient in food grain production. However, recent population growth rate and current trends in productivity of food grains, natural and anthropogenic constraints generate a fear among the scientific community that the country may not be in a position to feed India's future projected citizens of 1.6 billion by 2050 AD (Siddiq, 2000). Thus greater emphasis has to be given to bridging the gap between average existing (< 3.5 t ha^{-1}) and potential productivity (13.5 t ha^{-1}) of rice. It makes call for sustained productivity from the limited land and water resources, which is further, thwarted by the multiplicity of resource degradation problems.

Degraded soils especially saline and poorly drained together with climatic adversities and acute shortage of good quality irrigation water contribute to the poor livelihood security and low rice productivity in the coastal tracts (Rex Immanuel, 2008). Moreover, Uncertainty of rainfall coupled with long dry spell, seasonality of labour demand and the seasonal migratory nature of the labour market are increasingly becoming a serious concern for the timely transplanting of rice (Ladha *et al*., 2003).

Growing wet seeded rice instead of the conventional puddled transplanted rice is one of the ways to increase the rice productivity under resource constraint situation. Wet seeding involves sowing of pre-germinated seeds in saturated puddled soils. Wet seeding rice eludes the cost and labour requirement for nursery and transplanting of seedlings, which works about 25 to 30 per cent and requires 27 per cent less water to complete land preparation than transplanting. Additionally, it saves the time required for nursery and field duration by around 10 days (Bhuiyan *et al.*, 1995). In this context, improved agronomic strategies are the only way to sustain the rice productivity in resource constraint coastal regions.

Fertilizer N plays a key role in increasing the yield of rice and the response of rice to nitrogen is universal. Rice productivity is at stagnant situation or declining in areas where N-fertilizer application is very high; it has also raised the concerns about sustainability, efficiency of applied N and soil N in monoculture rice (Jeyabal and Kuppuswamy, 2001). The basal N application is less efficient and mismatch for the low N requirement of young plants; the practice of suspending irrigation 10–20 DAS to hasten seedling survival and to stabilize soil may trigger high N loss; and an early high-N supply through basal application also give more chance for weeds to compete with rice. To increase the N use efficiency as well as to keep the soil productivity intact and to certain extent reduce the quantity of N fertilizer used, integrated nutrient management concept has come into existence (Raju and Reddy, 2000).

Agroforestry based multipurpose tree species (MPT's) such as *Azadirachta indica*, *Albizia lebbeck, Lannea grandis*, *Leucaena leucocephala*, *Pongamia pinnata*, are being well fitted in agro-ecosystems of the Northern coastal Tamil Nadu (Rex Immanuel, 2008). They are relatively fast-growing, widely adaptable species and produce larger amount of biomass with in a shorter period. With this background, field experiments were conducted to optimize the agronomic N strategies for enhancing plant growth and physiological dynamics of wet spot-seeded rice in the coastal agroecosystem of Northern Tamil Nadu.

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. The mean annual rainfall of the experimental farm is 1,500 mm distributed over 60 rainy days. Out of the total rainfall, 1,000 mm is received during North-East monsoon, 400 mm during South-West monsoon 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 350 – 550 mm year^{-1}. The maximum temperature ranged from 28.0 to 43.0° C with a mean of 33.0° C while the minimum temperature ranged from 18.5 to 27.5° C with a mean of 23.0° 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.

According to FAO/UNESOC (1974) the soil of the experimental farm is taxonomically classified as Udic Chromustert (clay). The soil is deep, moderately saline, low in organic carbon (0.23 %) and available nitrogen (227 kg ha^{-1}), medium in available phosphorus (17 kg ha^{-1}) and high in available potassium (346 kg ha^{-1}).

The experiments were laid out in Randomized Block Design (RBD) with four replications. The experiment consisted of four treatments *viz*., integrated management of N by using agroforestry based green leaf manures *viz*., T_1: control (RDN), T_2 - 50 % N *via*., *Pongamia pinnata* and 50 % N *via*., inorganic fertilizer, T_3: 50 % N *via*., *Albizia lebbeck* and 50 % N *via*., inorganic fertilizer and T_4: 50 % N *via*., *Azadirachta indica* and 50 % N *via*., inorganic fertilizer. The green leaf manure was obtained from the trees grown on field bunds, the average nutrient content of green leaf manures are furnished in Table 1 and incorporated in the experimental plots as per the treatment schedule before 15 days of puddling.

Table 1 C: N ratio and nutrient content of GLM (%) on fresh weight basis

Green leaf manure	C: N ratio	N	P_2O_5	K_2O
Azadirachta indica	12.6	0.68	0.15	0.31
Albizia lebbeck	11.8	0.74	0.12	0.46
Pongamia pinnata	13.2	0.59	0.09	0.38

The rice variety CO 43 (medium duration) was used as test variety. Sprouted seeds were carefully spot sowed @ 3 seeds per hole in the field with a thin film of standing water by adopting 25 x 25 cm spacing. As per the Tamil Nadu state government fertilizer recommendation formedium duration crop – 150 : 50 : 50 N, P_2O_5 and K_2O kg ha^{-1}, respectively were applied in the form of urea (46% N), single super phosphate (16% P_2O_5)and muriate of potash (60% K_2O). Need based plant protection measures were carried out based on the economic threshold level of insect pests and diseases.

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 were selected at random in the 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 and expressed as kg ha^{-1}.

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 as out lined by Palaniswamy and Gomez (1974) and Crop Growth Rate (CGR) during the growth period was calculated by the method 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).

3. RESULTS AND DISCUSSION

3.1 Growth Characters

All the sources of green leaf manure exerted significant influence on plant height. The maximum plant height of 99.11 cm for Thaladi and 97.73 cm for Navarai seasons were observed in 50 per cent N *via., Albizia lebbeck* along with 50 per cent N *via.*, inorganic fertilizer (T_3) treatment. The application of nitrogen, an essential element for plant growth as an organic (50% N *via.*, *Albizia lebbeck* GLM) and inorganic form (50% N at three splits through urea) could ascribed to the higher urea hydrolysis which might have released more NH_4-N into soil solution and this combination continuously increased the availability of nutrients in balanced form throughout the crop growth period in the rhizosphere for efficient utilization of available and applied nutrient which in turn higher plant height. In rice, increased plant height due to green leaf manure and split application of nitrogen was reported by Mishra *et al.* (2005), Selvi and Kalpana (2009) and Coumaravel *et al.* (2012).

Table 2 Growth characters of rice as influenced by green leaf manures and inorganic nitrogen fertilizer

Treatments	Plant height (cm)			Number of tillers (m^{-2})			Dry mater production (kg ha^{-2})		
	Thaladi	Navarai	Mean	Thaladi	Navarai	Mean	Thaladi	Navarai	Mean
T_1	78.33	75.95	77.14	269.56	250.77	260.17	5739	4474	5107
T_2	95.81	94.85	95.33	391.71	356.49	374.10	10047	8810	9429

T_3	99.37	98.19	98.78	407.44	374.94	391.19	10589	9252	9921
T_4	92.84	91.01	91.93	372.90	338.80	355.85	9398	8035	8717
S.Ed	1.43	1.51	1.45	5.80	5.61	6.60	269	191	218
C.D (0.05)	2.88	3.02	3.15	11.62	11.25	13.50	538	385	449

The number of tillers m^{-2} at maximum tillering stage was significantly influenced by integrated use of different sources of green leaf manure and inorganic N. Among the combination of green leaf manuring and inorganic N treatments, the treatment T_3 (50% N *via.*, *Albizia lebbeck* and 50 % N *via.*, inorganic fertilizer) recorded the maximum tillers number of 407.44 m^{-2} and 374.94 m^{-2} at maximum tillering stage during Thaladi and Navarai season, respectively. Organic sources of plant nutrient offer more balanced nutrition to the plants, which has caused better affectivity of tiller in plants grown with green leaf manures.

Dry matter production enhancement is the ultimate goal of application of any inputs in crop because it is directly related to the yield. Among the different treatment combinations, a consistently superior difference was observed in the treatment T_3 (50% N *via.*, *Albizia lebbeck* and 50 % N *via.*, inorganic fertilizer) which registered the maximum DMP of 10589 and 9252 kg ha^{-1} during Thaladi and Navarai seasons, respectively.

3.2 Root Characters

With regard to integrated N management, maximum root length of 24.82 and 23.37cm and root volume of 17.72cc and 20.07 cc during Thaladi and Navarai, seasons respectively were observed in 50 per cent N *via.*, *Albizia lebbeck* along with 50 per cent N *via.*, inorganic fertilizer (T_3). In wet land agroecosystem, gradual and steady decomposition of GLM released organic acids and CO_2 that increase the solubility of Ca-P compounds such as octa-calcium phosphate, tri-calcium phosphate, hydroxyapatite and fluorapatite by complexing Ca^{2+} ions and thereby disturbing the solubility equilibrium of Ca-P (Kaleeswari *et al*., 2007). It favoured for enhancing the root growth as well as root volume of rice plant.

3.3 Physiological Characters

The difference in LAI and CGR due to the integrated addition of green leaf manure and inorganic N was significant. The highest LAI values were observed in 50 per cent N *via*., *Albizia lebbeck* along with 50 per cent N *via*., inorganic fertilizer (T_3) which registered 5.25 and 4.35 during Thaladi and Navarai seasons, respectively. Higher CGR value was observed in T_3 treatment (50 % N *via*., *Albizia lebbeck* and 50 % N *via*., inorganic fertilizer) which recorded a value of 12.01 and 11.15 mg m^{-2} day^{-1} during Thaladi and Navarai seasons, respectively. The green leaf manure along with split application of inorganic nitrogen maintained optimum N content in the leaf, enhanced tiller survival and continuously supply of the other macro and micronutrients which, promote the leaf growth in terms of higher leaf number, width and length which in turn greater photosynthate accumulation leading to higher LAI and CGR. Increased LAI due to combined application of GLM and inorganic nutrients were also reported by Mishra *et al*. (2005) and Kaushal *et al*. (2011).

Table 3 Root characters of rice as influenced by green leaf manures and inorganic nitrogen fertilizer

Treatments	Root length (cm)			Root volume (cc)		
	Thaladi	Navarai	Mean	Thaladi	Navarai	Mean
T_1	13.33	13.60	13.47	14.29	12.72	13.51
T_2	22.87	21.82	22.35	19.81	18.89	19.35
T_3	24.82	23.37	24.10	21.06	20.07	20.57
T_4	21.89	20.74	21.32	18.96	17.86	18.41
S.Ed	0.93	0.51	0.75	0.36	0.47	0.55
C.D (0.05)	1.86	1.02	1.52	0.72	0.96	1.15

Table 4 Physiological parameters of rice as influenced by green leaf manures and inorganic nitrogen fertilizer

Treatments	Leaf area index (LAI)			Crop growth rate (mg m^{-2} day^{-1})		
	Thaladi	Navarai	Mean	Thaladi	Navarai	Mean
T_1	3.71	3.12	3.42	7.66	6.62	7.14
T_2	5.06	4.17	4.62	11.35	10.40	10.88
T_3	5.25	4.35	4.80	12.01	11.15	11.58
T_4	4.92	3.90	4.41	10.76	9.66	10.21
S.Ed	0.05	0.07	0.07	0.28	0.31	0.27
C.D (0.05)	0.11	0.15	0.16	0.56	0.63	0.58

4. CONCLUSION

From the present study it was revealed that organic manures have significant influence on the growth pattern of direct wet spot seeded rice. Organic manure can be a better supplement of inorganic fertilizer to achieve better growth. In view of the above comparative growth advantages, it could be concluded that application of 50 per cent of nitrogen through *Albizia lebbeck* green leaf manure and 50 per cent of nitrogen through inorganic fertilizer pave way for higher growth and physiological attributes of wet spot seeded of rice in the Northern coastal agroecosystem Tamil Nadu.

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