International Journal for Research in Applied Sciences and Biotechnology

ISSN: 2349-8889
Volume-8, Issue-2 (March 2021)

www.ijrasb.com

https://doi.org/10.31033/ijrasb.8.2.25

Rice (*Oryza sativa* L.) Seed Priming: It's Effect on Seed Germination and Seedling Emergence of Spring Varieties in Kapilvastu District, Nepal

Sabita Ghimire[1], Hariom Yadav[2], Prabesh Acharya[3] and Raju Kharel[4]
[1]Faculty of Agriculture, Agriculture and Forestry University, Chitwan, NEPAL
[2]Faculty of Agriculture, Agriculture and Forestry University, Chitwan, NEPAL
[3]Faculty of Agriculture, Agriculture and Forestry University, Chitwan, NEPAL
[4]Department of Genetics and Plant Breeding, Agriculture and Forestry University, Chitwan, NEPAL

[2]Corresponding Author: yadav.hari09045@gmail.com

ABSTRACT

This study aimed to determine the effect of seed priming (on-farm, hydro, halo, osmo, vitamin c priming, and hardening) on the germination and seedling growth of spring rice varieties: hardinath-3, hardinath-1, and chaite-5 at ambient room temperature. A factorial completely randomized design (CRD) was carried out with two factors: methods of priming and varieties at agriculture knowledge center (AKC), kapilbastu during march 2020. There were, in total, 21 treatment combinations and four replications. Parameters observed were germination percentage, speed of germination, vigor index, root length, shoot length, fresh weight, and dry weight of rice seedlings. Hardinath-3 had superior performance in terms of germination percentage (95.35 %), vigor index (183.86), root length (11.51 cm) and shoot length (7.39 cm) compared to hardinath-1 and chaite-5; the speed of germination, however, was greater in hardinath-1. Seed hardening - alternate soaking (tap water for 24 hours) and drying - induced higher germination percentage (94.91 %), speed of germination (96.00), and vigor index (197.43) than did other priming methods; germination percentage of vitamin c primed seeds (94.75 %), nevertheless, were at statistical par with hardened seeds. Hardened hardinath-3 seeds were better in regards to germination percentage (97.50 %) and root length (12.92 cm), while the speed of germination (97.50) and vigor index (210.50) was greater in hardened hardinath-1. Vitamin c primed seeds of hardinath-3 and hardinath-1 were finer with dry weight, shoot length, and vigor index. In conclusion, farmers' are suggested to hardened seeds of hardinath-3 before sowing to promote uniform germination and growth.

Keywords- Germination percentage, Hardening, Speed of germination, Vigor index, Vitamin C priming.

I. INTRODUCTION

Rice (*Oryza sativa* L.) is a prominent cereal crop that has tremendous potential to improve the national economy, maintain food security, and enhance the general welfare of people; hence, it is generally deemed as "Grain of Gold" in Nepalese society. Rice contributes 20% to the agricultural gross domestic product (AGDP) and almost 7% to GDP (CDD, 2015). It is cultivated in 43.24 % of the total cereal covered area, with average productivity of 3.76 metric tons per hectares (Mt/ha). The staple crop, Rice, is sown twice (spring and main season) in a year; spring rice varieties cover 8.05 % of the total rice production area with a yield of 4.50 Mt/ha, while main season rice varieties encompass 91.95 % with a yield of 3.70 Mt/ha. Nepal has exported 11,898 metric tons (Mt) of rice; however, there is a trade deficit of 3.26 trillion Nepalese rupees (MoAD, 2017/18). Kapilbastu, a plain region of Nepal, has a 4.24 % stake in total rice production; spring rice varieties contribute 0.45 % to its total rice production area with a yield of 4.45 Mt/ha (MoAD, 2017/18).

The requirement of rice seed in Nepal is about 73,477 Mt, while domestic production of seed covers merely 18.42 %. Farmers' are struggling: meager seed supply, poor seed germination, and seedling establishment, inadequate technical knowledge, and unpredictable weather parameters. The growth of rice, during the spring season in Nepal, is scarce due to poor seedling establishment, resulting in the lowered vigor, crop stand, and final yield (Poudel and Ghimire, 2019).Some farmers are practicing seed priming as a method to curtail this problem, but the execution is not enough. Seed priming is a technique that may boost the germination percentage, speed, and uniformity of germination in rice seeds. Seed priming is based on seed imbibition, which can be divided into three phases: the imbibition phase - which allows the seed to imbibe water to activate enzyme activity; the activation phase, during which, food reserve degradation, cell membrane reorganization, and starch biosynthesis occur to support root protrusion; the third phase is the growth phase, where radicle protrusion can be seen and then root growth and seedling growth continue (Ruttanaruangboworn et al., 2017). This research, on seed priming, aims to identify an effective method of seed treatment to administer the hardships faced by the farmers of Kapilbastu, due to poor seed germination and seedling establishment, eventually enhancing uniform seed germination and germination percentage of rice.

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II. MATERIALS AND METHODS

The experiment studied the effect of seed priming on seed germination and seedling establishment of spring rice varieties at Agriculture Knowledge Center, Kapilbastu. A factorial completely randomized design was carried out with two factors: methods of priming (with seven levels) and Varieties (with three levels); hence, there were, in total, 21 treatments, and 4 replications. Selected varieties of rice, for research, were commonly cultivated in the study area, Kapilbastu, during the spring season. Each plot, in total 84 plots, subsumes 100 seeds kept in wet germination paper, tied with rubber, and placed at ambient room temperature.

Treatment details

Factor 1: Methods of priming

C_1: On-farm priming (seeds were soaked overnight in water before sowing)

C_2: Hardening (alternate soaking of seeds in tap water for 24 hours and drying)

C_3: Hydro priming (seeds were soaked with distilled water for 48 hours)

C_4: Halo priming (seeds were soaked with 1 mole NaCl solution for 24 hours)

C_5: Osmo-priming (seeds were soaked with 10% PEG solution)

C_6: Vitamin C (Vit-C) priming (seeds were soaked with 1 gram ascorbic acid solution)

C_7: Control (No priming)

Factor 2: Varieties

V_1: Hardinath-3

V_2: Hardinath-1

V_3: Chaite-5

Data and data types

Seed quality parameters such as germination percentage, speed of germination, germination energy, vigor index, root and shoot length, fresh and dry weight of seedlings were collected at different days after placing (DAP).

Germination percentage

The germination percentage was computed by dividing the number of germinated seeds by the total number of seeds for the test, multiplying by 100.

Speed of germination

The formula used for the estimation of the speed of germination was the number of seeds germinated after 72 hours divided by the number of seeds germinated after 168 hours.

Vigor index

It is the total of all attributes of seeds that indicates the potential level and activity of seed during germination and seedling emergence. It was calculated by using the formula given by Maguire ID (1962).

$$\textbf{Vigor index} = X_1/N_1 + X_2/N_2 + \ldots\ldots\ldots\ldots\ldots + X_n/N_n$$

Where,

X_1= number of seedlings at first count
N_1= number of days at first count
X_2= number of seedlings at second count
N_2 = number of days at second count
X_n= number of seedlings at final count
N_n = number of days at final count

Statistical analysis

Data recording and tabulation were done using programs: MS Word and MS Excel, and statistically evaluated using analysis tools: R-stat and MS Excel. Duncan's Multiple Range Test (DMRT) was enacted for mean comparison following the methods stated by Gomez & Gomez, (1984).

III. RESULTS

Seed priming has a significant influence on germination percentage, speed of germination, vigor index, root and shoot length, and dry weight of rice seedlings. Hardened and vitamin Ctreated seeds portrayed the highest germination (94.91 % and 94.75 % respectively), while the speed of germination was greater (96.00) in hardened seeds. Both hardened and hydro-primed seeds had equal vigor index and root length, but shoot length was more in hydro-primed seeds at 7 days after pacing (DAP) as shown in table 1. Moreover, hydro-primed seeds performed better in terms of root length (11.31 cm), shoot length (7.53 cm), and dry weight (315 mg) of seedlings at 15 DAP (as shown in table 3).

Table 1: Effect of different priming methods and varieties on seed quality parameters of rice at 7 DAP in Kapilbastu, Nepal, 2020

Treatments	Germination (%)	Speed of germination	Vigor index	Root length (cm)	Shoot length (cm)
Methods of priming					
C_1	93.58^{bc}	92.16^{d}	155.51^{c}	4.394^{c}	1.54^{f}
C_2	94.91^{a}	96.00^{a}	197.43^{a}	6.86^{a}	2.69^{c}
C_3	92.66^{c}	95.53^{ab}	193.57^{a}	7.42^{a}	3.67^{a}
C_4	91.25^{d}	92.91^{cd}	111.16^{d}	6.88^{a}	1.87^{ef}
C_5	93.58^{b}	95.58^{ab}	175.48^{b}	7.38^{a}	2.307^{d}

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C_6	94.75^{a}	94.83^{abc}	192.43^{a}	7.11^{a}	3.17^{b}
C_7	93.00^{c}	93.51^{bcd}	156.08^{c}	5.48^{b}	2.18^{de}
LSD (= 0.05)	0.54	2.18	14.38	0.54	0.34
SEm (±)	0.12	0.51	3.33	0.12	0.08
F probability	<0.001	<0.001	<0.001	<0.001	<0.001
Varieties					
V_1	95.35^{a}	94.07^{ab}	183.86^{a}	7.07^{a}	2.42^{b}
V_2	92.82^{b}	95.42^{a}	174.59^{a}	6.23^{b}	2.74^{a}
V_3	91.82^{c}	93.50^{b}	147.98^{b}	6.21^{b}	2.31^{b}
LSD (= 0.05)	0.35	1.43	9.41	0.35	0.23
SEm (±)	0.19	0.77	5.08	0.19	0.12
f-probability	<0.001	0.01	<0.001	<0.001	<0.001
CV (%)	0.71	2.83	10.22	10.18	17.02

Note: The common letter(s) within the column indicate non-significant difference based on DMRT at 0.05 level of significance.

Table 2: Seed quality parameters influenced by the interaction of priming methods and spring rice varieties at 7 DAP in Kapilbastu, Nepal, 2020

Treatments (Interaction)	Germination (%)	Speed of germination	Vigor index	Root length (cm)	Shoot length (cm)
V_1 C_1	95.75	91.75	163.29^{cde}	5.02^{ij}	0.90^{g}
V_1 C_2	97.50	95.50	201.22^{ab}	7.95^{abc}	2.57^{bcd}
V_1 C_3	93.50	94.00	204.58^{ab}	8.10^{ab}	2.72^{bc}
V_1 C_4	91.75	91.50	145.56^{ef}	7.69^{bcd}	1.63^{f}
V_1 C_5	96.25	96.00	190.47^{abc}	8.88^{a}	2.59^{bcd}
V_1 C_6	96.50	95.00	213.61^{a}	7.74^{bc}	3.02^{b}
V_1 C_7	96.25	94.75	168.28^{cde}	4.09^{jk}	2.10$^{c\text{-}f}$
V_2 C_1	93.00	93.00	147.67^{ef}	3.96^{k}	0.99^{g}
V_2 C_2	93.75	97.50	210.50^{a}	6.19^{fgh}	3.10^{b}
V_2 C_3	93.00	94.50	203.55^{ab}	7.13$^{b\text{-}f}$	2.40$^{b\text{-}e}$
V_2 C_4	90.50	95.00	110.86^{g}	7.18$^{b\text{-}f}$	2.19$^{c\text{-}f}$
V_2 C_5	92.75	96.75	172.50^{cde}	5.92^{ghi}	2.51^{bcd}
V_2 C_6	94.50	96.75	210.15^{a}	6.65$^{d\text{-}h}$	3.97^{a}
V_2 C_7	92.25	94.50	166.83^{cde}	6.55$^{e\text{-}h}$	2.52^{bcd}
V_3 C_1	90.75	91.75	155.56^{def}	4.19^{jk}	4.13^{a}
V_3 C_2	93.50	95.00	180.54^{bcd}	6.44$^{e\text{-}h}$	3.89^{a}
V_3 C_3	91.50	97.50	172.58^{cde}	7.03$^{b\text{-}f}$	2.99^{b}
V_3 C_4	91.50	92.25	153.25^{def}	5.76^{hi}	1.78^{ef}
V_3 C_5	91.75	94.00	163.46^{cde}	7.33$^{b\text{-}e}$	1.81^{ef}
V_3 C_6	93.25	92.75	153.52^{def}	6.93$^{c\text{-}g}$	2.52^{bcd}
V_3 C_7	90.50	91.25	133.13^{fg}	5.79^{hi}	1.92^{def}
LSD (= 0.05)	NS	NS	24.91	0.94	0.59
SEm (±)	0.33	1.33	8.81	0.33	0.212
f-probability	0.40	0.34	<0.001	<0.001	<0.001
CV (%)	0.71	2.83	10.22	10.18	17.02
Grand mean	93.33	94.33	172.43	6.50	2.49

Note: The common letter(s) within the column indicate non-significant difference based on DMRT at 0.05 level of significance.

ISSN: 2349-8889
Volume-8, Issue-2 (March 2021)
https://doi.org/10.31033/ijrasb.8.2.25

Table 3: Effect of different priming methods and varieties on root and shoot length, fresh and dry weight of rice seedlings in Kapilbastu, Nepal, 2020

Treatments	Root length (cm)		Shoot length (cm)		Fresh weight (mg)	Dry weight (mg)
	10 DAP	15 DAP	10 DAP	15 DAP	15 DAP	15 DAP
Methods of priming						
C_1	8.45^{d}	9.65^{d}	5.02^{c}	6.23^{d}	538.75	269.58^{b}
C_2	10.13^{a}	11.31^{a}	6.28^{a}	7.53^{ab}	598.83	315.75^{a}
C_3	9.71^{abc}	10.95^{ab}	5.23^{c}	6.59^{cd}	555.58	277.75^{b}
C_4	9.51^{bc}	10.73^{ab}	5.19^{c}	6.54^{cd}	533.16	266.83^{b}
C_5	8.61^{d}	9.89^{cd}	5.80^{b}	7.00^{bc}	544.41	275.33^{b}
C_6	10.06^{ab}	11.07^{ab}	6.60^{a}	7.34^{a}	549.91	280.91^{ab}
C_7	9.41^{c}	10.45^{bc}	5.32^{c}	6.70^{cd}	505.50	252.83^{b}
LSD (= 0.05)	0.56	0.57	0.45	0.55	NS	35.54
SEm (±)	0.15	0.15	0.12	0.45	14.96	8.23
f-probability	<0.001	<0.001	<0.001	<0.001	0.18	0.05
Varieties						
V_1	10.43^{a}	11.51a	5.99^{b}	7.39^{a}	561.39	281.71
V_2	9.13^{b}	10.27^{b}	6.33^{a}	7.46^{a}	558.28	284.39
V_3	8.67^{c}	9.96^{b}	4.57^{c}	5.85^{b}	520.10	264.89
LSD (= 0.05)	0.36	0.37	0.29	0.38	NS	NS
SEm (±)	0.22	0.24	0.18	0.22	22.86	12.57
f-probability	<0.001	<0.001	<0.001	<0.001	0.10	0.20
CV (%)	7.28	6.71	9.78	9.69	14.48	15.72

Note: The common letter(s) within the column indicate non-significant difference based on DMRT at 0.05 level of significance.

Table 4: Effect of interaction (priming methods and spring rice varieties) on fresh weight, root length, shoot length of rice seedling in Kapilbastu, Nepal, 2020

Treatments (Interaction)	Root length (cm)		Shoot length (cm)		Fresh weight (mg)	Dry weight (mg)
	10DAP	15 DAP	10 DAP	15 DAP	15 DAP	15 DAP
V_1 C_1	9.44^{cd}	10.68^{c}	5.23^{f-j}	6.44^{f-i}	600.00^{ab}	300.00^{abc}
V_1 C_2	11.82^{a}	12.92^{a}	4.90^{ij}	6.48^{f-i}	466.50^{bc}	233.50^{cd}
V_1 C_3	10.77^{b}	11.91^{ab}	7.23^{ab}	8.36^{ab}	633.50^{a}	316.50^{ab}
V_1 C_4	10.91^{ab}	11.94^{ab}	5.99^{def}	7.40^{b-f}	533.00^{abc}	267.00^{a-d}
V_1 C_5	9.82^{bcd}	11.08^{ab}	5.84^{d-h}	7.14^{c-g}	600.00^{ab}	300.00^{abc}
V_1 C_6	10.39^{bc}	11.24^{bc}	6.87^{bc}	7.82^{a-d}	596.75^{ab}	305.00^{abc}
V_1 C_7	9.85^{bcd}	10.84^{bc}	5.91^{d-g}	8.10^{abc}	500.00^{abc}	250.00^{bcd}
V_2 C_1	8.20^{ef}	9.30^{def}	5.78^{d-i}	6.90^{d-h}	516.50^{abc}	258.50^{a-d}
V_2 C_2	8.28^{ef}	9.45^{def}	6.15^{cde}	7.31^{b-g}	600.00^{ab}	300.00^{abc}
V_2 C_3	9.45^{cd}	10.79^{bc}	6.53^{bcd}	7.63^{bcde}	500.00^{abc}	250.00^{bcd}
V_2 C_4	9.59^{cd}	10.79^{bc}	5.53^{e-i}	6.68^{e-h}	533.25^{abc}	266.75^{a-d}
V_2 C_5	9.08^{de}	10.28^{cde}	6.55^{cd}	7.63^{b-e}	600.00^{ab}	309.25^{ab}
V_2 C_6	9.94^{bcd}	10.93^{bc}	7.75^{a}	8.81^{a}	608.25^{a}	331.25^{a}
V_2 C_7	9.38^{cd}	10.33^{cd}	6.00^{def}	7.26^{c-g}	550.00^{abc}	275.00^{a-d}
V_3 C_1	7.69^{f}	8.98^{f}	4.05^{k}	5.33^{jk}	499.75^{abc}	250.25^{bcd}

ISSN: 2349-8889
Volume-8, Issue-2 (March 2021)
https://doi.org/10.31033/ijrasb.8.2.25

V_3 C_2	7.73^{f}	9.14^{ef}	4.63^{jk}	5.97^{hij}	583.25^{ab}	309.25^{ab}
V_3 C_3	8.90^{de}	10.15^{cde}	5.07^{g-j}	6.59^{e-i}	533.25^{abc}	266.75^{a-d}
V_3 C_4	8.02^{ef}	9.46^{def}	4.05^{k}	5.54^{ijk}	533.25^{abc}	266.75^{a-d}
V_3 C_5	9.49^{cd}	10.73^{c}	4.99^{hif}	6.22^{g-j}	433.25^{c}	216.75^{d}
V_3 C_6	9.86^{bcd}	11.05^{bc}	5.19^{f-j}	6.57^{c-i}	591.50^{ab}	311.00^{ab}
V_3 C_7	9.02^{de}	10.20^{cde}	4.04^{k}	4.75^{k}	466.50^{bc}	233.50^{cd}
LSD (= 0.05)	0.96	1.01	0.77	0.94	111.90	61.56
SEm (±)	0.34	0.35	0.27	0.33	21.78	39.59
f-probability	0.05	0.05	0.01	0.01	0.01	0.01
CV (%)	7.28	6.71	9.78	9.69	14.48	15.72
Grand mean	9.41	10.58	5.63	6.90	546.59	277

Note: The common letter(s) within the column indicate non-significant difference based on DMRT at 0.05 level of significance.

The effect of spring rice varieties on germination percentage, speed of germination, vigor index, root length, and shoot length were found statistically significant; Hardinath-3 had the highest germination (95.35 %), vigor index (183.86), and root length (7.07 cm), while Hardinath-1 had a greater speed of germination (95.42) and shoot length (2.74 cm) at 7 DAP (as shown table 1). Later, Hardinath-3 surpassed its counterparts in terms of root and shoot length (11.51 cm and 7.39 cm respectively) at 15 DAP as shown in table 3.

However, hardened Hardinath-3 seeds performed superior concerning germination (97.50 %), while the speed of germination was higher (97.50) in hardened Hardinath-1 seeds. Notably, the vigor index was finer in vitamin C treated Hardinath-3 and Hardinath-1 seeds and hardened Hardinath-1 seeds (as shown in table 3). Besides, root length was higher (12.92 cm) in hardened Hardinath-3 seeds, but the shoot length was more (8.81 cm) in vitamin C treated Hardinath-1 - which was at statistical par with hydro-primed and vitamin C treated Hardinath-3 seeds at 15 DAP. Furthermore, fresh weight was maximum (633.50 mg) in hydro-primed Hardinath-3 seeds, and dry weight (331.25 mg) was in vitamin C treated Hardinath-1, but it was at statistical par with Hardinath-3 seeds primed with distilled water and vitamin C respectively (as shown in table 4).

IV. DISCUSSION

Seed priming fostered the germination of seed by waxing the speed and uniformity of germination. They are prominent parameters specifically for field crop seeds to vie with weed seeds. Seed priming by alternate soaking (in tap water for 24 hours) and drying increased the rate of germination and germination percentage in rice seeds. Andoh and Kobata (2013) presented similar findings, where seeds of Norin 61, a wheat variety, were imbibed for 24 hours at 23°C under controlled room conditions for disparate durations followed by air-drying. Imbibition increased the water content to 64 % followed by redrying significantly accelerated the germination and seedling emergence.A research carried out by Basra et al., (2003) to study changes in germination and seedling vigor after priming of rice seed propounded higher germination percentage, root length, shoot length, and root shoot ratio in seeds hardened for 24 hours at 25°C.

Hardening and vitamin C primed seeds had significantly increased vigor index, and vitamin C treated Hardinath-3 seeds had higher vigor index ensured by hardened Hardinath-1 seeds. Farooq, M et al., (2007) have reported the positive effect of priming on seedling vigor, resulted in improved growth, yield, and quality of transplanted fine rice. However, the effect of priming: on-farm priming, halo priming, and Osmo priming on vigor index were similar with control treatment on Hardinath-3, while, in Hardinath-1, on-farm and Osmo priming performed similar with control, but halo priming was substandard. Chaite-5, a spring rice variety, performed poorly with all parameters under study even with different methods of priming.

V. CONCLUSION

Seed priming is a technique that encompasses the controlled hydration of seeds up to a level that permits the start of germination preparatory processes without allowing radicle protrusion. It has a significant influence on seed quality parameters such as germination percentage, speed of germination, vigor index, root and shoot length, and fresh and dry weight of rice seedlings. Among different methods of priming, hardening: alternate soaking (seeds in tap water for 24 hours) and drying was identified as an effective method of seed priming followed by vitamin C treatment. Hardinath-3, a spring rice variety, had superior performance ensued by Hardinath-1 for most of the parameters. Also, Hardinath-3 seeds, either hardened or vitamin C treated, were

ISSN: 2349-8889
Volume-8, Issue-2 (March 2021)
https://doi.org/10.31033/ijrasb.8.2.25

supreme than others; however, hardened Hardinath-3 was better. Therefore, farmers' are recommended to sow hardened Hardinath-3 seeds during the spring season to meliorate seed germination and seedling establishment.

CONFLICT OF INTEREST

There is no conflict of interest.

ACKNOWLEDGMENT

The authors would like to acknowledge Agriculture and Forestry University (AFU), Prime Minister Agriculture Modernization Project (PMAMP), Kapilbastu for their continuous support and motivation during the research duration.

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