SKUAST Journal of Research 25(2): 354-362; (2023)
(*10.5958/2349-297X.2023.00035.1*); NASS rating: 4.17

Research Paper

Influence of irrigation scheduling and crop establishment methods on growth parameters: periodic LAI, SPAD and PAR in Rice (*Oryza sativa* L.)

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(Received May 16, 2023; accepted June 11, 2023)

ABSTRACT

An experiment was carried out at research farm of Division of Agronomy, SKUAST-K, Wadura, Jammu and Kashmir, during the *kharif* seasons of the year 2021 and 2022 to appraise marked effect of different rice establishment methods and irrigations regimes. The experiment included rice establishment methods as main plot treatments (SRI: System of rice intensification; DSR: Direct seeded rice; TPR: Transplanted Rice) and different irrigation regimes as sub plot treatments (I_1: Continuous submergence (flooding) upto 3cm depth; I_2: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water throughout crop growth; I_3: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water upto panicle initiation and then submergence upto dough stage; I_4: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water upto flowering and then submergence upto dough stage; I_5: Saturation throughout (1cm of standing water). Over TPR and DSR establishment methods, SRI showed significantly higher periodic Leaf Area Index, SPAD and PAR values. Amid different irrigation regimes, I_1 showed significantly higher values for periodic LAI, SPAD and PAR in contrast to I_2 and I_4, nevertheless, was at par with I_3 and I_5. Lowest values for periodic LAI, SPAD and PAR were found under I_2.

Key words: Irrigation regimes, PAR, rice establishment methods, SPAD, SRI

Rice regarded as main staple food amidst half of the population in world (Zhao *et al*., 2023), is grown as semi-aquatic crop requiring steady supply of irrigation to certify less yield curtailment (Upadhyay, 2016). Towards the end of the year 2050, demand in rice is prognosticated to 800 metric tons (Rana *et al*., 2020). Seventy-nine million hectares (m ha) irrigated lowland produce 75 per cent of rice production, albeit, 22 m ha will count economic water shortage (Midya *et al*., 2017). Nonetheless, this paucity of the global freshwater has rendered the inaccessibility of irrigation to the crop and thus annexed water-saving irrigation technologies (WSIs) to augment water conservation techniques in exclusive (He *et al*., 2020). One cultural norm that affects the growth and development of the rice crop is the method of establishment. In India, rice is mostly grown by transplantation. In northern India, rice is often grown by transferring 25–30 day-old nursery seedlings into a puddled field. The bulk of weeds are inhibited by the standing water, giving rice seedlings planted in flooded areas a significant competitive edge against weeds (Pathak *et al*., 2011). This classic puddle rice system is, however, losing its sustainability and economic viability since it requires a lot of water and manpower to cultivate rice, and because labour is becoming increasingly scarce and water supplies are depleting (Akbar *et al*., 2011). Over and above that, transplanted rice (TPR) accord global warming due to greenhouse gas emissions (Kaur and Singh, 2017). All of these elements call for a significant switch from the cultivation of puddle transplanted rice to the cultivation of rice through WSIs in irrigated areas. Direct Seeded Rice (DSR) locally

called "*wotur*" as far as, one of the sustainable water conservation techniques in rice production, is gaining paramount importance across the globe. DSR put to good use, has less irrigation requirements and offers permanent diminution in values of climate change (Kaur and Singh, 2017). However, major economic losses are encountered in DSR owing to weed infestation only. Losses in yield are prognosticated from 50 per cent to complete crop failure (Dhaliwal *et al*., 2021). So, divising of other sustainable techniques in rice cultivation is must. SRI (System of Rice Intensification), has also picked up attention of researchers vis-à-vis increased rice water productivity and efficiency in nutrient uptake (Bhat *et al*., 2022) and its use (Shahane *et al*., 2020). The primary components of SRI include young seedlings under 15 days of age, mechanical weeding with a rotating push weeder that aerates the soil, transplanting of single seedlings, widely spaced, and so on (Randriamiharisoa *et al*., 2006). The further benefits include seed and water conservation. Increases in yield of 50–100% are typical, and occasionally they even triple (Yamah, 2002). As in case with flooded rice which develops anoxic conditions, aerobic rice has completely different frame of environment in soil and different set of weed species (Anwar *et al*., 2010). Nutrient management tools become censorious when water saving techniques are employed as redox potential commuting, impacts the accessibility of various soil nutrients to the crop.

The parameters of water depth, which include the minimum acceptable water depth after rainfall, the maximum allowable water depth, and the upper limit of allowable water depth, govern both irrigation and drainage in the field of irrigation management (Chen *et al*., 2022). Two irrigation systems, namely conventional irrigation and water-saving irrigation, are now used in the irrigation management of rice. The latter covers alternate wetting and drying irrigation (AWD), regulated irrigation, rain-fed irrigation, "thin, shallow, wet, and dry" irrigation, and so forth. The former mostly refers to flooded irrigation (FI). When shallow groundwater persists within about 0-30 cm, AWD can cut water use by up to 15% in relation to the usual irrigated lowlands in Asia without yield losses (Belder *et al*., 2004). According to reports, the use of AWD can benefit water use and fertilizer (such as nitrogen and phosphorus) efficiency, grain heavy metals reduction (Tanner *et al*., 2018), and combating greenhouse gas emissions (Cheng *et al*., 2022). So, in order to investigate the effects of different crop establishment methods and irrigation regimes on rice productivity in Kashmir Valley, current study was undertaken with the following objectives: (1) To investigate the influence of different crop establishment methods and irrigation regimes on LAI in rice; (2) To evaluate the impact of different crop establishment methods and irrigation regimes on PAR and SPAD values in rice.

MATERIALS AND METHODS

The experimentation for the study was carried out in the research farm of the Agronomy Division, Faculty of Agriculture, Wadura, SKUAST-K, India, during the seasons of 2021 and 2022 to examine the effects of various crop establishment techniques and irrigation regimes on rice crop productivity. The experiment was carried out at a place with a 1590 masl altitude, between 34°210 N and 74°230 E in terms of latitude and longitude, respectively. The soil has the consistency of clay loam. The results of the soil analysis showed that the soil included 322.5, 19.95, and 173.2 kg ha^{-1} of readily available nitrogen, phosphorus, and potassium. There was medium organic carbon (0.67%) and a neutral pH. The experiment was laid in split plot design with three main plot treatments viz SRI (System of Rice Intensification), DSR (Direct Seeded Rice) and TPR (Transplanted Rice) and 5 subplot treatments viz I_1: Continuous submergence (flooding) upto 3cm depth; I_2: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water throughout crop growth; I_3: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water upto panicle initiation and then submergence upto dough stage; I_4: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water upto flowering and then submergence upto dough stage; I_5: Saturation throughout (1cm of standing water). There were total 45 plots each plot having size 6.0 m x 3.0 m. Variety of the crop was SR-4. The Cochran and Cox technique, (1936) was used to statistically analyse the data obtained for a number of observations. Treatment differences were assessed using the F test of significance.

RESULTS AND DISCUSSION

Periodic LAI: The leaf area index is a reliable indicator of crop growth and a key factor affecting the crop's ability to absorb nutrients and overall yield. Figs. 1, 2, 3 and 4 exhibit the periodic leaf area index. The findings showed that in both the years of experimentation, LAI showed increasing trend up to 85 DAS and then after declined till crop harvest in all treatments. Data analysis revealed that, when compared to transplanted and direct-seeded rice over both years, the system of rice intensification recorded significantly higher leaf area index

at 40, 55, 70, and 85 DAS. The greatest leaf area index with SRI was discovered to be at 85 DAS which was 4.46 and and 4.86 (Figure 1 and Figure 3) compared to transplanted rice, which had a leaf area index of 4.18 and 4.32; nevertheless, direct seeded rice had the lowest leaf area index at 85 DAS in 2021 and 2022, at 3.86 and 4.03, respectively. SRI recorded highest LAI that could be as a result of the fact that SRI enhances soil health by giving crops a good amount of nutrients, which led to a higher crop leaf area. Under SRI, there is only one seedling per hill, and sufficient leaf exposure to sunlight for photosynthesis, which may account for the greater LAI (Thakur *et al*., 2011). Amid different irrigation regimes, I_1 in SRI recorded highest LAI of 4.62 and 4.84 during both the years at 85 DAS yet at par with I_3 and I_5 at 85DAS (Figure 2 and Figure 4). Lowest LAI at 85DAS was recorded in I_2 with values of 3.46 and 3.56. Results are in line with Nazir *et al*. (2022); Nazir *et al*. (2023). Saha and Bharti (2010) reported findings that were comparable.

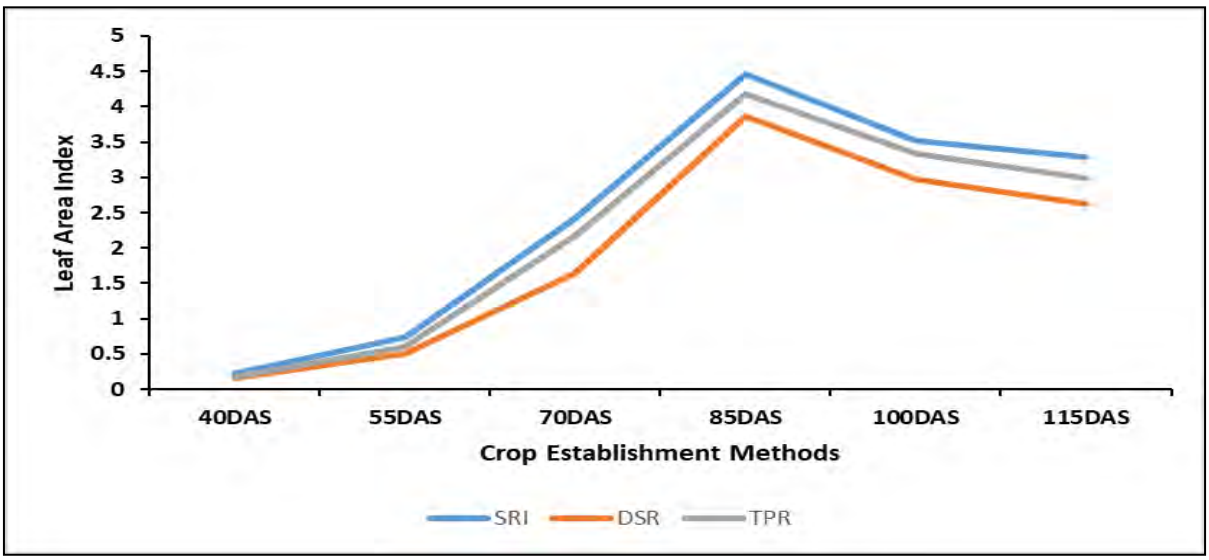

Fig. 1: LAI of Rice as influenced by crop establishment methods in 2021
(where SRI-System of Rice Intensification, DSR-Direct Seeded Rice, TPR-Transplanted Rice)

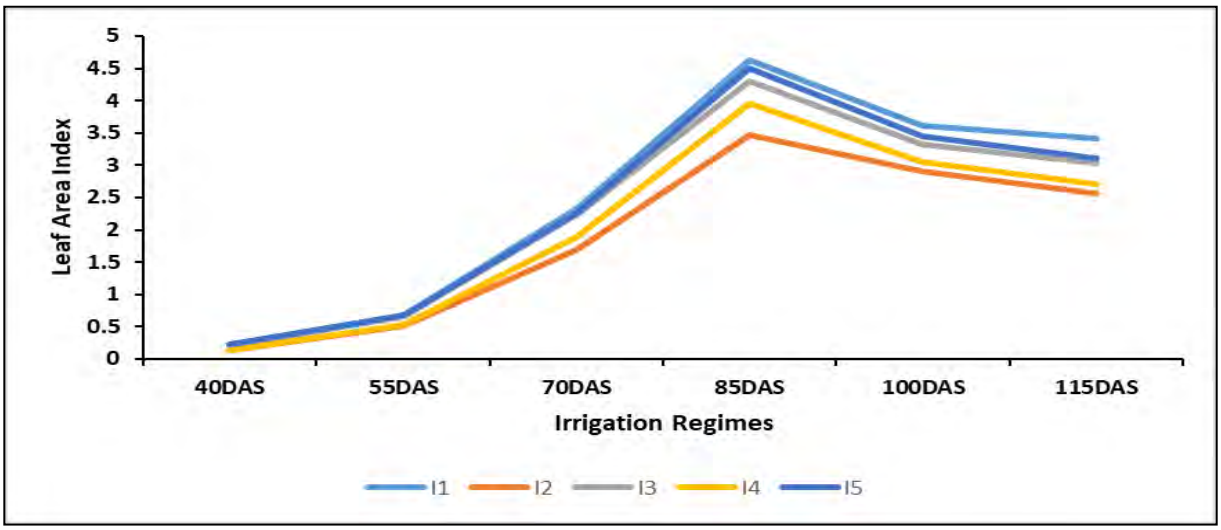

Fig. 2: LAI of Rice as influenced by irrigation regimes in 2021
(where I_1: Continuous submergence (flooding) upto 3cm depth; I_2: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water throughout crop growth; I_3: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water upto panicle initiation and then submergence upto dough stage; I_4: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water upto flowering and then submergence upto dough stage; I_5: Saturation throughout (1cm of standing water)

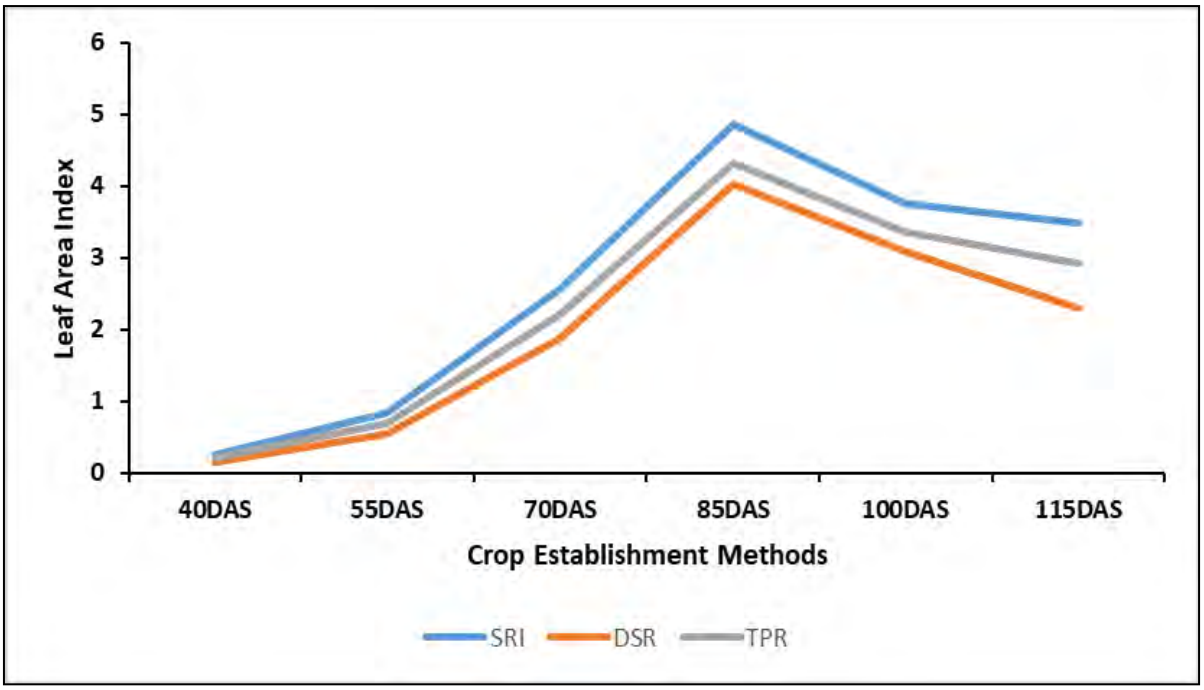

Fig. 3: LAI of Rice as influenced by crop establishment methods in 2022

(where SRI-System of Rice Intensification, DSR-Direct Seeded Rice, TPR-Transplanted Rice)

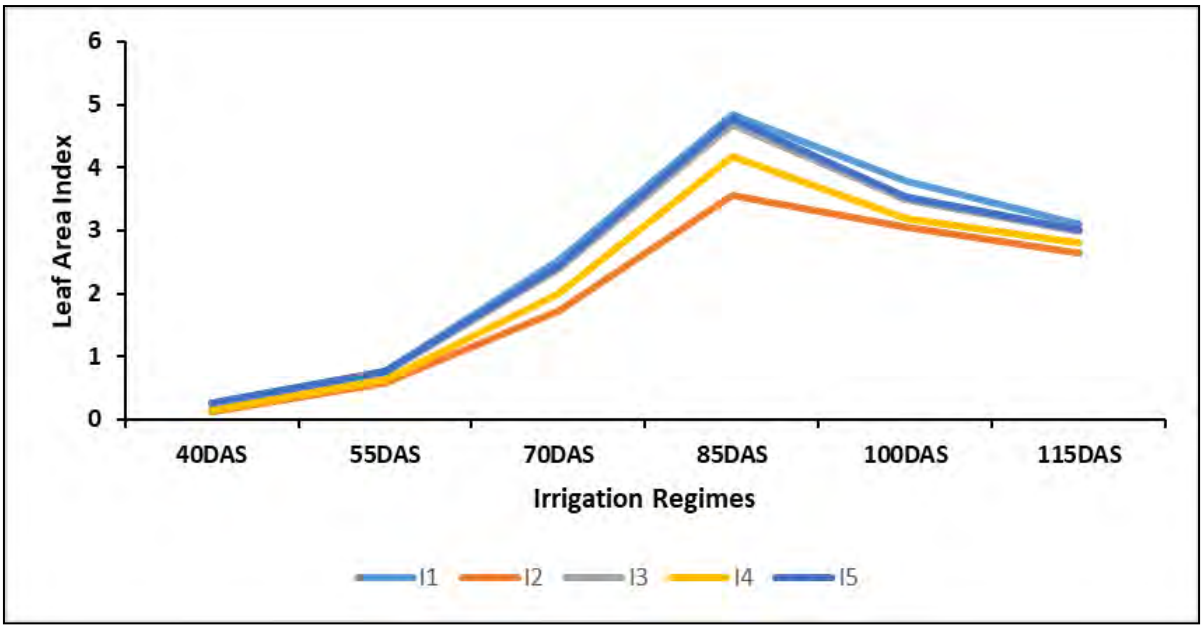

Fig. 4: LAI of Rice as influenced by irrigation regimes in 2022

(where I_1: Continuous submergence (flooding) upto 3cm depth; I_2: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water throughout crop growth; I_3: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water upto panicle initiation and then submergence upto dough stage; I_4: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water upto flowering and then submergence upto dough stage; I_5: Saturation throughout (1cm of standing water)

PAR (%): PAR was found to be significantly influenced by different crop establishment methods (Table 1). Amid different crop establishment methods, SRI was found to have statistically significant higher PAR at 40DAS, 55AS, 70DAS, 85DAS, 100DAS and 115DAS during both the years of experimentation. SRI recorded highest PAR of 85.03 per cent and 86.86 per cent during 2021 and 2022 at 100DAS where after it was found to decline.

This might be as a result of the greater leaf area index under SRI. The outcomes closely resemble those of Ahmad *et al*. (2008). Among different irrigation regimes, I_1 in SRI recorded highest PAR of 89.27 and 91.16 per cent during both the years at 100 DAS but was at par with I_3 and I_5 (Table 1). Lowest PAR at 100 DAS was recorded in I_2 with values of 73.00 and 75.55 per cent. Similar results were found by Nazir *et al*. (2022); Nazir *et al*. (2023).

Table 1: PAR (%) of Rice as influenced by crop establishment methods and irrigation regimes in 2021 and 2022

Treat-ments	40DAS	40DAS	55DAS	55DAS	70DAS	70DAS	85DAS	85DAS	100DAS	100DAS	115DAS	115DAS
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Crop Establishment Methods												
SRI	36.26	37.6	45.73	47.86	64.6	67.43	81.56	84.5	85.03	86.86	83.63	85.73
DSR	26.51	27.32	35.1	37.07	54.51	57.24	69.77	72.30	73.87	77.93	74.70	75.77
TPR	32.41	32.88	41.52	43.61	60.75	63.25	75.88	78.41	79.85	82.52	79.28	80.82
SE (m) ±	0.62	0.44	618.00	0.75	0.87	0.90	0.97	1.01	1.25	1.06	1.06	1.23
CD (p≤0.05)	2.46	1.74	2.42	2.96	3.43	3.55	3.84	3.99	4.94	4.18	4.17	4.86
Irrigation Regimes												
I_1	34.53	36.78	45.17	47.78	64.117	67.22	83.00	85.89	89.27	91.16	88.70	89.16
I_2	28.05	28.38	36.27	38.16	56.05	58.55	71.16	73.77	73.00	75.55	72.05	71.05
I_3	33.11	34.13	42.21	43.99	61.11	63.72	76.27	78.88	80.04	82.43	79.82	81.93
I_4	28.61	29.33	37.11	39.00	55.94	58.44	70.61	73.22	73.00	75.66	72.94	74.38
I_5	34.32	34.37	43.17	45.32	62.54	65.26	77.65	80.26	82.59	87.38	82.40	87.32
SE (m) ±	0.82	0.91	0.96	0.96	1.73	1.75	1.88	1.93	2.02	2.31	2.33	2.45
CD (p≤0.05)	2.41	2.48	2.80	2.80	5.05	5.13	5.49	5.64	5.90	6.76	6.80	7.16

(where SRI-System of Rice Intensification; DSR-Direct Seeded Rice; TPR-Transplanted Rice; I_1: Continuous submergence (flooding) upto 3cm depth; I_2: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water throughout crop growth; I_3: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water upto panicle initiation and then submergence upto dough stage; I_4: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water upto flowering and then submergence upto dough stage; I_5: Saturation throughout (1cm of standing water)

SPAD values: SPAD values of rice were significantly influenced by different crop establishment methods and irrigation regimes (Fig.5, 6, 7, 8). SPAD values were found to increase upto 85DAS and declined after 85DAS. SPAD values in SRI were statistically higher over to DSR and TPR during 2021 (Figure 5) and 2022 (Figure 7).

SRI recorded highest SPAD values at 85DAS during both the years (46.13 and 47.73) compared to other crop establishment methods. Lowest values were recorded in DSR (41.1 and 42.7). I_1 in SRI at 85DAS recorded highest SPAD values of 48.66 and 50.00 during 2021 (Figure 6) and 2022 (Figure 8) respectively. These values were statistically significant to I_2 and I_4 nevertheless at par with I_5 and I_3. Lowest values at 85DAS were found under I_2 (36.94 and 38.16). The findings are in conformity with those of Nazir *et al*. (2022); Nazir *et al*. (2023).

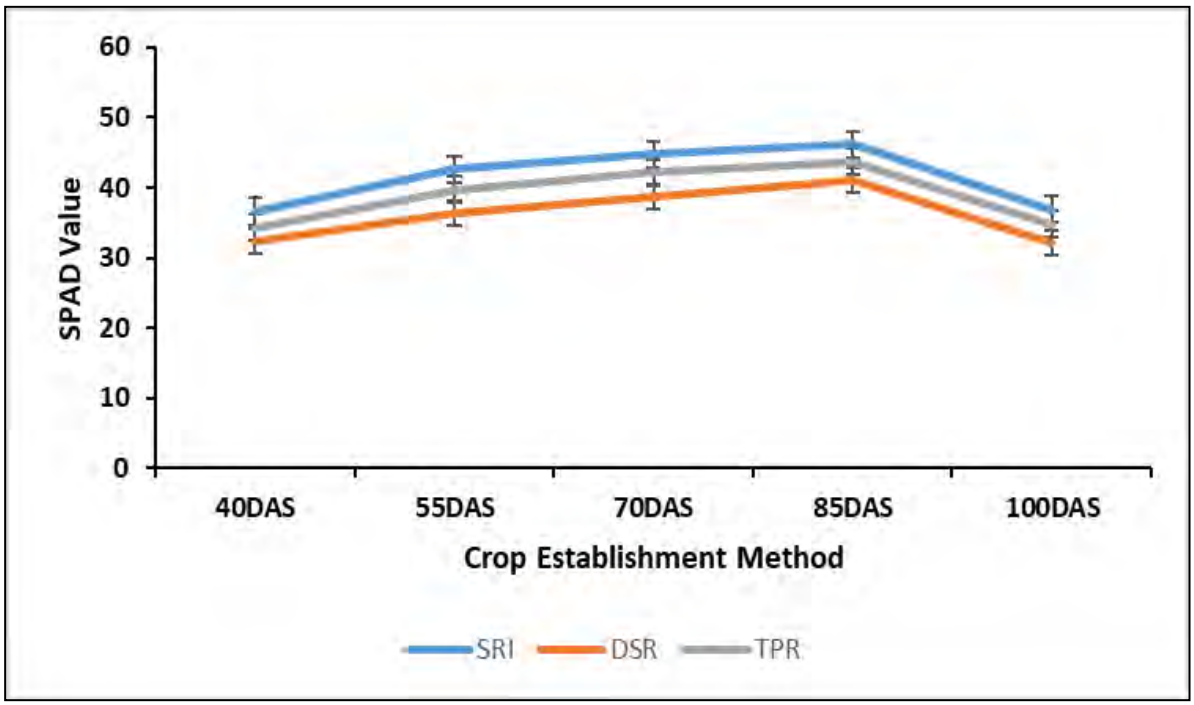

Fig. 5: SPAD Values of Rice as influenced by crop establishment methods in 2021

(where SRI-System of Rice Intensification, DSR-Direct Seeded Rice, TPR-Transplanted Rice)

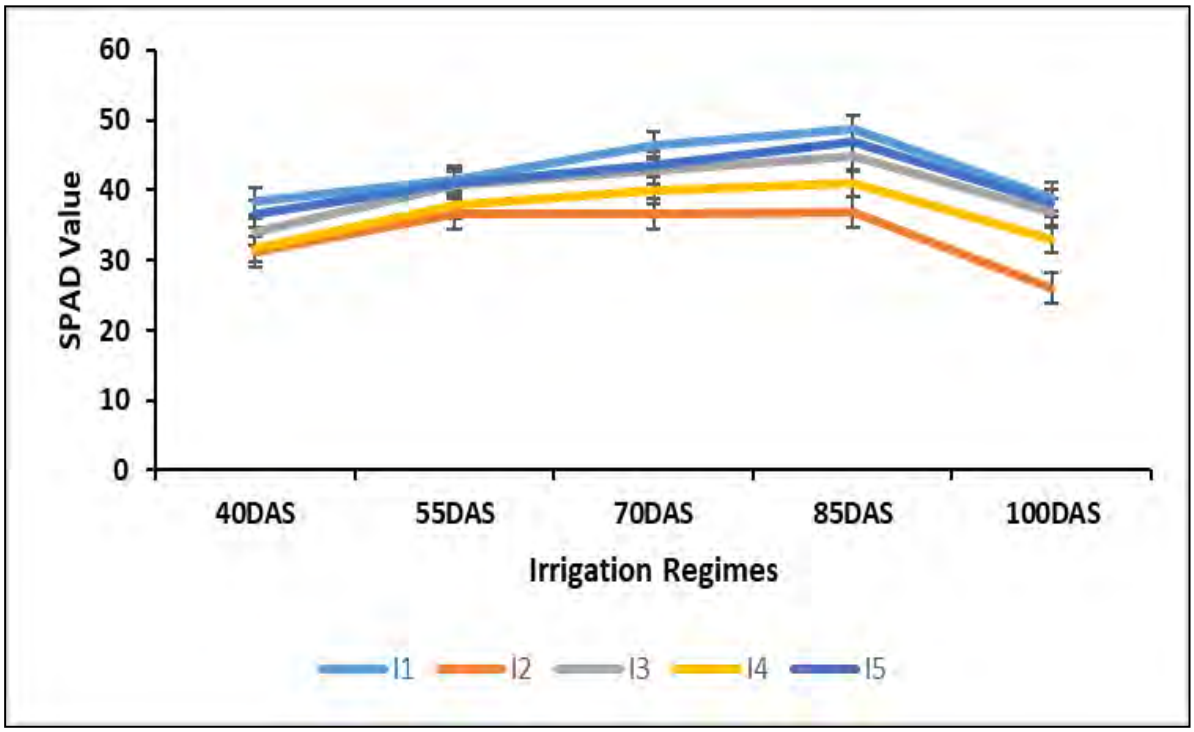

Fig. 6: SPAD Values of Rice as influenced by irrigation regimes in 2021

(where I_1: Continuous submergence (flooding) upto 3cm depth; I_2: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water throughout crop growth; I_3: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water upto panicle initiation and then submergence upto dough stage; I_4: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water upto flowering and then submergence upto dough stage; I_5: Saturation throughout (1cm of standing water)

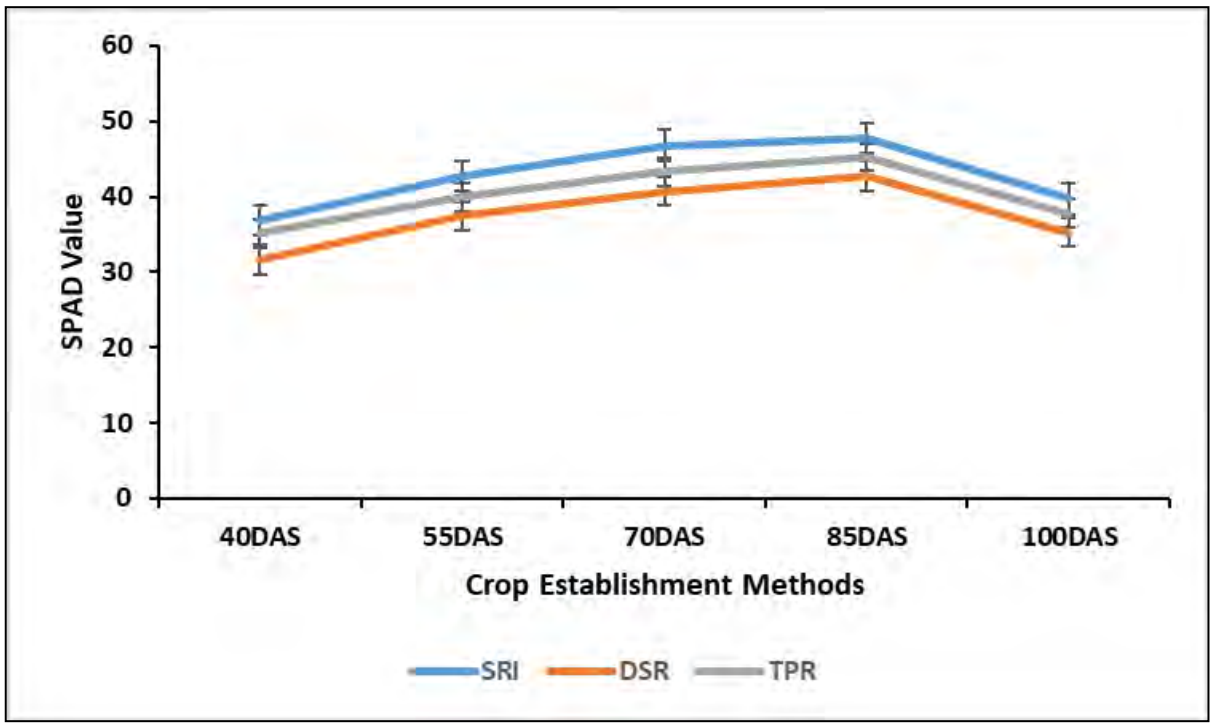

Fig. 7: SPAD Values of Rice as influenced by crop establishment methods in 2022

(where SRI-System of Rice Intensification, DSR-Direct Seeded Rice, TPR-Transplanted Rice**)**

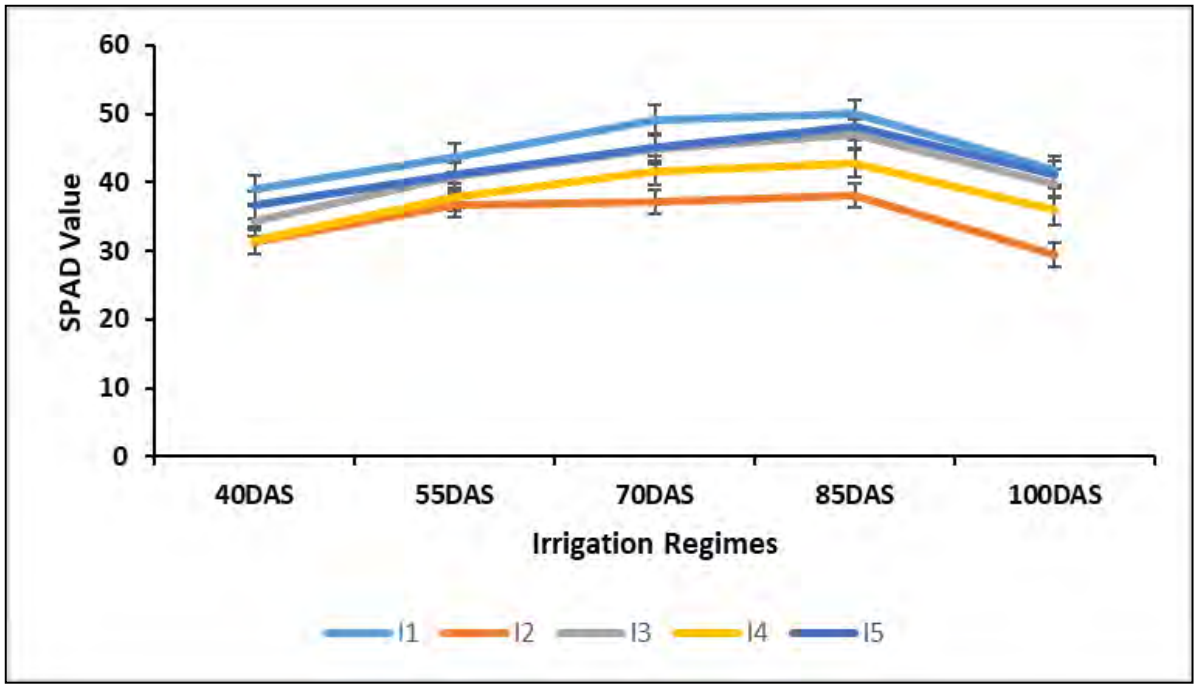

Fig. 8: SPAD Values of Rice as influenced by irrigation regimes in 2022

(where I_1: Continuous submergence (flooding) upto 3cm depth; I_2: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water throughout crop growth; I_3: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water upto panicle initiation and then submergence upto dough stage; I_4: Application of irrigation (24 litres m^{-2}) 4 days after disappearance of ponded water upto flowering and then submergence upto dough stage; I_5: Saturation throughout (1cm of standing water)

CONCLUSION

From the detailed inception of this experiment, we can conclude that SRI proved to be beyond doubt a better establishment method over to DSR and TPR establishment methods. Higher values for periodic LAI, SPAD and PAR was recorded under SRI in contrast to DSR and TPR. Amid different irrigation regimes, I_1 was found to be predominant over to I_2 and I_4 nonetheless was at par with I_3 and I_5. It can thus be brought to light that SRI method of establishment with I_1 (continuous submergence upto 3cm depth) regime of irrigation can be sustainable in north western region of India provided if the irrigation facilities are adequate.

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