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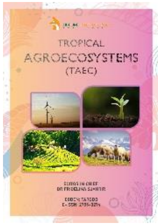

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RESEARCH ARTICLE

PERFORMANCE OF SPRING RICE CULTIVARS AGAINST PLANTING METHODS IN WESTERN TERAI, NEPAL

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ABSTRACT

Rice, the major staple food crop in Nepal, contributes significantly to the livelihood of a majority of people. The production of main season rice is insufficient for food self-sufficiency, where spring rice can be an alternative if better cultivars and planting methods can be identified. An on-station trial was conducted at the Agronomy Farm of Paklihawa Campus, Rupandehi from February to July 2021 to evaluate spring rice cultivars' growth and yield performance against the planting methods. The trial was set up in a split-plot design consisting of two crop establishment methods: Direct seeded rice (DSR) and Transplanting rice (TPR) as the main factor and seven cultivars as sub-factor, each replicated three times. The cultivars include five released varieties (Hardinath-1, Hardinath-3, Hardinath Hybrid-1, Hardinath Hybrid-3, and Chaite-5) and two promising varieties (IR-15L-1008, and PR-126). 100% spikelet sterility was observed at the maturity stage (115~125 DAS) in all the cultivars and planting methods due to high temperature-induced heat stress, as the average maximum temperature during April was 370 C and the daily maximum temperature throughout the last week of April was above 370 C, coinciding with the flowering stage. Plant height (94.89 cm), leaf area index (5.02), and panicle weight (1.39 g) at 120 DAS were significantly higher in TPR. Spikelet fertility was observed at 150 DAS, when yield attributing characters like panicle length (22.05cm), grains per panicle (130.13), thousand-grain weight (19.79 g), above-ground biomass yield (8.2 tons/ha), and spikelet fertility (75.6%) were found better in TPR than DAR. Thus, TPR was better than DSR in terms of growth, yield attributes, and spikelet fertility parameters. IR-15L-1008 had better plant height (94.54cm), panicle weight (1.39 g), and grains per panicle (130.13); however, it couldn't fit the cropping system due to its long duration. Chaite-5 (84.47%) and PR-126 (84.62%) had significantly($p<0.005$) higher spikelet fertility at 150 DAS, so these could be promising cultivars for the spring season. Cultivars exhibited different responses for various growth and yield attributing parameters due to high-temperature stress. The upcoming research should focus on the selection of elite heat-tolerant cultivars and adjustment of sowing dates that could escape the critical period of high temperature during the reproductive phase of spring rice at Western Terai of Nepal.

KEYWORDS

DSR, High-temperature stress, Spikelet sterility, TPR, Cultivars

1. INTRODUCTION

Rice is the staple food for the majority of the world's population; provides 20% of the global dietary energy supply which is followed by wheat (19%) and maize (5%) (Food and Nutrition Division, 2004). In Nepal, rice ranks first in the terms of area cultivated, production, and livelihood of the people; the total area under rice cultivation is 1.46 million ha producing 5.56 million metric tons with the productivity of 3.81mt/ha (Ajaib, 2014; MOALD, 2019). In Nepal, Spring rice, also known as Chaite rice, contributes 8%of the total rice supplement, while main season rice contributes 92%. (MOALD, 2019). Nepal, the country rich in multiple agro-climatic regions, is enriched in rice genetic resources with more than 1,700 rice landraces growing from 60 m to 3050 m altitude (Thakur et al., 2013). In comparison to main season rice, spring rice is short duration crop; the spring season can be best utilized through its cultivation. Generally, the photoperiod-insensitive varieties of rice are grown in the spring season. Spring rice gives a higher yield than main season rice: more sunny days, better fertilizer use efficiency, better control of water, less weed infestation, etc. Also, spring rice is resistant to many diseases and pests.

In Nepal, rice is established mainly by two principal methods: transplanted rice (TPR) and direct-seeded rice (DSR). The conventional system of rice transplantation involves planting rice seedlings,25-30 days old grown in the nursery, into the puddled field (Shah et al., 2005). Transplanting is cost, time, and labor ineffective: transplanting alone costs about 15% of total rice production cost and also delays transplanting due to labor shortage. Puddling destroys the soil structure forming hardpan in the subsoil; leading to the release of methane, anaerobic decomposition of soil organic matter, and contributing to global warming (Tripathi, 2003; Gao, 2006). DSR could be a good alternative method to overcome these shortcomings. The majority of farmers in Western Terai cultivate monsoon season rice keeping their land fallow during the spring. There are varieties recommended for the spring season in the Terai region by Seed Quality Control Centre, however, their performance in the western part of the Terai region is still a question to extension workers. The trial would provide an insight into the growth and yield performance of the prevailing and promising varieties under DSR and TPR planting methods during the spring season.

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2. Materials and Methods

An on-station experiment was conducted to understand the possibility of spring rice in the Western Terai region of Nepal. The experiment was carried out at the agronomy farm of Paklihawa Campus situated in Rupandehi District from February to July 2021. Geographically, the site is situated at 27.48007°N latitude, 83.44727°E longitude, and 108 meters above sea level. The physical and chemical properties of soil were analyzed before sowing of rice and found to be alkaline (8) with low organic matter (1.57%), low total nitrogen (0.07%), medium phosphorus (34 kg/ha), and potassium (134 kg/ha). The experimental site received a total rainfall of 1416.22 mm during the experimentation period. The average maximum and minimum temperatures during the experimental period were 32.4 ºC and 23.6 ºC respectively. The average maximum temperature during April was 37^0 C and the daily maximum temperature throughout the last week of April was above 37^0 C, coinciding with the flowering stage.

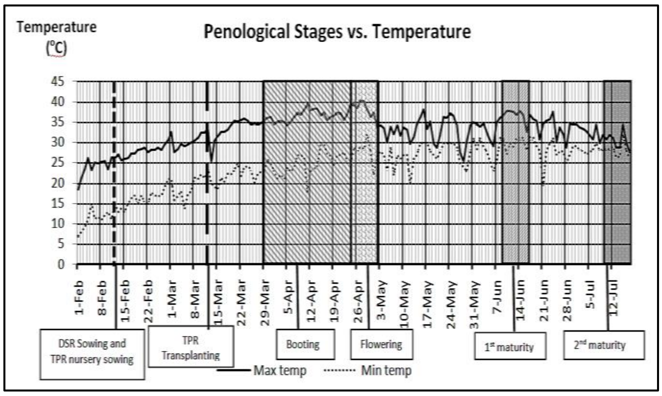

Figure 1: The atmospheric temperature during the experimental period

The trial was set up in a split-plot design consisting of two crop establishment methods (DSR and TPR) as the main factor and seven cultivars as sub-factor, each replicated three times. The cultivars include five released varieties: Hardinath-1(H1), Hardinath-3(H3), Hardinath Hybrid-1(HH1), Hardinath Hybrid-3(HH3), and Chaite-5(C5) and two promising varieties: IR-15L-1008 and PR-126. The size of the experimental unit was 3m*2m. Direct seeding was done continuously in line with 20 cm row spacing and thinning was done 30 days after sowing (DAS) to maintain plant geometry of 20 cm*15 cm. For the transplanting method, 30 days old seedlings were transplanted in line maintaining the same geometry as for DSR. The application rate of organic manure was 20 tons/hectare and chemical fertilizer was 100:60:40kg NPK per hectare. Hand weeding operation was done at 30 DAS in DSR and 60 DAS in TPR.

Growth observations recorded were plant height, leaf area index, above-ground dry matter production, and the number of tillers m^{-2} at 60and 120 DAS.100% spikelet sterility was observed at the maturity stage (115~125 DAS) in all the cultivars and planting methods. However, spikelet fertility was observed in some plants in all the plots at 150 DAS, as we had left the plot unharvested for investigating the reason behind the spikelet sterility. We randomly selected ten panicles from each plot to record yield attributing parameters like panicle length, number of filled and unfilled grains per panicle, sterility percentage, and 1000 grain weight. Above-ground biomass yield was computed from the 1 m^2 sample. Recorded data were subjected to analysis of variance using R analytics software and mean separation was done by Duncan's multiple range test.

3. Results and Discussion

3.1 Effect of Cultivars and Planting Methods on Growth Performance of Spring Rice

Plant height was significantly influenced due to cultivars at 60 DAS but not at 120 DAS. The maximum plant height was observed in IR-15L-1008 at both 60 DAS (30.48 cm) and 120 DAS (94.54 cm) and it was governed by the genetic makeup of this variety. Plant height was significantly higher in TPR plots at both 60 DAS (28.33cm) and 120 DAS (94.8cm). The overall result was found to be similar to the finding of (Poudel et al., 2020). Taller plants in TPR were due to a deeper rooting system as seedlings were firmly planted into the puddled soil and availability of sufficient space and nutrients for growth (Kumar & Jnanesha, 2017) and lesser weed population (Singh et al., 2005).

Leaf Area Index (LAI) was significantly influenced by planting methods at both 60 and 120 DAS. Higher LAI was observed in DSR at 60 DAS (1.282), whereas in TPR at 120 DAS (5.016). Transplanting shock is the reason behind lower LAI in TPR plots at 60 DAS as reported in (Dingkuhn et al., 2000), later at 120 DAS, it was observed higher in TPR plots due to lower plant population that reduced competition between plants and favored the growth of leaves. Cultivars had a non-significant effect on LAI at 60 DAS, while at 120 DAS, HH-1(6.277) had a significantly higher LAI.

The number of tillers m^{-2} was observed to be significantly higher in DSR plots at both 60 DAS (159.52) and 120 DAS (262.38) due to continuous sowing of seeds and higher plant population although thinning were done (Yadav et al., 2011). Among the cultivars, the highest number of tillers m^{-2} was observed in PR-126 (137.66) at 60 DAS and in HH-3 (311.33) at 120 DAS.

Table 1: Effect of Planting Methods and Cultivars on Plant Height, Leaf Area Index, and Number of Tillers/m2 at Different Crop Growth Stages

Treatments	Plant Height (cm) at 60 DAS	Plant Height (cm) at 120 DAS	LAI at 60 DAS	LAI at 120 DAS	Tiller m^{-2} at 60 DAS	Tillers m^{-2} at 120 DAS
Planting Method						
TPR	28.33^{a}	94.89^{a}	0.89^{b}	5.02^{a}	85.95^{b}	204.76^{b}
DSR	25.39^{b}	86.10^{b}	1.28^{a}	4.64^{b}	159.52^{a}	262.38^{a}
SEM (±)	2.72	6.94	27.05	0.032	27.05	13.74
LSD	2.19*	3.49**	0.382*	0.23*	69.05*	49.22*
Cultivars						
Hardinath-1	27.97^{abc}	91.57^{a}	0.8443^{a}	3.64^{b}	93.00^{b}	223.00^{b}
Hardinath-3	24.90^{bc}	88.40^{a}	1.32^{a}	4.86^{ab}	133.83^{a}	202.00^{b}
Hardinath Hybrid-1	25.65^{bc}	91.24^{a}	0.90^{a}	6.27^{a}	112.83^{ab}	223.00^{b}
Hardinath Hybrid-3	28.13^{ab}	88.30^{a}	1.18^{a}	4.55^{ab}	133.50^{a}	311.33^{a}
Chaite-5	24.10^{c}	91.78^{a}	1.01^{a}	3.99^{b}	118.33^{ab}	218.83^{b}
IR-15L-1008	30.48^{a}	94.54^{a}	1.34^{a}	5.24^{ab}	130.00^{ab}	156.33^{b}
PR-126	26.80^{abc}	87.58^{a}	0.98^{a}	5.25^{ab}	137.66^{a}	200.50^{b}
SEM (±)	10.67	43.91	0.22	3.58	10.15	35.5
LSD	3.89*	7.89	0.56	2.26	37.96	71.05***
CV (%)	6.14	7.32	43.15	39.21	25.95	15.87
Grand Mean	26.86	90.48	1.08	4.83	122.73	233.57

In a column figures having the common letter(s) do not differ significantly as per LSD; DAS= Days after sowing; SEM= Standard error of mean * Significant at 0.05 level of significance; ** Significant at 0.01 level of significance; *** Significance at 0.001 level of significance

3.2 Effect of Cultivars and Planting Methods on Yield Attributing Characters of Spring Rice at 120 DAS

100% spikelet sterility was observed at the maturity stage (115~125 DAS) in all the cultivars and planting methods. However, we weighted panicles and found them to be significantly different among the cultivars and planting methods. The highest panicle weight was recorded in TPR (1.39 g) and IR-15L-1008 (1.46 g). High temperature-induced heat stress was the reason for spikelet sterility in spring rice. The average maximum temperature during April was 370 C and the daily maximum temperature throughout the last week of April was above 370 C, coinciding with the flowering stage.

Rice plants are most sensitive to high temperatures during the flowering stage (Satake and Yoshida 1978). The high temperature at this stage significantly decreases spikelet fertility in rice or can even lead to no harvest (Satake and Yoshida 1978; Fu et al. 2012). A maximum of 35 °C fertility decreases under high temperatures because of anther dehiscence inhibition and a reduction of pollen activity like pollen sterility, failed germination on the stigma (Jagadish et al., 2010, 2014; Sunoj et al., 2017), and cessation of pollen tube elongation in the pistil (Karapanos et al., 2010; Snider et al., 2011). Additionally, high temperatures inhibit grain filling during the early stages of ripening (Wei et al., 2002).

3.3 Effect of Cultivars and Planting Methods on Yield Attributing Characters of Spring Rice at 150 DAS

Spikelet fertility was observed in some plants (late tillers) in all the plots at 150 DAS, as we had left the plot unharvested for investigating the reason behind the spikelet sterility. We randomly selected ten panicles from each plot to record yield attributing parameters like panicle length, number of filled and unfilled grains per panicle, sterility percentage, and 1000 grain weight.

Panicle length was significantly affected by both planting methods and cultivars. The longest panicle was observed in TPR plots (22.05 cm), which was similar to as observed in (Kumhar et al., 2016). Among the cultivars, HH-1(23.3 cm) has the longest panicle. Planting methods had no significant effect on the number of grains per panicle, whereas IR-15L-1008 (185) had the significantly highest number of grains per panicle among the cultivars due to its varietal characters. Thousand-grain weight was significantly affected by cultivars, but not by planting methods. The highest 1000 grain weight was obtained in H-3 (24.10) while the lowest in IR-15L-1008 (13.20) due to the varietal characters.

There was no significant difference among planting methods on spikelet sterility percentage at 150 DAS, even though it was higher in DSR (30.13%) in comparison to TPR (24.41%). Cultivars had a significant difference in spikelet sterility percent at 150 DAS, the highest was recorded in H-1(47.01%) and the lowest in C-5 (15.53%) and PR-126 (15.38%) being statistically at par. Biomass yield at 150 DAS was significantly higher in TPR (8.22 t/ha) between planting methods, however, it was statistically at par among the cultivars.

Table 2: Influence of Planting Methods and Cultivars on Panicle Length, Number of Grains/Panicle, 1000 Grain Weight, Grain Yield, Biomass Yield, Panicle Weight, and Spikelet Sterility.

Treatments	Panicle Length (cm)	Grains per Panicle	1000 Grain Weight (g)	Spikelet Sterility (%)	Biomass Yield (t/ha)	Panicle Weight (g) at 120 DAS
Transplanting Method						
TPR	22.05[a]	130.13[a]	19.79[a]	24.41[a]	8.22[a]	1.39[a]
DSR	20.69[b]	118.50[a]	19.47[a]	30.13[a]	7.06[b]	1.076[b]
SEM (±)	0.48	14.19	1.01	159.02	0.45	0.00906
LSD (p=0.05)	0.92*	50.03	1.33	16.74	1.97*	0.13**
Cultivars						
Hardinath-1	19.95[c]	96.65[c]	20.00[c]	47.01[a]	6.77[a]	1.001[e]
Hardinath-3	20.58[bc]	97.98[c]	24.10[a]	20.94[b]	8.52[a]	1.185[cd]
Hardinath Hybrid-1	23.30[a]	110.79[c]	22.12[b]	31.40[ab]	7.51[a]	1.176[cd]
Hardinath Hybrid-3	20.25[c]	110.13[c]	22.37[b]	21.43[b]	7.69[a]	1.166[d]
Chaite-5	21.42[bc]	139.51[b]	16.25[d]	15.53[b]	8.64[a]	1.298[bc]
IR-15L-1008	22.02[ab]	185.00[a]	13.20[e]	39.19[a]	7.64[a]	1.465[a]
PR-126	22.06[ab]	130.16[b]	19.40[c]	15.38[b]	6.72[a]	1.341[e]
SEM (±)	1.577	19.78	0.376	204.71	0.33	0.0107
LSD (p=0.05)	1.49**	16.75***	0.73***	17.04**	2.1	0.124***
CV (%)	3.25	11.31	3.12	46.26	8.81	8.40
Grand Mean	21.37	124.32	19.63	27.27	7.64	1.233

In a column figures having the common letter(s) do not differ significantly as per LSD; DAS/T= Days after sowing/transplanting; SEM= Standard error of mean * Significant at 0.05 level of significance; ** Significant at 0.01 level of significance; *** Significance at 0.001 level of significance.

4. Conclusion

Spring rice is a new intervention for the western terai of Nepal. An on-station experiment was conducted to study its growth and yield performance; however, 100% spikelet sterility was observed at the maturity stage (115~125 DAS) in all the cultivars and planting methods due to high temperature-induced heat stress, coinciding with the flowering stage. Plant height, leaf area index, and panicle weight at 120 DAS were significantly higher in TPR. Spikelet fertility was observed at 150 DAS, when yield attributing characters like panicle length, grains per panicle, thousand-grain weight, above-ground biomass yield, and spikelet fertility were found better in TPR than DSR. Thus TPR was found to be better than DSR in terms of growth, yield attributes, and spikelet fertility parameters. IR-15L-1008 had better plant height, leaf area index, panicle weight, and grains per panicle; however, it couldn't fit the cropping system due to its long duration. Chaite-5 and PR-126 had significantly higher spikelet fertility at 150 DAS. Cultivars exhibited different responses for various growth and yield attributing parameters so, we couldn't come to a concrete conclusion about the suitable cultivars for the spring season. Hence, the upcoming research should focus on the selection of elite heat-tolerant cultivars and adjustment of sowing dates that could escape the critical period of high temperature during the reproductive phase of spring rice at Western Terai of Nepal.

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