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Study on Physiological and Yield attributing characters in system of rice intensification and normal Transplantation under integrated nutrient management

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ABSTRACT

An investigation entitled "Study on physiological and yield attributing characters in system of rice intensification and normal transplantation under integrated nutrient management" at Indian Institute of Rice Research farm located at ICRISAT, Patancheru, Hyderabad. The experimental study was laid in split – plot design with three replications with an objective to find out the effect of different methods of cultivation on physico-morphological characters. The main treatments consisting of two methods of cultivation i.e., System of Rice Intensification (SRI) and Normal Traditional Planting (NTP) and sub treatments consisting of four different nutrient management including Complete organic, 25 % organic + 75% inorganic, 100 % inorganic and control. Altogether there were four treatments which are replicated thrice.Results indicated significant differences in physiological yield attributing characteristics, viz., leaf area duration, SPAD chlorophyll meter reading, panicle length, panicle weight, spikelet/panicle and yield under system of rice intensification (SRI). Data on physiological and yield attributing parameters were collected from 15 days intervals. Physiological, yield attributing parameters were significantly higher in SRI than NTP. This is due to under SRI, early planting of young seedlings at one seedling per hill under wider spacing resulted in optimum availability of resources particularly light and space for enhancing seedling growth initially in the main field.
Keywords: System of Rice Intensification (SRI), Normal Traditional Planting (NTP), leaf area duration, SPAD chlorophyll meter reading

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INTRODUCTION

Rice (*Oryza sativa L.*) is both a major staple food for much of the world's population. The largest consumer of water in the agricultural sector is rice crop. The standard system for growing rice crop around the world is to flood paddy fields and maintain standing water in the field. This uses a large amount of water because of high water losses through evaporation, seepage and percolation .The challenge for sustainable rice production is to decrease the amount of water used while maintaining or increasing grain yields to meet the demands of an ever-growing population by improving water use efficiency. Water is much reduced during the vegetative growth phase and only a minimum of water is kept on the field during the reproductive phase.

Among the factors limiting production, water is the most constraint factor in grain production. The key physiological principle behind the SRI method is to provide optimal growing conditions to individual rice plants. So that, tillering is maximized and phyllocrons are shortened and higher number of phyllocrons in the main field is seen which is believed to accelerate growth rates and reduced mortality. Further, more intermittent irrigation is believed to improve oxygen supply to rice roots there by decrease aerenchyma formation. SRI method does not require continuous flooding. Irrigation is given to maintain soil moisture near saturation initially and water is let in when surface soil develops hairline cracks. Modern methods of rice cultivation utilize 3000-5000 litre of water to produce one kilogram of rice. System of Rice Intensification saves water by 30-40 per cent due to its alternate wetting and drying system.

Integrated Nutrient Management refers to the maintenance of soil fertility and supply of plant nutrients at an optimum level through optimization of the benefits from all possible sources of organic, inorganic and biological components in an integrated manner. Organic manures/vermi compost are recommended in SRI cultivation as they give better response and improve soil health. The seedlings with 2-3 leaves stage have great potential for profuse tillering and root development. It results to achieve maximum yield potential of varieties/hybrids. Application of FYM / compost (10-12 tons/ ha) before ploughing and incorporation of *in situ* grown 45-60 days old green manures crops are beneficial. SRI methods have been reported now in almost 50 countries to give higher yield than is achieved with usual rice-growing practices .The SRI was recently introduced into India and slowly gaining momentum since 2003.

MATERIAL AND METHODS

Location of the Experimental site

The present investigation entitled "Study on physiological and yield attributing characters in system of rice intensification and normal transplantation under integrated nutrient management" was conducted during the *kharif* season, 2015 at Indian Institute of Rice Research farm at ICRISAT, Patancheruv, Hyderabad. The experiment was laid out in a split plot design with main plots consisting of two methods of cultivation *i.e.,* System of rice intensification (SRI) and normal traditional cultivation (NTP) and sub plots comprising of four treatments. The treatments were replicated three times.

I. Main plots: 2

i. System of rice intensification (SRI)

ii. Normal traditional cultivation (NTP)

II. Sub plot treatments: 4

T_1 -Complete organic

T_2 – Control

T_3 - 25 % organic + 75% inorganic

T_4 – 100 % inorganic

With the above, the experiment consisted of the following treatment combinations.

III. Variety: Varadhan

IV. Treatment table

Plot size and spacing

Plot size: 90 x 25 m

Spacing: SRI: 25 cm x 25 cm

NTP: 30 cm x10 cm

Nursery bed preparation for SRI method: Puddling of the field was done similar to traditional nursery bed preparation and then raised (about 10 cm) bed of 1.0 m width and 3.0 m length was prepared. Around the bed, 50 cm drainage cum irrigation channels was prepared. On this nursery bed soil and well decomposed FYM (1:1) mixture was spread to 4 - 5 cm thickness. Nursery bed was prepared one day before sowing seed.

Seeds and Sowing: Seeds of cultivar varadhan were soaked for 12 hours and incubated in moist gunny cloth bag for 24 hours. The sprouted seeds were broadcasted uniformly and sparsely on nursery bed. Seed rate adopted was 5 kg for 100 m2 area of nursery bed which is sufficient totransplant one hectare of main field. After broadcasting the sprouted seed, 1:1 soil-FYM mixture was spread again in a thin layer of 1-2 cm. Over the seed bed net was spread to prevent the seed from direct exposure to birds and other loses etc.

Nursery bed preparation for NTP method: Puddling of field was done and a bed of 1.0 m width and 3.0 m length was prepared. Around the bed, 50 cm drainage cum irrigation channels was prepared. Recommended dose of fertilizer was applied. Nursery bed was prepared one day before sowing.

Transplanting:

SRI: Twelve days old seedlings were up rooted from the nursery bed carefully and transplanted in the main field (saturated puddle) with no standing water. Nursery bed was thoroughly irrigated before lifting the seedlings. Seedlings were not pulled from the nursery; rather they were lifted from the nursery bed along with the soil, intact seed sac and roots. The lifted seedlings were transported from nursery bed to main field in plastic trays and separated carefully to avoid any damage to roots. The separated seedlings were immediately transplanted at shallow depth in the main field with gentle placement but not with harsh pushing. At each hill, only one seedling was transplanted at a spacing of 20 cm x 15 cm using marked ropes to achieve square planting.

NTP: Twenty one day old seedlings were taken from nursery bed and transplanted in the main field with no standing water. Nursery bed was thoroughly irrigated before lifting the seedlings. The lifted seedlings were transported from nursery bed to main field in plastic trays.These seedlings were transplanted in to main field at a spacing of 30 cm x 10 cm. 3-4 seedlings were transplanted per each hill.

B. Physiological parameters:

1. Leaf area duration (cm^2 days):

$$LAD = (LA_2 + LA_1)(t_2 - t_1) \times 1/2$$

2. Measurement of chlorophyll content (SCMR Values): The SPAD-502 (Soil plant analytical development) meter was used for measuring the relative chlorophyll content of leaves. The chlorophyll content was measured for recent fully expanded leaves. Mean of the five values from five hills was obtained. This meter enables obtaining instant readings without destroying the plant tissue.

C) Yield characteristics:

1. Panicle weight (g): The weight of randomly selected ten panicles were counted, averaged and recorded as grain weight per panicle and expressed in grams.

2. Panicle length (cm): Ten panicles were randomly selected and length of each panicle was measured from base of the primary rachis to the top most spikelet. The mean length of panicle was averaged and expressed in centimeters.

3. No. of spikelets /panicle: : The total number of spikelets per panicle were counted, averaged and recorded for randomly selected panicles and expressed as number per panicle.

4. Test weight (1000 grain weight) : Thousand filled grains were counted from each plot and their weight was expressed in grams

5. Grain Yield (kg/ ha) : Grain from net plot area was thoroughly sun dried and weighed and then yield per hectare was determined based on net plot area.

RESULTS AND DISCUSSION

Physiological parameters: These parameters are related to physiological processes like SPAD chlorophyll meter reading, leaf area duration etc.

Yield and yield attributes: These parameters are related to yield which are contributed to increase output.

Physiological parameters

Leaf area duration (LAD) (cm^2 day^{-1})

The data pertaining to leaf area duration at 30, 45, 60, 75 and 90 DAT as influenced by methods of crop establishment and different nutrient management practices are presented in Table 1 and Figure 1. Leaf area duration increased from 30 DAT to 75 DAT later, there was decreasing trend was observed at 90 DAT in both the methods of cultivation for all treatments.

In methods of crop establishment, SRI showed significantly higher mean leaf area duration at all the crop growth stages for all treatments compared to NTP. Higher mean leaf area duration (cm^2 day^{-1}) was observed at 75 DAT in SRI (164.28) and NTP (48.62).

Among the nutrient management practices, T_3 recorded higher leaf area duration (cm^2 day^{-1}) at 75 DAT (162.35) followed by T_4 (158.95). T_2 was recorded lower leaf area duration (cm^2 day^{-1}) at 75 DAT (149.03).

Interaction effect between methods of crop establishment and nutrient management showed significant on leaf area duration at all the stages of crop growth. Highest LAD of 169.23 cm^2 day^{-1} was recorded with T_3 in SRI while lowest in T_2 with NTP (140.92 cm^2 day^{-1}).

The reason for higher leaf area per plant in SRI might be due to more production of tillers per plant and wider spacing below and above ground leading to more leaf number in turn increases leaf area per plant. Increase in leaf area increases leaf area duration and photosynthetic area, which helps in production of higher yields. The results are in agreement with the findings of Nayak*et al*. (1998), Singh and Zaman (1998), Sarath and Thilak (2004) and Thakur (2010) . The high yield of super hybrid rice mostly was due to the products of photosynthesis after heading, which is shown by the increased CGR at middle and later stages. Higher leaf area duration may have higher grain yield (Ludlow and Munchow, 1990 and Ashraf *et al*., 1992).

SPAD Chlorophyll Meter Readings (SCMR)

The data on SCMR as influenced by method of crop establishment and various nutrient management at 45, 60, 75, 90 and 105 DAT presented in Table 2 and Figure 2. SCMR was recorded at 15 days interval. Chlorophyll content was increased from 30 DAT to 90 DAT in all the treatments. Later, there was decrease trend was observed in chlorophyll content from 90 DAT to 105 DAT in both the methods of cultivation and for all treatments.

In methods of crop establishment, SRI showed significantly higher chlorophyll content at all the crop growth stages in all treatments compared to NTP. Mean higher chlorophyll content was recorded at 90 DAT in SRI (41.77) and NTP (40.16). SRI recorded 4% of SCMR values higher than NTP.

Among the nutrient management practices, T_3 recorded higher chlorophyll content in SRI at 90 DAT (41.77) followed by T_4 (40.01).Lowerchlorophyll content was recorded under T_2 (control).

Interaction effect of methods of crop establishment and nutrient management was significant in chlorophyll content at all growth stages from 30 DAT to till harvest. Highest SCMR of 41.77 was recorded with T_3 in SRI while lowest in T_2 with NTP (36.23).

The chlorophyll content was slightly increased with time and then after decreased. Similar results were reported by Thakur *et al.* 2015. The chlorophyll content of the flag leaves and third leaves decreased with ripening, the rate of decrease is different among planting densities and chlorophyll content was higher with wider spacing than with the narrow spacing (Mishra and Salokhe, 2010). Similar results were reported by Thakur *et al.* (2015) that the rate of increase in leaf chlorophyll content and photosynthetic rate due to an incremental change in leaf N concentration which are greater in SRI compared to transplanted flooded rice. All the plants maintained high chlorophyll content from panicle initiation to grain filling, which is more important in determining grain yield (Padmaja Rao*et al.,* 1986 and Ashraf *et al.,* 1993). SPAD chlorophyll meter is a simple diagnostic tool to measure the chlorophyll content of plant leaves. There is a close link between leaf chlorophyll content and leaf nitrogen content. Thus, the chlorophyll meter can be used to assess the leaf nitrogen status at different stages of crops (Kumar *et al*., 2005).

Yield characteristics

Panicle Length (cm)

Results of panicle length as influenced by methods of cultivation and different nutrient management are presented in Table 3.

In methods of crop establishment, SRI recorded significantly more panicle length compared to NTP. Higher mean panicle length was recorded in SRI (25.6 cm) compared to NTP (24.8 cm).

Among the nutrient management practices, T_3 recorded higher panicle length (25.6 cm) followed by T_4 (25.3 cm). Lower panicle length was observed in T_2 (24.7 cm) which was significantly inferior to all other treatments.

Interaction effect between methods of crop establishment and nutrient management was non-significant for panicle length. However highest panicle length of 25.9 cm was recorded with T_3 in SRI while lowest in T_2 with NTP (24.3 cm).

Avil Kumar *et al.* (2006) reported that higher number of panicles m^{-2} (8-17 per cent), panicle length (8-11 per cent) in SRI over conventional transplanting. Similar results were reported by Subramaniam Gopalakrishnan*et al.* (2013) that the panicle length was significantly higher with the SRI-organic + inorganic treatments over BMP (Currently recommended best management practices). Thakur *et al.* (2010) observed that significant improvement in the performance of individual hills under wider spacing in terms of panicle length.

Panicle weight (g)

The observations on panicle weight as influenced by methods of crop establishment and nutrient management (Table 3).

In both the methods of cultivation, SRI recorded significantly more panicle weight compared to NTP. Maximum mean panicle weight was observed in SRI (5.45 g) on NTP (4.90 g).

Among all the nutrient management practices, T_3 recorded higher panicle weight (5.48 g) followed by T_4 (5.20 g). Lower panicle weight was recorded in T_2 (4.92 g).

Interaction effect between methods of crop establishment and nutrient management was significant for panicle weight. Highest panicle weight of 5.77 g was recorded with T_3 in SRI while lowest in T_2 with NTP (4.61 g).

Thakur *et al.* (2014) reported that plants grown in SRI method had 32% longer panicles containing more grains, with significantly higher grain filling increased grain weight compared to plants grown with CTS methods. The higher grain yields in all varieties under SRI compared to traditional method of cultivation. This is mainly due to higher panicle weight and more number of filled grains per panicle as compared to traditional method of cultivation (Anjani Devi, 2007). SRI recorded the highest grain yield as compared to conventional practice of transplanting due to more number of panicles per m^2 and panicle weight (Ajay Kumar *et al.,* 2007).

Number of spikelets per panicle

Methods of crop establishment, nutrient management practices as well as interaction effect was found significant on spikelets per panicle and shown in Table Table 4.

In the methods of crop establishment, SRI recorded significantly more number of spikelets per panicle compared to NTP. Maximum mean number of spikelets per panicle was recorded in SRI (12) and NTP (10).

Among the nutrient management practices, T_3 recorded higher number of spikelets per panicle 12 followed by T_4 (11). Lower number of spikelets per panicle was found in T_2 (9). T_3 recorded 25% higher spikelets than T_2.

Interaction effect of methods of crop establishment and nutrient management was non-significant in the production of number of spikelets per panicle. Highest spikelet per panicle of 13 was recorded with T_3 in SRI while lowest in T_2 with NTP (8).

Norman Uphoff*et al.* (2015) found that improved growth and functioning of roots and shoots under SRI management contributed directly to larger SRI panicles (more spikelets per panicle). Amod Kumar Thakur *et al.* (2013) found that yield components like spikelet number per panicle and per cent of filled spikelets were also significantly greater with SRI methods by 27.8% and 9.7%, respectively, compared to TFR (transplanted flooded rice). Higher CGR can sustain an increase in spikelet numbers by controlling their degeneration together with high dry matter production which will contribute to boosting yield potential (Takai *et al*., 2006).

Grain yield (tons ha^{-1})

Methods of crop establishment, nutrient management practices as well as interaction effect was found significant on grain yield are presented in Table 4 and Figure 3.

SRI method gave significantly higher grain yield of 5.76 tons ha^{-1} as compared to NTP (5.09 tons ha^{-1}). SRI obtained 11% higher grain yield than NTP.

Among the nutrient management practices, T_3 recorded higher grain yield (6.01 tons ha^{-1}) followed by T_4 (5.87 tons ha^{-1}). Lower grain yield was recorded by T_2 (4.14 tons ha^{-1}) over other treatments.

Interaction effect of methods of crop establishment and nutrient management was significant and highest grain yield of 6.43 tons ha^{-1}was recorded with T_3 in SRI while lowest in T_2 with NTP (3.93 tons ha^{-1}).

Dinesh Kumar *et al.* (2006) reported maximum grain yield with 50 per cent compost + 50 per cent NPK source, which was on par with 50 per cent FYM + 50 per cent NPK produced significantly higher grain yield over FYM or compost or NPK fertilizer alone. Mandal and Pramanick (2015) found that higher grain yield was observed by planting younger seedlings under SRI than by planting older seedlings under submergence (conventional). Thakur *et al.* (2015) stated that percentage increases in grain yield from the S-RF (Rainfed SRI), S-IRR (SRI rice with supplemental irrigation from groundwater) and S-INT (SRI rice with supplemental irrigation from stored run-off water) treatments over the conventional method. It was further noted that a 52% yield enhancement in S-RF compared to C-RF (Conventional rainfed rice) was due to differences in the method of rice cultivation, notably as a result of using younger seedlings and greatly reduced plant density. This resulted in significant improvements in morpho-physiological characteristics and in yield-contributing characteristics. SRI practices -on average across the different N-treatments enhanced grain yield by 49 %. This was a significant increase in comparison to conventionally grown flooded rice.

Similar results were reported by Thakur *et al.* (2014) throughout all the water management treatments, significantly higher grain per unit quantity of water applied was produced under SRI as compared to CTS. This means that SRI rice plants were 75 % more efficient in utilizing water for grain production. SRI produced 49% higher grain yield compared with CTS (common transplanted system). Yield enhancement under SRI practice can be attributed by better plant phenotypes (vigorous root growth and tillering) and to enhanced physiological performance of the individual hills in terms of maintaining a greater xylem exudation rate and higher leaf photosynthetic rate during the grain-filling stage of crop growth.

Table 1: Effect of SRI and NTP methods of cultivation and fertilizer levels on Leaf Area Duration (cm^{2}d^{-1}) in rice

Treatments	Days after transplantation (DAT)														
	30			45			60			75			90		
	SRI	NTP	Mean	SRI	NTP	Mean	SRI	NTP	Mean	SRI	NTP	Mean	SRI	NTP	Mean
T1	117.21	101.77	109.49	132.86	116.63	124.75	149.03	132.68	140.86	164.32	146.63	155.48	157.69	139.23	148.46
T2	111.66	96.94	104.30	125.53	111.63	118.58	142.23	127.36	134.80	157.13	140.92	149.03	151.06	132.07	141.57
T3	121.38	109.62	115.50	138.32	124.92	131.62	155.16	141.71	148.44	169.23	155.46	162.35	163.93	141.79	152.86
T4	119.71	105.36	112.54	135.41	120.31	127.86	151.43	136.36	143.90	166.42	151.48	158.95	159.31	137.76	148.54
Mean	117.49	103.42	110.46	133.03	118.37	125.70	149.46	134.53	142.00	164.28	148.62	156.45	158.00	137.71	147.86
	SEm±	CD		SEm±	CD		SEm±	CD		SEm±	CD		SEm±	CD	
M	0.45	2.79		0.47	2.91		0.48	2.96		0.51	3.11		0.66	4.02	
T	0.15	0.48		0.18	0.55		0.18	0.57		0.18	0.58		0.15	0.47	
MiTi-MiTj	0.22	0.69		0.25	0.79		0.26	0.81		0.26	0.82		0.21	0.67	
MiTi-MjTi	0.49	2.80		0.52	2.93		0.53	2.98		0.56	3.12		0.68	4.02	

M=Main plots T= Treatments CD=0

Table 2: Effect of SRI and NTP methods of cultivation and fertilizer levels on SPAD chlorophyll meter reading in rice

Treatments	Days after transplantation (DAT)														
	45			60			75			90			105		
	SRI	NTP	Mean	SRI	NTP	Mean	SRI	NTP	Mean	SRI	NTP	Mean	SRI	NTP	Mean
T1	34.13	33.10	33.62	36.10	34.49	35.18	37.12	36.02	36.57	39.63	37.92	38.78	37.91	35.56	36.74
T2	33.83	32.60	33.22	35.19	33.25	34.84	36.12	35.26	35.69	37.32	36.23	36.78	33.92	32.03	32.98
T3	36.47	34.67	35.57	37.05	36.52	36.79	39.43	37.69	38.56	41.77	40.16	40.97	40.53	38.24	39.39
T4	35.40	33.87	34.64	36.42	35.01	35.72	37.39	36.62	37.01	40.01	38.63	39.32	38.63	36.46	37.55
Mean	34.96	33.56	34.26	36.29	35.07	35.68	37.52	36.40	36.96	39.68	38.24	38.96	37.75	35.57	36.66
	SEm±	CD		SEm±	CD		SEm±	CD		SEm±	CD		SEm±	CD	
M	0.02	0.14		0.02	0.11		0.02	0.11		0.02	0.13		0.04	0.22	
T	0.02	0.05		0.01	0.04		0.02	0.06		0.03	0.03		0.04	0.13	
MiTi-MiTj	0.02	0.07		0.02	0.06		0.03	0.09		0.04	0.12		0.06	0.19	
MiTi-MjTi	0.03	0.15		0.02	0.12		0.03	0.12		0.04	0.16		0.06	0.26	

M=Main plots T= Treatments CD=0.05

Table 3: Effect of SRI and NTP methods of cultivation and fertilizer levels on panicle in rice

Treatments	Panicle weight (g)			Panicle length (cm)		
	SRI	NTP	Mean	SRI	NTP	Mean
T1	5.34	4.85	5.10	25.6	24.8	25.2
T2	5.21	4.61	4.92	25.1	24.3	24.7
T3	5.77	5.18	5.48	25.9	25.2	25.6
T4	5.48	4.91	5.20	25.6	25.0	25.3
Mean	5.45	4.90	5.17	25.6	24.8	25.2
	SEm±	CD		SEm±	CD	
M	0.004	0.027		0.13	0.79	
T	0.001	0.005		0.34	NS	
MiTi-MiTj	0.002	0.008		0.48	NS	
MiTi-MjTi	0.005	0.027		0.44	NS	

Table 4: Effect of SRI and NTP methods of cultivation and fertilizer levels on No. of spikelets /panicle and Grain Yield (t/ha) in rice.

Treatments	No. of spikelets /panicle			Grain yield		
	SRI	NTP	Mean	SRI	NTP	Mean
T1	148	136	142	6.03	5.33	5.68
T2	139	128	134	4.35	3.93	4.14
T3	156	144	150	6.43	5.59	6.01
T4	151	140	146	6.23	5.51	5.87
Mean	149	137	143	5.76	5.09	5.42
	SEm±	CD		SEm±	CD	
M	0.41	2.48		0.031	0.19	
T	0.00	NS		0.019	0.06	
MiTi-MiTj	0.00	NS		0.028	0.09	
MiTi-MjTi	0.41	NS		0.039	0.19	

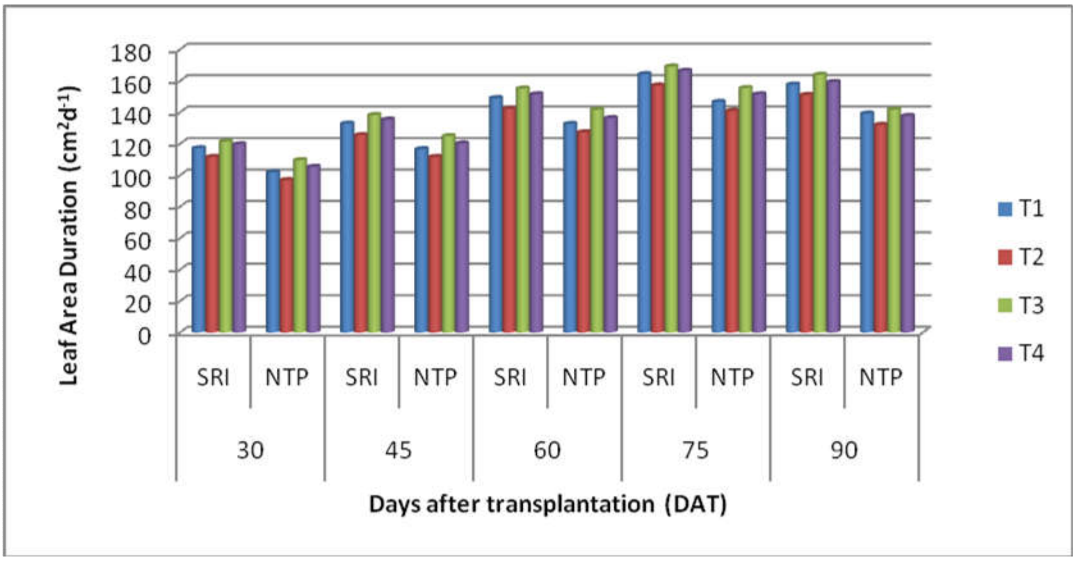

Figure 1 Effect of SRI and NTP methods of cultivation and fertilizer levels on Leaf Area Duration (cm^2d^{-1}) in rice

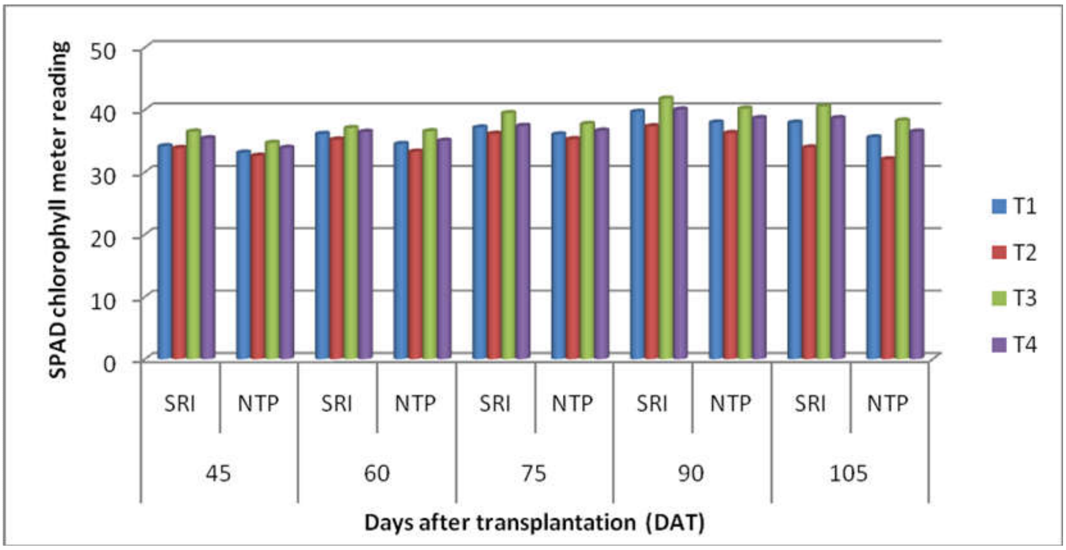

Figure 2 Effect of SRI and NTP methods of cultivation and fertilizer levels on SPAD chlorophyll meter reading in rice

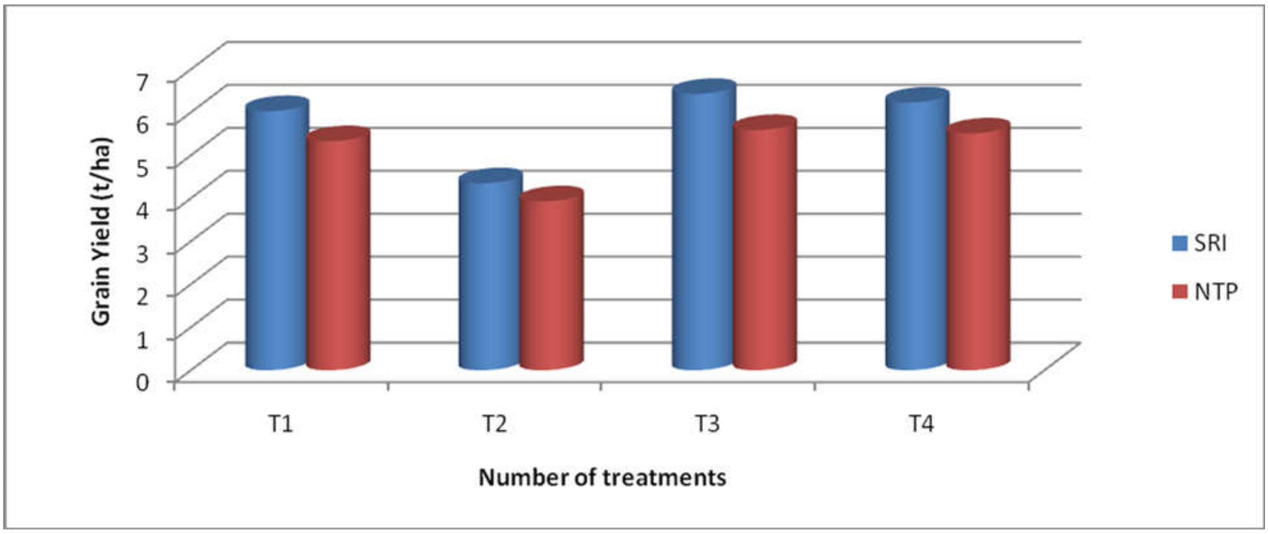

Figure 3 Effect of SRI and NTP methods of cultivation and fertilizer levels on Grain Yield (t/ha) in rice

SUMMARY & CONCLUSIONS

Investigations were undertaken to study on **"Study on physiological and yield attributing characters in system of rice intensification and normal transplantation under integrated nutrient management"** was conducted in *kharif* season during 2015 Directorate of Rice Research farm at ICRISAT, Patancheruv, Hyderabad. The main treatments consisting of two methods of cultivation *i.e.,* System of Rice Intensification (SRI) and Normal Traditional Planting (NTP) and sub treatments consisting of four different nutrient management including Complete organic, 25 % organic + 75% inorganic, 100 % inorganic and control.

- Among the methods of cultivation, the system of rice intensification (SRI) recorded superior in leaf area duration, SPAD chlorophyll meter reading, panicle length, panicle weight, spikelet/panicle, yield compared to normal traditional planting (NTP).
- In SRI, early planting of young seedlings at one seedling per hill under wider spacing resulted in optimum availability of resources particularly light and space for enhancing seedling growth initially in the main field.
- The increase in tiller number with concomitant increase in leaf area per plant contributed for higher leaf area duration, SCMR for assimilate production. Though tiller production recorded higher in SRI compared to NTP, it maintained better and significantly higher productive tillers resulting in higher yields.Chlorophyll content also significantly increased in SRI with time and there after declined compared to NTP. Growth parameters like SCMR and LAD are showed significant improvement in system of rice intensification.
- SRI (System of Rice Intensification) was found to produce significantly higher yield and yield attributes than normal transplantation. In case of physiological and morphological characters also SRI obtained higher yield over conventional practices.

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