

ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
<http://ansijournals.com/ja>

JOURNAL OF AGRONOMY



ANSI*net*

Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

System of Rice Intensification Principles on Growth Parameters, Yield Attributes and Yields of Rice (*Oryza sativa* L.)

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Abstract: The present investigation was undertaken to evaluate System of Rice Intensification (SRI) principles on the growth parameters, yield attributes and yield of rice. System of Rice Intensification (SRI), a method of rice cultivation developed in Madagascar has been found to reduce the water use besides increasing the yield. Four crop management factors viz., seedling age, number of seedlings/hill, weed control and irrigation under SRI (14 days old younger seedlings, one seedling/hill, mechanical weeding with a rotary weeder and shallow irrigation (2.5 cm) were compared with conventional (recommended) cultivation practices viz., 21 days old seedlings, 3 seedlings/hill, weed management with herbicide plus hand weeding and recommended 5 cm irrigation in all possible combinations. Adoption of younger seedling, 3 seedlings/hill, shallow irrigation and weeder use ($T_{14}: P_2S_1I_2W_2$) recorded the highest number of tillers (425 m^{-2}) at tillering stage. Inclusion of one of the SRI factors along with the other conventional factors registered an increase in tiller density. The effect was conspicuous with the use of weeder. The management practices followed in SRI method of cultivation produced significantly more number of panicles m^{-2} and number of grains panicle⁻¹. Inclusion of all the SRI components ($T_{16}: P_2S_1I_2W_2$) was found to increase the yield significantly by 18.6% when compared to conventional practice ($T_1: P_1S_1I_1W_1$).

Key words: Plant height, system of rice intensification, tiller density, yield attributes

INTRODUCTION

Rice accounts for significant contribution to the total food grain production in India. As the rice production area either stabilizes or declines there is a wide gap between projected demand and current levels of production (Vijayakumar *et al.*, 2005). But rice continues to hold the key component for sustainable food production in India. The demand for rice is projected at 128 MT by the year 2012 and will require yield level of 3.0 t ha^{-1} that is significantly greater than present average yield of 1.93 t ha^{-1} (Wanjari *et al.*, 2006). In the state of Tamil Nadu, rice is the major food crop consuming 70% of water available for agriculture. In recent years, the amount of water available for rice production is declining due to the increasing demand for non-agricultural purposes while the uncertainty in water availability increased due to the failure of monsoons as well as the unequal distribution of rainfall during the year. Water shortage in this state has already resulted in the reduction of the irrigated rice area and in a shift towards less water demanding crop

activities. During the past four decades, the rice area declined at a rate of 22, 900 ha year⁻¹ which was compensated for by a yield increase of 82 kg/ha/year (Thiyagarajan *et al.*, 2000). Reducing the amount of water in irrigated rice production has become a global concern and water saving irrigation techniques receives renewed attention (Bouman and Tuong, 2001). The System of Rice Intensification (SRI) developed in Madagascar follows a more comprehensive approach that addresses various management practices at the same time, with promising results (Uphoff, 2001; Stoop *et al.*, 2002). The components of SRI include the use of young seedlings, single seedling per hill, wide spacing of transplanted seedlings, limited irrigation, aerated soil condition by frequent disturbance of the soil and the use of organic manures. As one of the components implies a reduced requirement of water, this system has inspired the search for a complete System of Rice Intensification (SRI) by developing agronomic packages that suit location specific conditions. Evaluation of SRI in Tamil Nadu (Thiyagarajan *et al.*, 2002) with a certain package of crop management showed that it not

only had the benefit of reducing the water requirement for rice cultivation but also increased the productivity.

SRI is not a new method of rice cultivation but comprises certain changes in the existing components of agronomic practices in irrigated and transplanted rice. Instead of 3-4 week old seedlings, younger seedlings, i.e., 14 days or less are used. Instead of multiple seedlings, single seedling/hill is recommended. While the present planting density is 15×10 cm for short duration rice and 20×10 cm for medium and long duration rice, in SRI a wider and square spacing of 20×20 cm is recommended. In view of these changes, the number of seedlings required per unit area gets drastically reduced leading to a very low seed requirement of 7.5 kg ha^{-1} instead of 20 kg ha^{-1} . In actual practice, farmers use a seed rate of $60\text{--}75 \text{ kg ha}^{-1}$. The low seed rate also requires a smaller nursery area of 40 m^2 instead of 800 m^2 for planting 1 ha. Thus, SRI has a distinct advantage in the nursery itself. Wider spacing and square planting provides an opportunity to use a mechanical weeder in between rows in both the directions. The weeder use is not a mere weed control operation only. The disturbance given to the soil by the weeder operation appears to have an influence in creating a better environment for root growth and tillering and having a positive impact in increasing the yield (Thiyagarajan *et al.*, 2005). The water management strategy in SRI revolves around the fact that evapotranspiration rate of rice is similar to other annual crops and the major purpose of keeping flood water is only to control weeds. Though the individual agronomic factors of SRI may have their own effects, the synergistic effect of the components of SRI has a major role in the gains of SRI cultivation (Uphoff, 2002). Previous experiments (Thiyagarajan *et al.*, 2002) had shown the positive influence of the combined effect of the components of SRI (viz., younger seedlings, wider spacing, weeder use and shallow irrigation with alternate wetting and drying) in promoting the growth and yield of rice. In this study, the effect of these individual components in different combination with corresponding conventional practices was studied. With this background, the present investigation was undertaken to evaluate System of Rice Intensification principles on the growth parameters, yield attributes and yield of rice.

MATERIALS AND METHODS

Study area: A field experiment was conducted during November to February, 2005 at the wetlands of Central farm, Agricultural College and Research Institute, Killikulam, Tamil Nadu. The farm is located in the southern zone of Tamil Nadu and is geographically situated

between $8^\circ 46' \text{ N}$ latitude and $77^\circ 42' \text{ E}$ longitude at an altitude of 40 m above mean sea level. The soil was a Typic Ustropept with a sandy clay loam texture (58.4% sand, 32.3% clay and 9.3% silt) belonging to Killikulam series. The soil was neutral in reaction (pH 7.21). The fertility status revealed that the soil was low in available nitrogen (207.2 kg ha^{-1}) medium in available phosphorus (15.1 kg ha^{-1}) and medium in available potassium (198.0 kg ha^{-1}).

Experimental set up: The experiment was set up in a randomized block design with three replications. The treatments included different combinations of four crop management factors viz., seedling age (P), number of seedlings/hill (S), water management (I) and weed management (W) which are components of SRI. For each factor, two methods viz., conventional and SRI were adopted. Thus, there were 16 treatment combinations. The treatments were $T_1\text{--}P_1S_1I_1W_1$: Conventional seedlings (21 days), three seedlings/hill, 5 cm irrigation, herbicide+hand weeding, $T_2\text{--}P_1S_1I_1W_2$: Conventional seedlings (21 days), three seedlings/hill, 5 cm irrigation, mechanical weeding, $T_3\text{--}P_1S_2I_1W_1$: Conventional seedlings (21 days), single seedling/hill, 5 cm irrigation, herbicide+hand weeding, $T_4\text{--}P_1S_2I_1W_2$: Conventional seedlings (21 days), single seedling/hill, 5 cm irrigation, mechanical weeding, $T_5\text{--}P_2S_1I_1W_1$: Young seedlings (14 days), three seedlings/hill, 5 cm irrigation, herbicide+hand weeding, $T_6\text{--}P_2S_1I_1W_2$: Young seedlings (14 days), three seedlings/hill, 5 cm irrigation, mechanical weeding, $T_7\text{--}P_2S_2I_1W_1$: Young seedlings (14 days), single seedling/hill, 5 cm irrigation, herbicide+hand weeding, $T_8\text{--}P_2S_2I_1W_2$: Young seedlings (14 days), single seedling/hill, 5 cm irrigation, mechanical weeding, $T_9\text{--}P_1S_1I_2W_1$: Conventional seedlings (21 days), three seedlings/hill, 2.5 cm irrigation, herbicide+hand weeding, $T_{10}\text{--}P_1S_1I_2W_2$: Conventional seedlings (21 days), three seedlings/hill, 2.5 cm irrigation, mechanical weeding, $T_{11}\text{--}P_1S_2I_2W_1$: Conventional seedlings (21 days), single seedling/hill, 2.5 cm irrigation, herbicide+hand weeding, $T_{12}\text{--}P_1S_2I_2W_2$: Conventional seedlings (21 days), single seedling/hill, 2.5 cm irrigation, mechanical weeding, $T_{13}\text{--}P_2S_1I_2W_1$: Young seedlings (14 days), three seedlings/hill, 2.5 cm irrigation, herbicide+hand weeding, $T_{14}\text{--}P_2S_1I_2W_2$: Young seedlings (14 days), three seedlings/hill, 2.5 cm irrigation, mechanical weeding, $T_{15}\text{--}P_2S_2I_2W_1$: Young seedlings (14 days), single seedling/hill, 2.5 cm irrigation, herbicide+hand weeding, $T_{16}\text{--}P_2S_2I_2W_2$: Young seedlings (14 days), single seedling/hill, 2.5 cm irrigation, mechanical weeding.

Rice culture AD 99110 obtained from Tamil Nadu Rice Research Institute, Aduthurai was used for the study with

a seed rate of 7.5 kg ha^{-1} . The recommended fertilizer dose of $120:38:38 \text{ kg ha}^{-1}$ of N, P_2O_5 and K_2O was adopted in the experiment. The entire dose of P_2O_5 (38 kg ha^{-1}) was applied as single super phosphate before planting as basal dose. Potassium and Nitrogen were applied as muriate of potash and urea in split doses, respectively. Two types of nurseries were raised separately to elucidate information on different systems of establishment of rice crop. For the conventional nursery, the recommended nursery area (20 cents ha^{-1}) was puddled and leveled and treated sprouted seeds (20 kg ha^{-1}) were broadcasted uniformly with a thin film of standing water. The conventional nursery was managed well with irrigation and plant protection measures as per the recommendation. For SRI nursery, the required raised beds at the rate of 20 No. ha^{-1} were formed with the dimension of $5 \times 1 \text{ m}$ with 5 cm height without any undulation using the soil taken from the shallow channel of 30 cm width formed around the beds. Over this, cleaned polythene fertilizer bags were spread and above which puddled soil was applied to the thickness of 4 cm . Well powdered DAP at the rate of 95 g per bed was uniformly applied and mixed with puddled soil. Treated and sprouted seeds were broadcast uniformly in the beds. Seeds were covered with thin layer of sand. The beds were irrigated as and when necessary up to the saturation of the sand layer. For the first three days, the beds were covered with coconut thatches to maintain high humidity for uniform germination of seeds and quicker establishment. The seedlings were maintained in the nursery beds up to the specified days as per the treatment schedule. At the time of transplanting seedling mats were taken in slices to the main field. Depending upon the treatment, conventional (P_1) or younger (P_2) seedlings were planted as three seedlings/hill (S_1) or single seedling/hill (S_2). A common spacing of $20 \times 20 \text{ cm}$ was followed for all the treatments. For the conventional method of cultivation the plots were irrigated to 5 cm depth one day after the disappearance of ponded water (I_1) and for the SRI method the plots were irrigated to 2.5 cm depth after the development of hairline cracks up to panicle initiation stage (I_2). In the SRI method, hand operated rotary weeder was used which resulted in incorporation of weeds with simultaneous stirring up of soil. The weeder was operated between the rows in both the directions four times at 10 day interval from transplanting. Adequate and need based prophylactic measures were taken against insect pests and diseases. The plant height was measured from the base of the plant at tillering, panicle initiation, flowering and harvest stages of crop growth and the mean value expressed in cm . The ear bearing tillers were counted from the area selected for

counting total tillers and expressed as number m^{-2} . The total numbers of filled grains from five randomly selected panicles were counted and the mean values were expressed as number of filled grains/panicle. The panicle length was measured from the point of scar to the tip of the panicle from randomly selected five panicles and the mean value was expressed in cm . One thousand grains from each plot were drawn at random. The samples were oven dried (70°C) weighed and the average was expressed in mg/grain . The harvested produce from each plot was threshed manually and sun dried, winnowed separately and weighed. Moisture content was estimated and the grain yield was adjusted to 14% moisture content as suggested by Yoshida and Parao (1976) and expressed in kg ha^{-1} . Straw from each plot was sun dried and yield was recorded and expressed in kg ha^{-1} .

Statistical analysis: The data obtained from the field experiments, laboratory analysis were analyzed statistically by analysis of variance method for randomized block design (Gomez and Gomez, 1984). Critical differences were worked out at 5% probability level.

RESULTS AND DISCUSSION

Age of seedlings, number of seedlings/hill, irrigation method and weeder use exerted significant influence on plant height at different stages of rice growth. Planting of younger seedling, three seedlings/hill, conventional irrigation and weeder use ($\text{T}_6\text{-P}_2\text{S}_1\text{I}_1\text{W}_2$) resulted in the highest plant height of 54.9 and 77.6 cm at tillering and panicle initiation stages of the crop (Table 1). This was significantly higher by 21.2% than all conventional practices ($\text{T}_1\text{-P}_1\text{S}_1\text{I}_1\text{W}_1$). Migo and Datta (1982) reported that planting of very young seedlings (10 days old) produced taller plants compared to 21 days old seedlings. The result of the present study is in conformity with the above findings. Inclusion of one of the SRI factors along with other conventional factors in general increased the plant height. The effect was conspicuous with the use of weeder (T_2 : $\text{P}_1\text{S}_1\text{I}_1\text{W}_2$) which resulted in 6.3 to 22.5% increase in plant height. Murungu *et al.* (2006) found that early sowing resulted in highest plant height when compared to late sowing. The lowest plant height of 35.4 and 63.8 cm was recorded with the planting of younger seedling, single seedling/hill, shallow irrigation and herbicide+hand weeding treatment ($\text{T}_{15}\text{-P}_2\text{S}_2\text{I}_2\text{W}_1$) at tillering and panicle initiation, respectively. Contrary to the above findings, Gupta (1996) stated that planting four seedlings/hill significantly increased the plant height compared to less number of seedling/hill. Also,

Table 1: Effect of treatments on plant height of rice

Treatment No.	Treatments	Plant height (cm)			
		Tillering stage	Panicle initiation stage	Flowering stage	Harvest stage
T ₁	P ₁ S ₁ I ₁ W ₁	45.30	68.5	83.50	85.20
T ₂	P ₁ S ₁ I ₁ W ₂	45.30	74.0	88.80	86.90
T ₃	P ₁ S ₂ I ₁ W ₁	37.50	67.4	86.90	83.40
T ₄	P ₁ S ₂ I ₁ W ₂	40.80	68.4	87.90	88.10
T ₅	P ₂ S ₁ I ₁ W ₁	45.40	75.1	90.50	84.40
T ₆	P ₂ S ₁ I ₁ W ₂	54.90*	77.6*	88.60	84.50
T ₇	P ₂ S ₂ I ₁ W ₁	37.70	69.4	87.60	82.10
T ₈	P ₂ S ₂ I ₁ W ₂	45.10	71.3	91.70	89.30
T ₉	P ₁ S ₁ I ₂ W ₁	44.00	74.0	92.50	87.40
T ₁₀	P ₁ S ₁ I ₂ W ₂	45.20	74.6	91.60	89.00
T ₁₁	P ₁ S ₂ I ₂ W ₁	37.10	66.8	86.70	83.20
T ₁₂	P ₁ S ₂ I ₂ W ₂	44.70	69.2	89.10	87.70
T ₁₃	P ₂ S ₁ I ₂ W ₁	45.40	74.5	91.20	86.20
T ₁₄	P ₂ S ₁ I ₂ W ₂	47.90	75.9	91.30	89.50
T ₁₅	P ₂ S ₂ I ₂ W ₁	35.40	63.8	88.90	84.70
T ₁₆	P ₂ S ₂ I ₂ W ₂	40.70	72.0	90.30	85.60
CD (p = 0.05)		6.11	4.4	3.17	3.84

P₁: Conventional seedlings (21 days), S₁: 3 seedlings/hill, P₂: Young seedlings (14 days), S₂: Single seedling/hill, I₁: 5 cm irrigation, W₁: Herbicide application, I₂: 2.5 cm irrigation, W₂: Mechanical weeding. *Significant at p = 0.05

Table 2: Effect of treatments on tiller density

Treatment No.	Treatments	Tillers m ⁻²			
		Tillering stage	Panicle initiation stage	Flowering stage	Harvest stage
T ₁	P ₁ S ₁ I ₁ W ₁	383	475	500	457
T ₂	P ₁ S ₁ I ₁ W ₂	346	603	587	516
T ₃	P ₁ S ₂ I ₁ W ₁	213	433	478	438
T ₄	P ₁ S ₂ I ₁ W ₂	254	461	509	480
T ₅	P ₂ S ₁ I ₁ W ₁	362	537	554	502
T ₆	P ₂ S ₁ I ₁ W ₂	416	569	583	529
T ₇	P ₂ S ₂ I ₁ W ₁	296	446	501	441
T ₈	P ₂ S ₂ I ₁ W ₂	260	430	519	469
T ₉	P ₁ S ₁ I ₂ W ₁	316	453	496	464
T ₁₀	P ₁ S ₁ I ₂ W ₂	338	531	558	505
T ₁₁	P ₁ S ₂ I ₂ W ₁	215	403	473	422
T ₁₂	P ₁ S ₂ I ₂ W ₂	243	463	519	473
T ₁₃	P ₂ S ₁ I ₂ W ₁	309	558	574	515
T ₁₄	P ₂ S ₁ I ₂ W ₂	425*	582	597	*552
T ₁₅	P ₂ S ₂ I ₂ W ₁	220	448	488	461
T ₁₆	P ₂ S ₂ I ₂ W ₂	238	470	530	496
CD (p = 0.05)		94.2	70.9	57.8	53.5

P₁: Conventional seedlings (21 days), S₁: 3 seedlings/hill, P₂: Young seedlings (14 days), S₂: Single seedling/hill, I₁: 5 cm irrigation, W₁: Herbicide application, I₂: 2.5 cm irrigation, W₂: Mechanical weeding. *Significant at p = 0.05

Shrirame *et al.* (2000) found that planting of two-seedling/hill recorded significantly higher number of total tillers over single seedling/hill. Boydak *et al.* (2007) reported that highest plant height and seed yield increased when irrigated at six days interval.

Tiller density was significantly influenced by the age of the seedlings, number of seedlings/hill, irrigation and weeder use. Adoption of younger seedling, 3 seedlings/hill, shallow irrigation and weeder use (T₁₄: P₂S₁I₂W₂) recorded the highest number of tillers (425 m⁻²) at tillering stage. At panicle initiation the tiller density ranged from 403 to 603 m⁻² (Table 2). Inclusion of one of the SRI factors along with the other conventional factors registered an increase in tiller density. The effect was conspicuous with the use of weeder (T₂: P₁S₁I₁W₂) recording the maximum number of tillers (603 m⁻²) at

panicle initiation. At flowering stage, younger seedling, three seedlings/hill, shallow irrigation and weeder use (T₁₄: P₂S₁I₂W₂) recorded the highest number of tillers (597 m⁻²). Plant height and tiller density were higher in the treatment involving weeder. The effect of weeder use on increasing the tiller density was also reported by Thiyagarajan *et al.* (2005) and Vijayakumar *et al.* (2005). Adoption of younger seedlings along with weeder use increased the tiller density. The higher tiller density was due to the much greater tillering potential of the square planted young seedling with wider spacing (Uphoff, 2002). The higher root growth and nutrient uptake promoted by weeder use and limited irrigation could have increased the tillering rate under SRI. Planting two-week-old seedlings resulted in maximum number of tillers followed by three-week-old seedlings

Table 3: Effect of treatments on yield attributes and yield of rice

Treatment No.	Treatments	Yield attributes					
		Panicle length (cm)	Filled spikelet panicle ⁻¹	Productive tillers m ⁻²	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	
T ₁	P ₁ S ₁ I ₁ W ₁	18.8	170	415	4065	9234	
T ₂	P ₁ S ₁ I ₂ W ₂	21.7	142	458	4152	8465	
T ₃	P ₁ S ₂ I ₁ W ₁	22.4	161	401	4692	8336	
T ₄	P ₁ S ₂ I ₂ W ₂	21.8	150	440	3872	9516	
T ₅	P ₂ S ₁ I ₁ W ₁	21.7	154	454	4936	8822	
T ₆	P ₂ S ₁ I ₂ W ₂	21.2	194	474	4436	9589	
T ₇	P ₂ S ₂ I ₁ W ₁	22.4	156	406	4613	8561	
T ₈	P ₂ S ₂ I ₂ W ₂	23.7	204	429	5090	8331	
T ₉	P ₁ S ₁ I ₂ W ₁	21.4	141	423	4378	9437	
T ₁₀	P ₁ S ₁ I ₂ W ₂	21.6	154	459	4113	8490	
T ₁₁	P ₁ S ₂ I ₂ W ₁	22.7	192	379	4306	8717	
T ₁₂	P ₁ S ₂ I ₂ W ₂	23.0	193	431	4573	9596	
T ₁₃	P ₂ S ₁ I ₂ W ₁	22.1	169	467	4659	8804	
T ₁₄	P ₂ S ₁ I ₂ W ₂	24.1*	211*	501	4778	9452	
T ₁₅	P ₂ S ₂ I ₂ W ₁	22.8	189	421	5327*	7867	
T ₁₆	P ₂ S ₂ I ₂ W ₂	23.8	194	464	4820	8499	
CD (p = 0.05)		2.88	51.3	46.8	703.9	229.9	

P₁: Conventional seedlings (21 days), S₁: 3 seedlings/hill, P₂: Young seedlings (14 days), S₂: Single seedling/hill, I₁: 5 cm irrigation, W₁: Herbicide application, I₂: 2.5 cm irrigation, W₂: Mechanical weeding. *Significant at p = 0.05

(Das *et al.*, 1988). Use of single seedling/hill in combination with other conventional practices (T₃: P₁S₂I₁W₁) resulted in lower tiller density at all he growth stages of the crop, when compared to the combination of all the SRI factors (T₁₆: P₂S₂I₂W₂). Use of single seedling/hill though resulted in lower number of tillers at tillering stage, increased significantly at flowering stage. But, when younger seedlings were used in three numbers hill⁻¹ the tiller density was higher at tillering stage as could be seen from the results. The result of the present study is in conformity with the above findings. At harvest stage the tiller density ranged from 422 to 552 m⁻². Adoption of younger seedling, three seedlings/hill, shallow irrigation and weeder use (T₁₄: P₂S₁I₂W₂) recorded the maximum number of tillers at harvest (552 m⁻²). Planting of older seedling, single seedling/hill, shallow irrigation and herbicide + hand weeding treatment (T₁₁: P₁S₂I₂W₁) gave the lowest tiller density (403, 473 and 422 m⁻²) at PI, flowering and harvest stages of the crop. Adoption of higher plant density of 80 hills m⁻² registered higher values of growth attributes at all stages of plant growth (Padmajarao, 1995). Early transplanting on 1st June resulted in maximum number of tillers (Khakwani *et al.*, 2006).

Adoption of younger seedling, three seedlings/hill, alternate wetting and drying and weeder use (T₁₄: P₂S₁I₂W₂) recorded the highest panicle length (24.1 cm). The above treatment increased panicle length by 28.2% compared to conventional practices (T₁: P₁S₁I₁W₁). The transplanting of young seedlings in combination with other SRI techniques resulted in three fold increase in the number of panicles hill⁻¹ irrespective of varieties used (Yamah, 2002). These results are consistent with Uphoff (2002) who reported

that less trauma to the SRI plants ensured to express its full potential of much grain/panicle due to greater tillering (30 to 80 tillers/plant) and more root growth. Similar findings were reported by Tsai and Lai (1987) observed better development of panicles with more fertile spikelets in the crop raised with younger seedlings. Filled grains panicle ranged from 141 to 211. Planting of younger seedling, three seedlings/hill, shallow irrigation and weeder use (T₁₄: P₂S₁I₂W₂) recorded the highest number of filled grains/panicle (Table 3). This was significantly higher by 24.1% when compared to all conventional practices. Number of productive tillers ranged from 379 to 501 tillers m⁻². Comparison of treatment combination with SRI and conventional practices showed that adoption of all the SRI practices (T₁₆: P₂S₂I₂W₂) increased the number of tillers m⁻² by 11.8%. However, Phogat and Pandey (1998) reported that continuous submergence increased the panicle length and grains/panicle compared to alternate wetting and drying. Shah *et al.* (2006) reported that the highest numbers of productive tillers were produced when sowing was done on 1st November.

Grain yield ranged from 3872 to 5327 kg ha⁻¹. Inclusion of one of the SRI factors in the treatment combinations along with other conventional factors increased the yield (Table 3). Planting of younger seedling, single seedling/hill, shallow irrigation and herbicide+hand weeding treatment (T₁₅: P₂S₂I₂W₁) registered the highest grain yield of 5327 kg ha⁻¹. Adoption of all the SRI factors (T₁₆: P₂S₂I₂W₂) increased the yield by 18.6% when compared to all conventional factors (T₁: P₁S₁I₁W₁). Comparison of the mean of treatments with P₁ combinations and P₂ showed that use of younger seedling increased the yield by 13.2%.

Planting of older seedlings, single seedling/hill, shallow irrigation and weeder use (T_{12} : $P_1S_2I_2W_2$) registered the highest straw yield. Adoption of all the SRI factors (T_{16} : $P_2S_2I_2W_2$) increased the yield by 18.6% when compared to all conventional factors (T_1 : $P_1S_1I_1W_1$). Vijayakumar *et al.* (2005) concluded that the grain yield and water productivity were significantly increased when applying SRI weeding with 14 days old dapog seedlings planted at 25×25 cm spacing to achieve yields of 7009 and 0.610 kg m⁻³. Transplanting seedlings at a younger stage provides sufficient nutrients for vegetative growth and also for the reproductive phase which ultimately leads to increased plant height and yield attributes thereby resulting in increased grain and straw yields (Krishna, 2000). The increased grain yield under SRI could be attributed to the higher root growth which enabled them to access to nutrients from much greater volume of soils. It helped to capture all the essential nutrient elements important for plant growth and thereby leading to higher tillering and grain filling (Thiyagarajan *et al.*, 2002). Rajput (1995) reported that the highest grain and straw yields were obtained with aged seedlings which were significantly superior over 20 day old seedlings. Sanusan *et al.* (2010) reported that Suphan Buri 1 produced more number of spikelets and seed yield than Patham thani 1.

CONCLUSION

It is clear from the study that inclusion of one of the SRI factors along with the other conventional factors resulted in increase in growth parameters and yield attributes. The effect was conspicuous with the use of weeder. The management practices followed in SRI method of cultivation produced significantly more number of panicles/m and number of grains/panicle.

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