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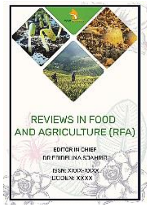

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RESEARCH ARTICLE

VARIETAL PERFORMANCE OF SPRING RICE SEEDLINGS AGAINST COLD STRESS IN WESTERN TERAI OF NEPAL

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ABSTRACT

Rice is an important commodity in Nepalese agriculture occupying 1.46-million-hectare area, where 92% area falls under main (Barkhe) season and 7% under spring (Chaite) season. Among various constraints for spring rice seedling raising, cold stress during early seedling establishment is the major one. To address the problem, an on-station trial entitled "varietal performance of spring rice seedlings against cold stress in Western Terai of Nepal" was conducted from February to March, 2021 at Horticulture research farm of Paklihawa Campus, Rupandehi. Research was carried out in Completely Randomized Design with two growing environment (inside and outside polyhouse) as main factor and seven varieties as sub-factor, each replicated three times. Spring rice varieties includes five released varieties (Hardinath-1, Hardinath-3, Hardinath Hybrid-1, Hardinath Hybrid-3, Chaite-5) and two promising varieties (IR-1008 and PR 126). Data related to growth of seedling were collected at one week interval up to 5 weeks. Significant difference was observed within two environmental conditions on days to germination parameters, shoot length, root length, seedling dry weight and leaf area. The values for all the parameters were found maximum in seedlings inside the polyhouse as compared to that of outside polyhouse and in the variety Hardinath - 1. For early transplanting of spring rice, it was found better to choose Hardinath- 1 variety and raise seedlings under polyhouse nursery to escape cold stress.

KEYWORDS

Nursery, Polyhouse Environment, Seedling, Temperature, Variety

1. INTRODUCTION

Rice (*Oryza sativa*) is an annual, self-pollinated and semi-aquatic plant of Poaceae Family. It is an important commodity in Nepalese agriculture occupying 1,491,744-hectare area with the production of 5.6 million metric ton (MoAD, 2076). Productivity of rice in Nepal is 3.51 mt/ha (AICC, 2019). Rice accounts for 20.75% of total Agricultural Gross Domestic Product (AGDP) and contributes about one-third of the total calorie intake in Nepal. Rice alone contributes 53% to the total cereal food production of Nepal (NARC, 2019). About 92% of rice area falls under main monsoon (*Barkhe*) season while 7% is under spring (*Chaite*) season (Ajay et al., 2020). Spring rice is planted after transplanting 30-40 day old seedlings in the last week of February to the first week of March. Spring rice coverage areas for mountain, hill, and Terai are 5.48, 24.85, and 69.67 percent, respectively (MoAD, 2015). Spring paddy is disease and insect resistant, as well as more efficient in terms of quantity and loss % throughout production. Hardinath-1, Chaite-6, Chaite-4, Chaite-2, Bindeshwori, and CH-45 are some of the most common spring paddy varieties. Spring paddy has a production of 4 tonnes per hectare, compared to 3.17 metric tonnes for ordinary paddy (Aryal, 2018). Spring rice has a short growing season, is resistant to many diseases and pests, and has a good yield potential despite being photoperiod insensitive. Spring rice is typically planted in areas where there is ample irrigation, which helps to reduce weed infestation. During the spring, the light intensity is stronger resulting in a higher yield. Spring rice can also be grown in areas that are susceptible to flooding and landslides during the rainy season (Subedi et al., 2018).

There is a significant difference in rice productivity between achievable yields and yields in most farmer's fields. Among various constraints for spring rice production, lack of knowledge about suitable variety for different agro-climatic zones and methods for early seedling establishment to avoid cold stress are the major ones (Biswas et al., 2019). Major problem associated with spring rice cultivation is that crop should be harvested in monsoon which is a tedious process and even leads to harvest loss during rainfall (CDO AND ASoN, 2017; Dawn, 2007). The cold and foggy weather of February and March is not suitable for the growth of seedlings. The irregular emergence and low plant population caused by non-uniform germination at freezing temperatures has an impact on overall productivity (Koirala et al., 2019). The research done under spring rice in Nepal is not yet as prominent as that of main season rice. The farmers are still following the tradition methods of cultivation and have not been able to upgrade themselves regarding spring rice cultivation techniques. Appropriate nursery growing techniques, as well as genotypes and varieties that can germinate and establish well in freezing temperatures are critical when developing nursery seedlings. By using a polyhouse nursery and covering the rice seed beds with plastic, the cold temperature can be minimized. These procedures allow seedlings to flourish even in cold weather, allowing for a month earlier transplanting and harvesting of spring rice (Dien, 2019; Donoso et al., 2015; Ehleringer and Monson, 1993; Gupta, 1993).

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2. METHODOLOGY

2.1 Experiment Details

A field experiment entitled "Varietal performance of spring rice seedlings against cold stress at western Terai of Nepal" was conducted at horticulture farm of Paklihawa Campus, Rupandehi from February to March, 2021 to evaluate the performance of different varieties and pipelines and identify suitable one for this agro-ecological zone. The site of study was inside Horticulture farm, Institute of Agriculture and Animal Sciences, Rupandehi at 27° 28′ 48.24′′ N; 83° 26′ 50.18′′ E and 108 meter above sea level. The experimental site consists of tropical climate with mean temperature of 26/14°C in February and 32/2°C in March, 2021. The average air temperature and soil temperature differences between inside and outside polyhouse ranges from 2-5°C (Gurjar et a., 2012k Hariman, 2014). The soil of research side was found alkaline in nature with pH 8. Research was carried out in Completely Randomized Design with two growing environment (inside and outside polyhouse) as main factor and seven varieties as sub-factor, each replicated three times. So the total number of treatments was 14 and the number of nursery seed beds reached to 42 with an area of 0.37 m2 each bed (1 ft * 4 ft). The nursery beds were randomly allotted by lottery method (IRRI, 2007). The setup of 21 nursery beds were done in outside environment. In a similar way, 21 beds were setup inside the polyhouse. The nursery seed bed were each of 0.37 m2 each separated by plywood pieces (Kraehmer et al., 2017; Krishnasamy and Seshu 1989). Total area of seed bed inside and outside polyhouse was 15.54 m2.

The treatment details is shown in table 1:

Table 1: Treatment Details for The Research

S.N.	Main factor (Nursery Environment Condition)	S.N.	Sub Factor (Varieties)
1.	Open Nursery Environment	1.	Hardinath-1
2.	Polyhouse Nursery Environment	2.	Hardinath-3
		3.	Hardinath hybrid-1
		4.	Hardinath hybrid-3
		5.	Chaite-5
		6.	IR-1008
		7.	PR-126

2.2 Seedling Management Practices and Data Collection

Framed structure of GI pipes with protective shade made up of polythene was setup for growing spring rice seedlings inside the polyhouse nursery. Temperature, humidity, ventilation of were controlled by the equipment fixed in the polyhouse (Mason, 2019; Nene, 2005; Patel, 2020). Hydro priming was done for the seeds on 9th February, 2021by keeping the seeds for 24 hours in water. Seed incubation was done on 10th February, 2021 by covering the seeds for 26 hours by a cloth. Land was levelled and made weed free to make it suitable for placement of tray for sowing of spring rice seeds. The area inside the plastic house was cleaned per need and for cold stress condition, homogenous area outside the plastic house was maintained. Plastic was set on the levelled floor for modified mat nursery. FYM was mixed along with sand and soil in the ratio of 1:1:1 for the preparation of modified Dapog method nursery on 11th February, 2021. After seed inoculation, the rice seeds were sown in the tray for calculating the germination percentage. 100 seeds were sown in each tray by making 5 columns. Remaining seeds were sown by broadcasting method in the modified mat nursery for both inside and outside polyhouse (Perumal et al., 2013; Pinoy Rice Knowledge Bank, 2020; Priyanka and Jaiswal, 2017; Sarangi et al., 2015). Light irrigation was provided daily in the nursery for growth of seedlings with the help of watering can as per requirement.

Number of seedlings emerged daily were counted from day of planting the seeds in the medium till the time germination is complete. Germination Percentage and germination index (G.I.) were computed by using formula (Saveer Biotech Limited, 2021; Singh, 2017; Singh, 2012; SQCC, 2018). Days to 50% germination and days to 100% germination of the seeds were measured from each tray. For seedling shoot length, ten destructive samples were collected at the interval of seven days and length of shoot from basal node to the tip of seedling was recorded. Similarly for seedling root length, ten destructive samples were collected at interval of 7 days and the length of root from basal node to the tip of root were recorded (TNAU, 2021; Tripathi et al., 2017; Watt, 1891; Yadav, 2010; Yoshida, 1981). To calculate the dry weight of seedlings, fresh sample (root and shoot parts) were taken and kept for oven drying at 105°C for 24 hours and then their dry weight was measured by electric digital weighing balance. Number of leaves from each of the five samples from each plot was recorded. The breadth and length of each leaves from the 5 sample were recorded to calculate leaf area,

2.3 Statistical Analysis

The collected data were tabulated in Microsoft-Excel worksheet and analysis was done with the help of R-stat program. ANOVA of all parameters was performed in CRD. Mean was separated by Duncan's Multiple Range Test at 5% level of significance. Final result was interpreted with the help of necessary tables with related references.

3. RESULT AND DISCUSSION

3.1 Germination Parameter

There was significant difference within two environmental conditions on germination percentage, days to 50% & 100% germination. Germination was seen 14% faster inside the polyhouse as compared to outside environment. The rate of germination and germination index were also found highest inside the polyhouse. There was significant differences among the varieties for germination percentage, days to 50% and 100% germination and germination index. Hardinath hybrid -1 showed the highest percentage of germination which is statistically similar to Hardinath-1. Days to germination was found fastest in Hardinath-1 (13.67) and slowest in IR-1008 (18.67). Germination index was found highest in Hardinath-1 (39.51) and lowest in IR-1008 (29.66). Rice seeds require warm temperatures for germination and are very sensitive to cold water which is the reason for better seedlings establishment inside the polyhouse. Similar trend was observed by in spring rice where seedling growth was 50% faster inside the polyhouse as compared to outside.

Table 2: Germination parameter of spring rice seedlings in different environmental conditions

	Germination Percentage (%)	Days to Germination 50%	Days to Germination 100%	Germination Index
Factor A				
Inside	79.48^{a}	16.05^{b}	21.14^{b}	34.26^{a}
Outside	77.43^{b}	17.52^{a}	24.05^{a}	32.36^{b}
LSD SEM F-value	1.78 0.61 5.56*	0.67 0.23 20.45***	0.88 0.31 45.38***	1.17 0.40 11.05**
Factor B				
Hardinath-1	80.17^{ab}	13.67^{c}	21.00^{c}	39.51^{a}
Hardinath-3	77.00^{bc}	14.50^{c}	21.83^{bc}	32.64^{bc}
Hardinath Hybrid-1	81.50^{a}	18.17^{a}	23.83^{a}	33.72^{b}
Hardinath Hybrid-3	75.67^{c}	18.33^{a}	23.00^{ab}	34.56^{b}
Chaite-5	79.50^{ab}	18.17^{a}	23.00^{ab}	30.83^{cd}
IR-1008	77.83^{bc}	18.67^{a}	23.00^{ab}	29.66^{d}
PR-126	77.50^{bc}	16.00^{b}	22.50^{abc}	32.23^{bc}
LSD SEM F-value	3.33 1.15 3.09*	1.25 0.43 22.62***	1.65 0.57 2.64*	2.18 0.75 17.98***
CV **Grand Mean**	**3.59** **78.46**	**6.30** **16.79**	**6.18** **22.60**	**5.54** **33.31**

In a column figure having the common letter(s) do not differ significantly as per LSD; 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 Shoot Length

There was significant difference within two environmental conditions on shoot length. Shoot development was found 43% higher inside the polyhouse as compared to outside environment on 28th DAS. There was significant difference among the varieties for shoot length in all studied durations. The results revealed that at 14 DAS the highest shoot length was found in Hardinath-1(4.14cm) and shortest shoot length was obtained in IR-1008(2.56cm) which is statistically similar with PR-126(2.69cm). Similarly at 21 DAS highest shoot length was obtained in Hardinath-1 (7.93cm) and shortest shoot length was obtained in chaite-5(4.27cm). On 28 DAS highest shoot length was found in Hardinath-3(10.93cm) which was statistically similar with Hardinath-1(10.31cm) and shortest shoot length was obtained in chaite-5 (7.5cm) which is statistically similar with IR-1008(7.59cm). Similar results were obtained in research of where average plant height of seedlings in polyhouse was 40% more as compared to that of outside environment (Rafeeq et al., 2020). A group researcher where crop establishment was 52% higher in poly house as compared to open condition (Rajan et al., 2011).

Table 3: Shoot Length and Root Length of Spring Rice Seedlings in Different Environmental Conditions

	Shoot Length (cm)				Root Length (cm)			
Factor A	14DAS	21 DAS	28 DAS	35 DAS	14 DAS	21 DAS	28 DAS	35 DAS
Inside	3.94a	6.88a	10.90a	15.15a	4.75a	5.99a	5.50a	6.79a
Outside	2.48b	5.20b	7.65b	10.55b	3.55b	3.97b	2.90b	4.84b
LSD	0.32	0.34	0.73	0.69	0.50	0.42	0.56	0.60
SEM	0.11	0.12	0.25	0.24	0.17	0.15	0.19	0.21
F-valueSD	87.49***	102.51***	83.89***	187.32***	24.60***	94.87***	91.40***	44.98***
Factor B								
Hardinath-1	4.14a	7.93a	10.31a	13.05b	4.65	6.02a	5.07a	5.57
Hardinath-3	2.89cd	6.10c	10.93a	14.42a	3.76	5.48ab	4.18ab	5.42
Hardinath Hybrid-1	3.62ab	7.21b	9.51a	13.05b	4.27	4.97bc	4.15ab	6.45
Hardinath Hybrid-3	3.44bc	6.13c	9.43a	14.41a	3.97	4.54c	3.44b	6.47
Chaite-5	3.15bcd	4.27d	7.57b	10.99d	4.64	4.28c	4.27ab	5.94
IR-1008	2.56d	4.30d	7.59b	11.58cd	4.08	4.12c	3.73b	5.29
PR-126	2.69d	6.34c	9.57a	12.43bc	3.69	5.45ab	4.56ab	5.60
LSD	0.60	0.64	1.36	1.29	0.93	0.79	1.04	1.12
SEM	0.21	0.22	0.47	0.45	0.32	0.27	0.36	0.39
F-value	7.36***	38.74***	7.33***	8.59***	NS	6.61***	NS	NS
CV	**15.75**	**8..91**	**12.42**	**8.48**	**19.02**	**13.51**	**20.99**	**16.23**
Grand Mean	**3.21**	**6.04**	**9.27**	**12.85**	**4.15**	**4.98**	**4.20**	**5.82**

3.3 Root Length

There was significant difference within two environmental conditions on root length. Root development was seen 89% higher inside the polyhouse as compared to outside environment on 28th DAS. There was significant difference among the varieties for root length in 21 DAS. The results revealed that at 21 DAS highest root length was obtained in Hardinath-1 (6.02 cm) which was at par with Hardinath-3 (5.48 cm) and PR-126 (5.45 cm) and shortest route length was obtained in IR-1008 (4.12 cm) which was statistically similar with Chaite-5 (4.28 cm) and Hardinath Hybrid-3 (4.54 cm). Similar results were obtained for boro rice seedlings where surface area and length of root showed 41 to 80 % higher growth inside the polyhouse over open condition in an research conducted in India (Rajan et al., 2011). The higher root growth observed under poly house condition might be due suitable soil temperature prevailed inside poly house and the soil temperature being constantly higher under poly house condition (NARC, 2078).

3.4 Leaf Number

There was no significant difference within two environmental conditions on seedling leaf number on 21 DAS, 28 DAS and 35 DAS. The results revealed that at 21 DAS highest leaf number was observed in Hardinath-1 (1.90) and lowest leaf number was obtained in Chaite-5 (1.20). Similarly at 35 DAS highest leaf number was observed in PR-126(3.05) and lowest leaf number was obtained in Chaite-5(2.27). Higher temperature and controlled environment enhanced the growth of leaves (NARC, 2021).

Table 4: Leaf Number and Leaf Area Parameter of Spring Rice Seedlings in Different Environmental Conditions

	Leaf Number			Leaf Area (cm)		
Factor A	21DAS	28 DAS	35 DAS	21DAS	28 DAS	35 DAS
Inside	1.59	2.04	2.67	0.13a		0.23a
Outside	1.51	2.01	2.55	0.08b	0.19b	0.23
LSD	0.15	0.14	0.17	0.014	0.02	0.038
SEM	0.05	0.05	0.06	0.005	0.007	0.013
F-value	NS	NS	NS	55.66***	19.63***	NS
Factor B						
Hardinath-1	1.90a	2.28a	2.97ab	0.13a	0.24ab	0.26a
Hardinath-3	1.60b	1.97b	2.37cd	0.12ab	0.21bc	0.29a
Hardinath Hybrid-1	1.60b	2.00ab	2.43cd	0.11ab	0.23ab	0.28a
Hardinath Hybrid-3	1.43bc	1.85b	2.52cd	0.12ab	0.26a	0.27a
Chaite-5	1.20c	1.92b	2.27d	0.09b	0.16d	0.18b
IR-1008	1.43bc	2.07ab	2.67bc	0.09b	0.17cd	0.20b
PR-126	1.68ab	2.10ab	3.05a	0.12ab	0.20bc	0.24ab
LSD	0.28	2.06	0.32	0.027	0.037	0.071
SEM	0.09	0.09	0.11	0.009	0.013	0.025
F-value	5.32***	NS	7.37***	NS	7.61***	3.024*
CV	**15.20**	**11.06**	**10.40**	**21.62**	**15.18**	**24.40**
Grand Mean	**1.55**	**2.03**	**2.61**	**0.11**	**0.21**	**0.25**

3.5 Leaf Area

There was significant difference within two environmental conditions on seedling leaf area on 21 DAS and 28 DAS. Seedling leaf area was seen 62.5% and 21.05% higher inside the polyhouse as compared to outside environment on 21st DAS and 28 DAS respectively. There was significant difference among the varieties for seedling leaf area in 28 DAS and significant difference in 35 DAS. In outside environment, average maximum leaf area was showed by Hardinath Hybrid-3 and minimum area was showed by Chaite- 5 in both 28 DAS and 35 DAS. Similar phenomenon was observed in experiment of in tomato where tallest plants, maximum number of branches/plants, higher leaf area expansion rate and LAI were seen in the plants grown under polyhouse as compared to natural condition (Parvej et al., 2010). Temperature is the principal environmental determinant of crop leaf appearance; higher temperature has positive effect on leaf area growth. (Hatfield and Prueger, 2015).

3.6 Seedling Dry Weight

There was significant difference on seedling dry weight among varieties and within nursery environmental conditions at 14 DAS and 21 DAS 14 DAS and 21 DAS. Seedling dry weight was seen 43% higher inside the polyhouse as compared to outside environment on 21st DAS. There was significant difference among the varieties for seedling dry weight in 14 DAS and 21 DAS. The results revealed that at 14 DAS highest seedling dry weight was obtained in IR-1008 (0.026 g) and lowest seedling dry weight was obtained in Hardinath Hybrid-1(0.017 g) which was statistically similar with rest of the varieties Similarly at 28 DAS highest dry weight was obtained in Hardinath-1 (0.051 g) which is similar with Hardinath-3(0.050 g) and lowest dry weight was obtained in IR-1008(0.022 g) which was statistically similar Hardinath hybrid-1(0.027 g). The obtained result is supported by published research on boro rice seedling where crop stand, and overall growth was superior under poly house over open condition. Root weight under poly house showed 98 % higher than open condition (Rashid and Yasmeen, 2017).

Table 5: Seedling Dry Weight of Spring Rice Seedlings in Different Environmental Conditions

	Seedling Dry Weight (g)			
Factor A	14DAS	21 DAS	28 DAS	35 DAS
Inside	0.024^{a}	0.028^{b}	0.041	0.053
Outside	0.016^{b}	0.040^{a}	0.031	0.057
LSD SEM F-value	0.003 0.001 33.72^{***}	0.007 0.003 11.48^{**}	0.011 0.004 NS	0.053 0.005 NS
Factor B				
Hardinath-1	0.020^{b}	0.034	0.051^{a}	0.051^{b}
Hardinath-3	0.020^{b}	0.037	0.050^{a}	0.054^{b}
Hardinath Hybrid-1	0.017^{b}	0.031	0.027^{b}	0.046^{b}
Hardinath Hybrid-3	0.019^{b}	0.037	0.031^{ab}	0.081^{a}
Chaite-5	0.018^{b}	0.033	0.034^{ab}	0.049^{b}
IR-1008	0.026^{a}	0.026	0.022^{b}	0.041^{b}
PR-126	0.021^{b}	-0.039	0.038^{ab}	0.062^{ab}
LSD SEM F-value	0.006 0.002 2.45^{*}	0.014 0.005 NS	0.021 0.007 2.59*	0.025 0.009 NS
CV **Grand Mean**	**23.21** **0.02**	**34.98** **0.034**	**47.38** **0.036**	**39.03** **0.055**

3.7 Correlation of Different Parameters With Seedling Dry Weight

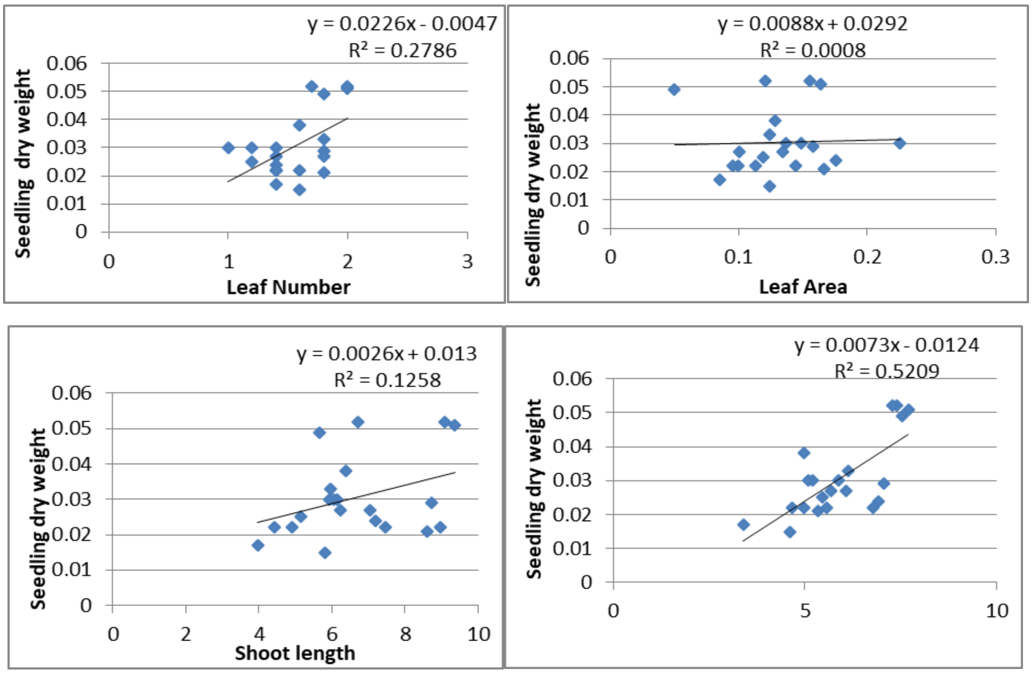

Figure 1: Relationship between different seedling parameters (shoot length, root length, leaf number & leaf area) with seedling dry weight (Paklihawa, Rupandehi, 2021).

The figures depict that there is positive correlation between the seedling dry weight with shoot length, root length, leaf number and leaf area each. With increase in shoot length, root length, leaf number and leaf area, the seedling dry weight has increased. The correlation was found non - significant on shoot length (0.354) and leaf area (0.028) but highly significant on root length (0.722**) and leaf number (0.722**).

4. Conclusion

Research entitled "Varietal Performance of Spring Rice against Cold Stress at Western Terai of Nepal" was conducted from February to March, 2021 at Horticulture research farm of Paklihawa Campus, Rupandehi. Research was carried out in Completely Randomized Design with two growing environment (inside and outside polyhouse) as main factor and seven varieties as sub-factor replicated thrice. Data related to germination and growth of seedling was collected at one week interval up to 5 weeks. The significant difference was seen within two environmental conditions on Days to germination, shoot length, root length, seedling dry weight and leaf area. Germination was seen 14% faster, shoot length development was 43% higher, root length development was 89% higher, seedling dry weight was 43% higher and leaf area development was 40% higher inside the polyhouse as compared to outside environment. Days to germination was found fastest in Hardinath-1 (13.67) The highest shoot length (4.14 cm), root length (6.02 cm), seedling dry weight (0.051 g) and highest leaf number (1.90) was found was found in check variety Hardinath-1. Similarly, the average maximum leaf area was showed by Hardinath

Hybrid-3. The nursery performance of Hardinath-1 was found best inside the polyhouse as it showed the best results for each recorded parameters. For early transplanting of spring rice, it was found better to raise seedlings under polyhouse nursery to escape cold stress. The nursery performance of Hardinath-1 was found better in terms of germination and seedling growth parameters. We can conclude about the best variety only after analyzing the yield of varieties on the field. Research on the similar topic with numerous genotypes and multi-seasonal trial should be conducted to find out best variety of spring rice against cold stress condition. Field performance should be observed in order to evaluate the overall performance of spring rice varieties.

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