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Comparison of Rice Cultivars (*Oryza sativa.* L.) under SRI and Normal Transplanting Method for Resource Conservation and Productivity Enhancement in Irrigated System

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Abstract

An experiment was conducted at the Indian Institute of Rice Research (IIRR) farm, ICRISAT for three consecutive *kharif* and *rabi* seasons from 2016 to 2018 to evaluate varieties under System of Rice Intensification (SRI) and Normal Transplanting (NTP) method. A total of 46 cultivars including hybrids (10), High yielding varieties (HYVs) (28) and elite cultures (8) were tested. Data pooled over years and seasons indicated that SRI was significantly superior in terms of number of tillers, number of panicles per square meter, days for 50% flowering and grain yield with low inputs *viz*; energy, man power and irrigation. Hybrids, HYVs and elite culture recorded a grain yield of 6.54 t/ha, 5.65 t/ha and 5.50 t/ha under SRI as compared to 5.13, 4.59 and 4.58 t/ha, respectively under NTP, thereby indicating that SRI excelled NTP in grain yield. Pooled data of six seasons, three years among the cultivars indicated that SRI recorded higher grain yield (5.90 t/ha) over NTP (4.77 t/ha) with mean percent grain yield increase of 23.4%. Intensification method was also promising over conventional transplanting in terms of energy use efficiency (SRI 10.17% over NTP 6.20%) and economy parameters (B:C ratio 2.0 in SRI and 1.20 in NTP). Water productivity was higher in SRI (7.08 kg/mm/ha) than NTP (3.93 kg/mm/ha).

Keywords: System of Rice Intensification (SRI), Normal Transplanting (NTP), Water saving, Water productivity.

Introduction

Rice is the most important staple food crop in the world. More than 50% of world population's daily energy requirement is fulfilled by rice and its derived products. System of Rice Intensification (SRI) is a set of ideas that comprises the use of younger seedlings, planting of single seedling with wider spacing, adopting intermittent irrigation, weeding by conoweeder during crop growth for four times during vegetative growth of crop which facilitates for aerobic conditions at rhizosphere zone of plants and use of organic fertilizers (Stoop *et al*., 2002; Uphoff, 2007). According to FAO report (FAOSTAT, 2020), global rice requirement by 2025 will be 800 mt. At current pace of growth, it will be less than 600 mt and hence, there will be deficit of 200 mt, which has to be produced by increasing productivity per unit area against the diminishing resources. Under these circumstances, SRI holds promise to save water and environment with less emissions of greenhouse gases (GHG). System of Rice Intensification (SRI) is best understood as an agronomic practice for small and marginal farmers to sustain with available resources such as organic fertilizers, water and man power. This has been found to be productive, resource conserving and environmentally benign in most of the countries when compared to normal transplanting method (Namara *et al*., 2008; Sato and Uphoff 2007; Sinha and Talati, 2007). In this context, the present experiment was conducted for three consecutive years (six seasons) to compare rice cultivars under SRI and NTP method for higher yield and resource conservation.

Methodology

A total of 46 cultivars including hybrids, high-yielding varieties and elite cultures were evaluated under SRI in comparison with NTP during three k*harif* and *rabi* seasons at the Indian Institute of Rice Research farm located in ICRISAT, Hyderabad (**Table 1**). The soils were sandy loam with pH 7.6, E.C. 0.26, organic carbon of 0.49% and with available N:P: K of 225: 42.5:323 kg ha^{-1}. The experimental design was a split plot with establishment methods (SRI and NTP) as main plots and cultivars as subplots with three replications and with a plot size of 6.0m x 1.8m. The recommended dose of fertilizer was 120:60:40 of N: P: K $kgha^{-1}$was applied, P and K as basal and N applied in splits of 50%, 25% & 25% as basal, at maximum tillering and panicle initiation, respectively. Twenty-five per cent of N was applied from an organic source (Vermicompost @ six tonnes per hectare) in the SRI method. Manual weeding was performed for NTP whereas in SRI conoweeder used in SRI method three to four times with a time interval of one week, from 12 days after transplanting to the maximum tillering stage. Alternate wetting and drying method was followed for irrigation in the SRI method up to the panicle initiation stage whereas in NTP saturation condition was maintained thorough out the crop period (**Table 2**). Total irrigation was 834 $mmha^{-1}$ for the SRI method and 1218 $mmha^{-1}$ for the NTP method. Water productivity was calculated by taking into account irrigation water supplied and the contribution from rainwater. The total yield is divided by the total water applied. Water productivity was expressed in kg ha mm^{-1}. (Water productivity = Grain yield (kg ha^{-1})/ total irrigation (Irrigation + effective rainfall) (mm).

Table 1. List of germplasm evaluated

Hybrids	High yielding varieties			Elite cultures
PA-6129	Shanti	Phalguna	Aditya	Improved-Chitti muthyalu
PA-6201	Dhanarasi	Jaya	Ravi	Vasumati
PA-6444	RP Bio-226	Rasi	Ajaya	Sugandamati
KRH-2	Akshayadhan	Swarna-Dhan	Nidhi	Kasturi
DRRH-3	Varadhan	Vikas	Triguna	PB1121
DRRH-2	Sampda	Sonasali	Krishna Hamsa	Taroari Basmati
US 305	Dhan - 38	Vikramarya	MTU1010	
US 312	Dhan - 39	Prasanna	RNR15048	
US 314	Mandhya vijaya	Suraksha	Swarna	
US 382	Sasyasree	Tulasi	BPT 5204	

Table 2. Details of the methods of cultivation under SRI and NTP

S.No.	Practice	SRI method	Normal Transplanting
1	Nursery	Raised bed nursery	Flat bed nursery
2	Seedling age for transplanting	8-12 days	25-30 days
3	Seedlings	Single seedling was planted	Average of three seedlings were planted
4	Spacing	25 x 25 cm wider spacing	20 x 15 cm spacing
5	Weeding	4 weeding by cono weeder 12 DAT with one week to 10 days interval	Hand and manual weeding at 20 and 35 DAT
6	Water management	Alternate wetting and drying irrigation from 12 DAT to panicle initiation stage	Saturation through the crop
7	Fertilizers	Use of organic manure- vermi compost/ FYM upto 25% of Recommended Dose of Fertilizer (RDF)	100% RDF as inorganic

Growth parameters *viz*; plant height, number of tillers were recorded at 30, 60, and 90 DAT. Yield attributes- panicle number, panicle length, panicle weight, test weight; physiological data – SPAD and days for 50% flowering and irrigation data were recorded. Plants in the net plot area were harvested, separately in each plot, threshed and grains were dried under the sun before recording the grain yield per plot. The yield was standardised at 13% moisture. From this, yield per plot was computed and expressed as t ha-1.

The data obtained on the different growth and yield parameters and yield was analysed statistically by the method of analysis of variance as per the procedure outlined for split-split plot design given by Gomez and Gomez (1984). Statistical significance was tested by F value at 0.05 level of probability and the critical difference was worked out where ever the effects were significant.

Results and discussion

SRI method of cultivation is significantly promising over NTP in terms of yield attributes in the *kharif* and *rabi* seasons of three years. SRI recorded significantly higher number of tillers and panicles per square meter in all seasons and years among hybrids, HYVs and elite cultures (**Table 3**). Pooled data of three years indicated that day to 50% flowering was 97 days for SRI and 108 days for NTP. This can be ascribed to the fact that transplanting younger seedlings without disturbing the rhizosphere soil of the seedling might have supported fast establishment in the field, which in turn resulted in the reduction of days for crop maturity (**Figure 1**).

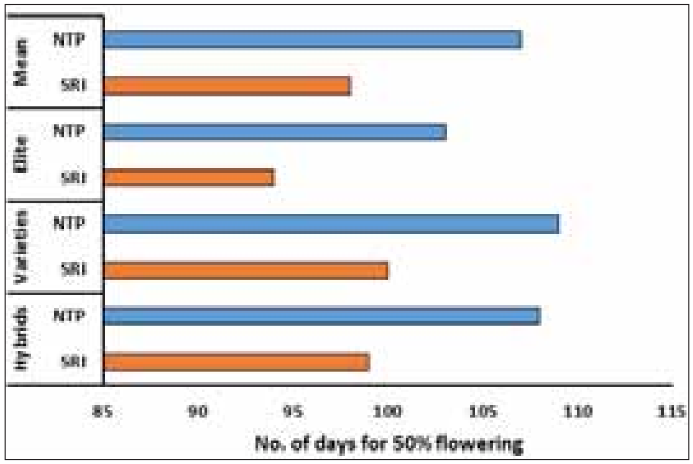

Figure 1. Days for 50% flowering as influenced by SRI vs NTP

Table 3. Effect of SRI method on yield attributes

Number of Tillers/m2												
Method	**Hybrids**				**High Yielding Varieties**				**Elite cultures**			
	2016	**2017**	**2018**	**Mean**	**2016**	**2017**	**2018**	**Mean**	**2016**	**2017**	**2018**	**Mean**
SRI	368	408	507	**428**	365	407	500	**424**	350	394	541	**428**
NTP	320	341	383	**348**	319	320	360	**333**	363	317	386	**355**
CD(0.05)	23.96	14.58	32.95		41.16	5.35	16.03		NS	18.42	67.45	
CV(%)	5.25	3.5	5.97		11.88	2.26	4.25		5.86	3.9	9.26	
Number of Panicles/m2												
Method	**Hybrids**				**High Yielding Varieties**				**Elite cultures**			
	2016	**2017**	**2018**	**Mean**	**2016**	**2017**	**2018**	**Mean**	**2016**	**2017**	**2018**	**Mean**
SRI	364	388	462	**405**	346	383	455	**394**	331	371	490	**397**
NTP	299	311	353	**321**	274	292	331	**299**	277	287	356	**307**
CD(0.05)	33.46	11.59	65.23		24.1	6.71	32.5		21.73	8.78	45.66	
CV(%)	7.6	2.99	12.88		7.67	3.05	9.41		3.52	2.01	6.87	

Panicle length (cm)												
Method	Hybrids				High Yielding Varieties				Elite cultures			
	2016	2017	2018	Mean	2016	2017	2018	Mean	2016	2017	2018	Mean
SRI	24.71	24.32	23.90	**24.31**	25.41	24.32	23.23	**24.32**	27.06	24.45	24.04	**25.18**
NTP	23.01	22.37	22.75	**22.71**	23.09	22.39	21.77	**22.42**	24.47	22.07	22.60	**23.05**
CD(0.05)	0.94	1.07	0.40		1.52	0.88	0.79		NS	0.41	NS	
CV(%)	2.98	4.13	1.38		6.16	5.81	4.00		5.40	1.34	4.94	
Panicle weight (g)												
Method	Hybrids				High Yielding Varieties				Elite cultures			
	2016	2017	2018	Mean	2016	2017	2018	Mean	2016	2017	2018	Mean
SRI	4.84	4.79	4.00	**4.54**	3.74	4.04	3.18	**3.65**	3.90	4.10	2.57	**3.52**
NTP	4.2	3.70	3.80	**3.90**	3.52	3.33	3.10	**3.32**	3.62	3.37	2.46	**3.15**
CD(0.05)	0.41	0.26	NS		NS	0.26	0.08		0.09	0.57	NS	
CV(%)	6.79	5.56	6.09		8.65	10.77	2.72		1.12	11.56	5.07	
Test weight (g)												
Method	Hybrids				High Yielding Varieties				Elite cultures			
	2016	2017	2018	Mean	2016	2017	2018	Mean	2016	2017	2018	Mean
SRI	21.22	21.28	21.31	**21.27**	20.71	22.22	18.99	**20.64**	20.09	20.18	22.75	**21.01**
NTP	19.66	19.78	20.18	**19.87**	20.53	20.14	18.20	**19.62**	16.34	18.47	22.26	**19.02**
CD(0.05)	0.3	NS	1.06		NS	0.66	NS		1.59	NS	NS	
CV(%)	1.09	11.45	4.11		9.55	4.75	9.5		4.29	9.11	7.23	

The SRI method was promising over NTP with higher yield parameters and yield with decreased days to 50% flowering and inputs **(Table 4)**. Hybrids due to their heterotic potential *viz*; KRH2, DRRH3, PA6129, PA6444 & US312 were found promising with higher grain yield (6.25 to 6.90 t/ha) under SRI and also excelled NTP by a margin of 19.37% to 34.5% along with reduced water application. Srinivas *et al*., (2017) observed that system of rice intensification method with alternate wetting and drying irrigation could be adopted for hybrid rice cultivation for those areas with fewer irrigation facilities. Among varieties, the per cent grain yield increase was to the tune of 17.2% to 31.9% and the promising varieties identified was RP Bio 226, Akshayadhan, Vardhan, Sampada, IR 64 and Krishnahamsa, which matured early and reduced seed rate and water requirements to a greater extent (80% in seed and 30% in water input) with SRI method of cultivation. Among the elite varieties, the per cent grain increase found in SRI over NTP ranged from 8.98% to 32.97% and promising elite cultures were Chittimuthyalu, Kasturi and Taroari basmati in terms of grain yield. It indicated that the elite and scented could be grown with the SRI method to enhance the productivity and profitability of these cultivars. Mean over the three years, the grain yield was significantly higher in SRI method over NTP (Hybrids: 6.54 t/ha; HYV; 5.65 t/ha and Elite; 5.50 t/ha) and the per cent grain yield increase was found to be higher in SRI over NTP i.e., 27.40% for hybrids, 22.93% for varieties and 20.0% for elite cultures **(Figure 2)**. Rice intensification and transplanting procedures were found to be more efficient in minimizing weed infestation and nitrogen removal by weeds, resulting in improved yield characteristics and yield (Singh *et al*., 2021). Kumar *et al*., (2021) observed that all growth and yield parameters were highest in the SRI. SRI practices create conditions for beneficial soil for microbes to prosper, saving irrigation water, and increasing grain yield (Subramanian *et.al*, 2013). The pooled data over the seasons and years indicates that the SRI method with less cost of cultivation (Rs.35555) and less energy input (14963 MJ/ha) recorded higher energy output (173.7 GJ/ha over NTP 141.7GJ/ha), Energy productivity (0.9 kg grain/MJ energy over NTP 0.6 kg grain/MJ), energy intensity MJ/Rs. (SRI 5.2: NTP 3.1) and B: C Ratio (SRI 2.0 vs NTP 1.21) (**Table 5**).

Table 4. Grain yield of Hybrid, HYVs and Elite cultures as influenced by SRI over NTP

Cultures/Method		Pooled Grain Yield (t/ha)			Mean Grain Yield (t/ha)
		2016	2017	2018	
Hybrids	**SRI**	6.25	6.90	6.47	6.54
	NTP	4.85	5.13	5.42	5.13
	CD(0.05)	0.2	0.12	0.29	
	CV(%)	2.78	1.74	3.99	
Varieties	**SRI**	5.11	6.04	5.79	5.65
	NTP	4.29	4.58	4.91	4.59
	CD(0.05)	0.15	0.21	0.27	
	CV(%)	3.24	6.13	5.78	
Elite	**SRI**	4.75	6.17	5.58	5.50
	NTP	3.99	4.64	5.12	4.58
	CD(0.05)	0.28	0.24	0.20	
	CV(%)	3.16	3.41	2.39	

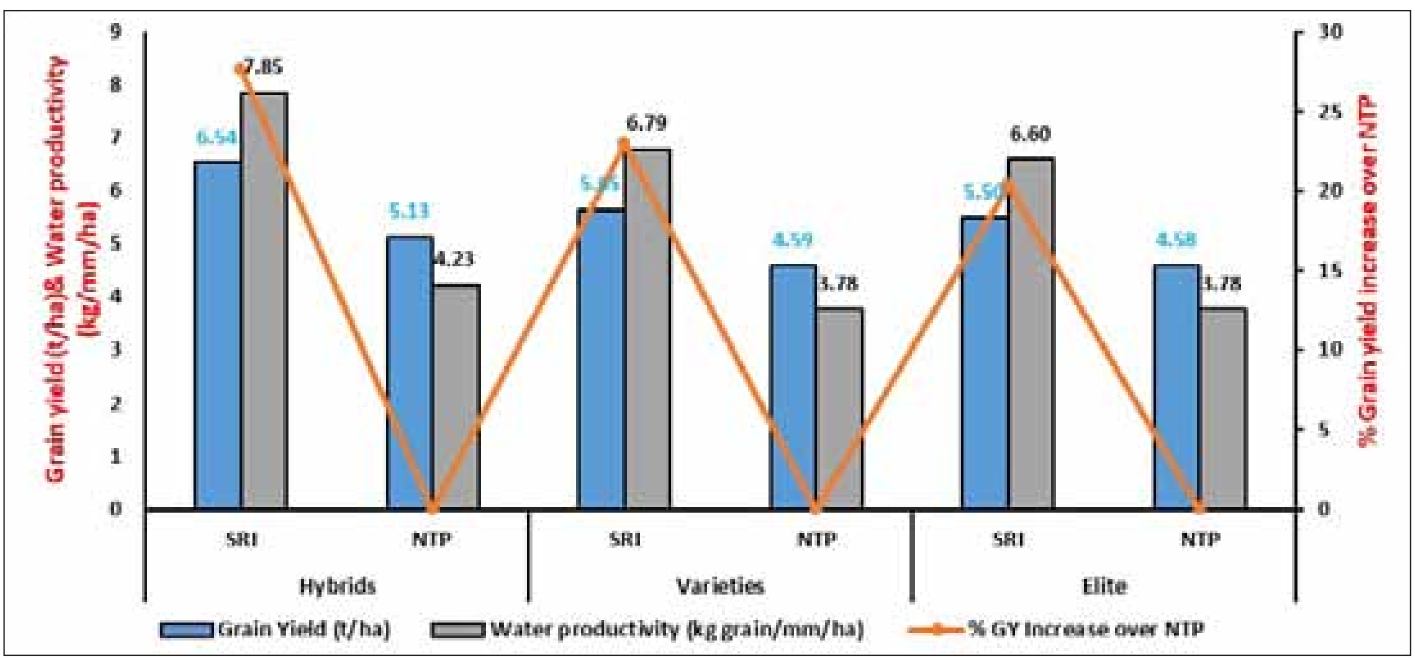

Figure 2: Grain Yield, and Water productivity in SRI method over NTP

Table 5. Energy and Economics as influenced by SRI vs NTP method

Method	Cost of cultivation (Rs/ha)	Energy Input (MJ/ha)	Total Energy Output (GJ/ha)	Net Energy (GJ/ha)	Energy Productivity (kg/MJ)	Energy intensity (MJ/Rs)	Energy use efficiency (%)	Gross returns (Rs/ha)	Net returns (Rs/ha)	Benefit: Cost ratio
SRI	35555	14963.0	173.7	158.7	0.9	5.2	10.6	101709	68154	2.0
NTP	45231	18451.0	141.7	123.2	0.6	3.1	6.7	79696	34101	1.21

It was observed that the paddy crop utilises up to 5000 litres of water per one-kilogram grain production in the conventional method whereas as SRI method of practice requires up to 3000 litres of water. Significant differences were observed between the varieties under SRI vs NTP (Kumar *et al*., 2017). The water productivity (kg grain produced per mm water applied) was significantly superior in SRI (7.08 kg/mm/ha) method over NTP (3.93 kg/mm/ha) in all the seasons for Hybrids, High yielding varieties and Elite and scented cultivars. Across the years, the water productivity ranged from 3.16 to 8.18 kg/mm/ha **(Table 6)** Irrespective of cultivars, SRI method saved 32% of water input **(Figure 3)** over NTP with increased output energy and 24% higher grain yield, with reduced manpower & input energy. The system of rice intensification improved the yield of crops and water productivity (Deelstra *et al*., 2018). Similar results of saving about 40% of irrigation water and increasing land productivity by about 46% while reducing the cost of cultivation by 23% over the conventional inundation method was reported by Naranayamoorthy and Jothi (2019**)**. The percentage of water saved was 33.57% in 2016, 29.10% in 2017 and 31.84% in 2018 over NTP method. Further, most of the cultivars were found promising and recorded higher grain yields with SRI method with reduced resources (seed, water & labour). Hybrid cultivars *viz*; KRH2, DRRH3, PA6129, PA6444 & US312 were found promising with higher grain yield. Among varieties, the per cent grain increase found in SRI over NTP was to the tune of 17.2% to 31.9% and the promising varieties identified were RP Bio 226, Akshayadhan, Vardhan, Sampada, IR 64 & Krishnahamsa, which matured early and reduced seed rate and water requirements to a greater extent (80% in seed and 30% in water input. Among the elite varieties, the per cent grain increase in SRI over NTP ranged from 8.98% to 32.97% and the identified promising elite cultures were Chittimuthyalu, Kasturi and Taroari basmati in terms of grain yield. It indicated that the elite and scented could be grown with the SRI method to enhance the productivity of these cultivars. Local and elite cultures' yield could also be increased with the adoption of the SRI method. By adopting the SRI technique, the farmer can save the existing land from deterioration by reducing the use of chemical fertilizers and getting the highest yields.

Table 6. Water productivity (kg grain/mm/ha)

Cultures		Water productivity (kg grain/mm/ha)			Mean
		2016	**2017**	**2018**	
Hybrids	**SRI**	7.45	8.18	7.91	7.85
	NTP	3.84	4.32	4.52	4.23
	CD(0.05)	0.22	0.17	0.31	
	CV(%)	2.94	2.48	4.01	
Varieties	**SRI**	6.1	7.17	7.09	6.79
	NTP	3.4	3.85	4.09	3.78
	CD(0.05)	0.16	0.24	0.29	
	CV(%)	3.35	6.76	5.93	
Elite	**SRI**	5.66	7.32	6.82	6.60
	NTP	3.16	3.9	4.27	3.78
	CD(0.05)	0.21	0.21	0.16	
	CV(%)	2.33	2.84	1.78	

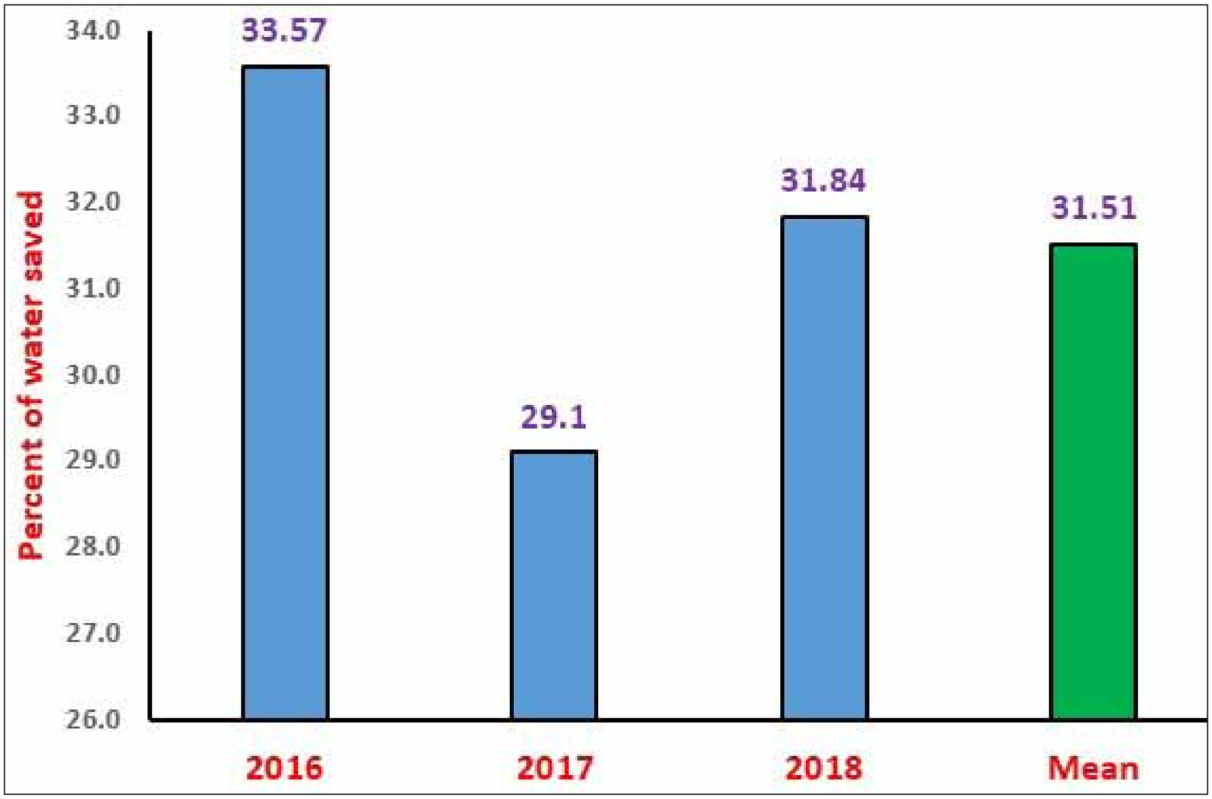

Figure 3: Percentage of water saved in SRI method over NTP

Conclusion

SRI method of cultivation was promising over NTP in terms of grain yield, energy output, net returns and Benefit: Cost Ratio. All the cultivars recorded higher yield in SRI method. Among the cultivars, hybrids (6.54 t/ha) performed better than HYVs (5.65 t/ha) and elite cultures (5.50 t/ha). The identified hybrids, cultivars and elite cultures could be promoted in SRI method for higher grain yield with lesser inputs especially seed (80%) and water (31%) which can be utilized for the increase of paddy cultivation area and other rice-based crops.

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