Effect of Seed Priming on Adaptive Morphological Traits of Anaerobic Germination Tolerant Upland Rice Genotypes

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ABSTRACT

The experiment was conducted at the Department of Agronomy, Yezin Agricultural University (YAU), Nay Pyi Taw, Myanmar from September to October 2023. The two experiments control (saturated) and anaerobic germination (flood 10 cm water depth immediately after seeding) were carried out separately and laid out factorial arrangement in randomized complete block design (RCB) with three replications for seed priming treatments: T_1= non-priming, T_2= hydro-priming, T_3= on-farm priming and T_4= osmo-priming as factor A and the newly selected AG tolerant upland rice genotypes (Pin To Yin, San Shwe Ni, Kha Lyein Khan-Lawe and Khao Mon HomKyae) and two check genotypes Khao Hlan On (tolerant) and Inpara-3 (susceptible) as factor B. The findings of the study indicated that different seed priming methods showed higher survival percent, days of leaf tip reached the flood water surface (DLTRS), shoot and root length, shoot and root dry weight, seedling vigour index (SVI)-I and seedling vigour index (SVI)-II than non-priming. All four newly selected tolerant genotypes showed higher performance in most of the traits than tolerant check in AG condition. The maximum survival percent was observed in Pin To Yin with hydro-priming treatment under control condition and Pin To Yin with osmo-priming treatment under AG condition whereas the minimum survival percent was observed in Inpara-3 with non-priming treatment under both conditions.

Keywords: rice, anaerobic germination, genotypes, seed priming

1. INTRODUCTION

Rice is Myanmar's most important agricultural commodity. Both small and large farms in Myanmar produce monsoon rice as their main crop (World Bank, 2021) [1], though Myanmar rice production has fluctuated substantially in recent years, over 27 million tons produced in 2019 (CSO, 2020)[2] and Myanmar accounted for more than 13 million metric tons of milled production in 2020 (USDA, 2020)[3]. Myanmar's major rice ecosystems include rainfed lowland rice, irrigated lowland rice, deep water rice and upland rice.Rice sown area is 7.05 million hectares with the national average yield of 3.86 metric ton per hectares (MOALI, 2022)[4]. Approximately 557 millions of resource-poor farmers in Southeast Asia depend on

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rice for their life and culture (Manzanilla et al., 2011)[5]. Farmers in both rainfed and irrigated fields in Asia are shifting from transplanting to direct seeding due to its lower cost, labor scarcity, operational simplicity and opportunity to crop intensification. Weeds are a serious threat to the direct seeded rice crop by competing for nutrients, light, space and moisture throughout the growing season. Flooding is the most efficient cultural method for controlling weeds soon after rice sowing. The ability of some rice varieties to germinate, grow and survive under oxygen-limiting conditions is known as anaerobic germination tolerance or AG tolerance (Ella & Setter, 1999)[6].Seed priming is a simple and low-cost hydration technique in which seeds are partially hydrated to a point where pre-germination metabolic activities start without actual germination and then re-dried until close to the original dry weight. Nowadays different priming techniques are developing to provide better seed quality (Selvarani & Umarani, 2011)[7]. Primed seeds usually exhibit an increased germination rate, greater germination uniformity, greater total germination percent (Basra, Ahmad, Farooq & Tabassam, 2005)[8] and improved germination under sub-optimal conditions (Lin & Sung, 2001)[9]. Seed priming is a physiological seed enhancement method (Ella, Dionisio-Sese & Ismail, 2011)[10] and developing rice varieties that can germinate under flooding condition is essential for direct-seeded system to be widely adopted by farmers. Combining genetic tolerance to AG with appropriate management options such as seed pre-treatment (priming, pre-soaking, etc.) improves seedling establishment of rice sown in flooded soils.The information enhancing performance of rice by seed priming under AG condition is limited in Myanmar. This study was conducted to evaluate the effect of seed priming on morphological adaptive characters of AG tolerant genotypes.

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2. MATERIAL AND METHODS

The two experiments (control and AG) were laid out factorial arrangement in randomized complete block design (RCB) with three replications separately in concrete ponds. The experiment was conducted at the Department of Agronomy, Yezin Agricultural University (YAU), Nay Pyi Taw, Myanmar from September to October 2023.

Factor A: Priming treatments

1) T_1 = Non-priming
2) T_2 = Hydro-priming (Seeds were soaked in distilled water for 16 hours and dried under shade before sowing)
3) T_3 = On-farm priming (Seeds were soaked in distilled water for 12 hours, surface drying them before sowing)
4) T_4 = Osmo-priming (Seeds were soaked with potassium nitrate (KNO_3) solution for 12 hours; KNO_3 10.0 gL^{-1} and dried under shade before sowing)

Factor B: Upland rice genotypes

The genotypes werePin To Yin, San Shwe Ni, Kha Lyein Khan- Lawe, Khao Mon HomKyae (which had higher survival percent than Khao Hlan On (Tolerant-check) and Inpara-3 (Susceptible-check) were selected from previous screening study).

Morphological parameters

The survival of the rice seedlings was recorded at 21 days after sowing (DAS) in both conditions. Survival percent (percentage of seedlings reached the flood water surface were counted after 21 days flooding). The number of days were recorded when the days leaf tip reached the flood water surface. Five seedlings per replicate for each genotype were used for shoot length, root length, shoot dry weight and root dry weight at 21 (DAS) in both conditions.

Calculations

The data were collected from both control and AG conditions.

$$\text{Survival percent} = \frac{\text{Number of plant emerged above the water} \times 100}{\text{Total number of seeds}}$$

$$\text{Germination percentage} = \frac{\text{Number of germinated seeds at final count} \times 100}{\text{Total number of seeds}}$$

(Abdul-Baki & Anderson, 1973)[11]

$$\text{Seedling vigour index (SVI)-I} = \frac{\text{Seedling length (cm)} \times \text{Germination (\%)}}{100}$$

$$\text{Seedling vigour index (SVI)-II} = \frac{\text{Dry matter content (g)} \times \text{Germination (\%)}}{100}$$

(Adebisi,2004)[12]

Data Analysis

The data were subjected to analysis of variances by using Statistix (version 8th) software and treatment means were compared by using Least Significant Difference (LSD) test at 5% level of significance(Gomez & Gomez, 1984)[13].

3. RESULTS AND DISCUSSION

Survival percent

At 21 days, survival percent was recorded in both control and anaerobic germination (AG) conditions. There were highly significantly difference in the mean effect of seed priming treatments on survival percent (Table 1). In the experiment, the maximum survival percent was observed in hydro-priming (94.330%), which was not significantly different from that of on-farm priming (94.080%), followed by osmo-priming (93.004%) andnon-priming (85.135%) under control condition. Under AG condition, the maximum survival percent was observed in osmo-priming (72.111%), which was significantly different from that of on-farm priming (67.750%), followed by hydro-priming (65.361%) and non-priming (63.141%). The highly significantly difference in the mean effect of genotypes were observed under both conditions (Table 1). The maximum survival percent was observed in Kha Lyein Khan-Lawe (92.941%), which was not significantly different from that of Pin To Yin (92.513%), followed by San Shwe Ni (91.988%), Khao Mon HomKyae (91.740%) and tolerant check, Khao Hlan On (91.667%) under control condition. Under AG condition, the survival percent of Pin To Yin (75.583%) was significantly higher than that of not only the tolerant check but also the other selected genotypes. The second highest survival percent was observed in San Shwe Ni (72.383%), followed by tolerant check, Khao Hlan On (71.483%), Khao Mon

HomKyae(69.094%) and Kha Lyein Khan-Lawe (62.625%). Therefore, AG condition can reduce survival percent in all genotypes especially in susceptible check, Inpara-3 (51.375%). There was significantly different interaction between seed priming treatments and genotypes under both conditions (Table 1). This indicated that the effect of seed priming on survival percent varied with the genotypes under both conditions. Under control condition, the maximum survival percent was observed in Pin To Yin with hydro-priming treatment. The maximum survival percent was observed in Pin To Yin with osmo-priming treatment under AG condition. It could be said thattolerant genotypes with priming, may increase survival percent of rice especially under AG condition. The higher survival percent was observed in pre-soaked or primed seeds under flooded condition than in non-primed seed (Ella et al., 2011)[10].

Days of leaf tip reached the flood water surface (DLTRS)

The days of leaf lip reached the flood water surface (DLTRS) is one of the important adaptive traits under AG condition. The mean effect of priming on DLTRS were significantly difference (Table 1). In the experiment, the shortest DLTRS was observed in on-farm priming (9.167 days), which was significantly different from hydro-priming (9.500 days), followed by osmo-priming (9.889 days) and non-priming (11.694 days). The highly significant in the mean effect of genotypes were observed in DLTRS under AG condition (Table 1). Under AG condition, the shortest DLTRS was observed in Khao Mon HomKyae (8.833 days), which was not significantly different from Pin To Yin (9.000 days) and San Shwe Ni (9.042 days), but which were significantly earlier than that of Kha Lyein Khan-Lawe (9.417 days) and followed by tolerant check, Khao Hlan On (11.542 days) and Inpara-3 (12.542 days). There was significantly different interaction between seed priming treatments and genotypes under AG condition (Table 1). This indicated that the effect of seed priming on DLTRS varied with the genotypes under AG conditions. The shortest DLTRS was observed in Pin To Yin with on-farm priming and San Shwe Ni with hydro-priming. The seedlings of the flooding-tolerant lines derived from primed seeds reached the soil surface earlier about 5 - 6 days than those from the non-priming seeds after sowing and flooding (Ella et al., 2011)[10].

Shoot and root length

There were highly significantly difference in the mean effect of seed priming treatments on shoot and root length at 21 days under both conditions (Table 1). In the experiment, the maximum shoot length was observed in hydro-priming (33.657 cm) and minimum was in non-priming (28.392 cm) under control condition. Under AG condition, the maximum shoot length was observed in osmo-priming (33.334 cm), which was significantly higher than that of on-farm priming (32.100 cm), followed by hydro-priming (30.891 cm) and non-priming (27.827 cm). Therefore, priming enhanced shoot length which was one of adaptive traits under AG condition. The highly significantly difference in the mean effect of genotypes were observed in shoot length at 21 days under both conditions (Table 1). The maximum shoot length was observed in San Shwe Ni (35.558 cm) and minimum was in non-priming susceptible check, Inpara-3 (25.997 cm) under control condition. Under AG condition, the shoot length of Khao Mon HomKyae (35.478 cm) was significantly longer than that of not only the tolerant check but also the other selected genotypes. The second longest shoot length was observed in Pin To Yin (33.102 cm) and followed by San Shwe Ni (32.513 cm), Kha Lyein Khan-Lawe (31.022 cm) and tolerant check, Khao Hlan On (28.720 cm). The susceptible check, Inpara-3 (25.393 cm) was the minimum shoot length under AG condition.

There was significantly different interaction between seed priming treatments and genotypes under both conditions (Table 1). This indicated that the effect of seed priming on shoot length varied with the genotypes under both conditions. The maximum shoot length was observed in Khao Mon HomKyae with on-farm priming treatment under control condition. Under AG condition, Khao Mon HomKyae showed highest shoot length with on-farm priming. Shoot length is one of the important tolerant traits under both conditions. Root length in both control and AG conditions showed a similar trend with shoot length. Tolerant genotypes with seed priming treatments showed higher shoot and root length than susceptible check with non-priming treatment under both conditions. Rapid and vigorous shoot growth is essential for escape flood stress in young seedlings (Vu et al., 2010)[14].The ability of tolerant genotypes to rapidly elongate coleoptiles and form roots under submerged conditions (Ismail et al., 2009)[15].

Shoot and root dry weight

There were highly significantly difference in the mean effect of seed priming treatments on shoot and root dry weight (Table 1). In the experiment, the maximum shoot dry weight was observed in hydro-priming (0.433 g), which was significantly higher than that of osmo-priming (0.410 g), followed by on-farm priming (0.409 g) and non-priming (0.334 g) under control condition. Under AG condition, the maximum shoot dry weight was observed in osmo-priming (0.166 g), which was significantly higher than that of on-farm priming (0.151 g), followed by hydro-priming (0.138 g) and non-priming (0.125 g).The highly significantly difference in the mean effect of genotypes were observed in shoot dry weight under both conditions (Table 1). The maximum shoot dry weight was observed in San Shwe Ni (0.464 g), which was not significantly higher than that of Pin To Yin (0.446 g), followed by Kha Lyein Khan-Lawe (0.425 g), Khao Mon HomKyae (0.386 g) and tolerant check, Khao Hlan On (0.329 g) under control condition. Under AG condition, the shoot dry weight of San Shwe Ni (0.163 g) was significantly higher than that of not only the tolerant check but also the others selected genotypes. The second highest shoot dry weight was observed in Khao Mon HomKyae (0.155 g) and tolerant check, Khao Hlan On (0.145 g), followed by Pin To Yin (0.144 g) and Kha Lyein Khan-Lawe (0.136 g). Genotypic significant differences were observed in shoot and root dry weight under saturated condition and submerged treatments (Salah et al., 2014)[16]. There was significantly different interaction between seed priming treatments and genotypes under both conditions (Table 1). This indicated that the effect of seed priming on shoot dry weight varied with the genotypes under both conditions. The maximum shoot dry weight was observed in Pin To Yin with hydro-priming treatment under control condition. Khao Mon HomKyae showed highest shoot dry weight after with osmo-priming treatment under AG condition. A similar trend was shown in root dry weight under both control and AG conditions. The present study indicated that shoot and root dry weight could be increased in tolerant genotypes by combining seed priming.

Seedling vigour index (SVI)-I

Seedling vigour index (SVI)-I is the multiplication of seedling length and germination percentage. There were highly significantly difference in the mean effect of seed priming treatments on seedling vigour index (SVI)-I at 21 days under both conditions (Table 1). In the experiment, the maximum seedling vigour index (SVI)-I was observed in on-farm priming (40.470), which was not significantly higher than that of hydro-priming (40.452), followed by osmo-priming (39.499) and non-priming (31.369) under control condition. Under AG condition, the maximum seedling vigour index (SVI)-I was observed in osmo-priming (32.157), which was significantly higher than that of on-farm priming (30.557), followed by hydro-priming (28.196) and non-priming (24.481). The highly significantly difference in the mean effect of genotypes were observed in seedling vigour index (SVI)-I under both conditions (Table 1). The maximum seedling vigour index (SVI)-I was observed in San Shwe Ni (42.147) and minimum was in susceptible check, Inpara-3 (30.608) under control condition. Under AG condition, Pin To Yin (32.699) markedly increased the seedling vigour index (SVI)-I when compared to tolerant check, Khao Hlan On and other genotypes. The second highest seedling vigour index (SVI-I) was observed in Khao Mon HomKyae (31.406), which was significantly higher than that of San Shwe Ni (30.377), followed by tolerant check, Khao Hlan On (26.829) and Kha Lyein Khan-Lawe (25.528) under AG condition. There was significantly different interaction between seed priming treatments and genotypes under both conditions (Table 1). This indicated that the effect of seed priming on seedling vigour index (SVI)-I varied with the genotypes under both conditions. The maximum seedling vigour index (SVI)-I was observed in San Shwe Ni with hydro-priming treatment under control condition. Under AG condition, osmo-priming treatment significantly enhanced the seedling vigor index (SVI)-I of Pin To Yin compared to other genotypes. The present study indicated that the combination of seed priming and tolerant genotypes significantly increased the seedling vigour index (SVI)-I.

Seedling vigour index (SVI)-II

Seedling vigor index (SVI)-II is determined by multiplication of the shoot and root dry weight and the germination percentage. There were highly significantly difference in the mean effect of seed priming treatments on seedling vigour index (SVI)-II (Table 1). In the experiment, under control condition, the maximum seedling vigour index (SVI)-II was observed in hydro-priming (0.558), which was significantly higher than that of on-farm priming (0.535), followed by osmo-priming (0.533) and non-priming (0.397). Under AG condition, the maximum seedling vigour index (SVI)-II was observed osmo-priming (0.191), which was significantly higher than that of on-farm priming (0.160), followed by hydro-priming (0.138) and non-priming (0.117). The highly significantly difference in the mean effect of genotypes were observed in seedling vigour index (SVI)-II under both conditions (Table 1). The maximum seedling vigour index (SVI)-II was observed in San Shwe Ni (0.564) and minimum was in susceptible check, Inpara-3 (0.420) under control condition. Under AG condition, the maximum seedling vigour index (SVI)-II was observed in Pin To Yin (0.176), which was not significantly higher than that of San Shwe Ni (0.173) and Khao Mon HomKyae (0.172), followed by tolerant check, Khao Hlan On (0.168), Kha Lyein Khan-Lawe (0.126) and susceptible check, Inpara-3 (0.094) under AG condition. There was significantly different interaction between seed priming treatments and genotypes under both conditions (Table 1). This indicated that the effect of seed priming on seedling vigour index (SVI)-II varied with the genotypes under both conditions. Pin To Yin expressed the highest seedling vigour index (SVI)-II with hydro-priming under control condition, while osmo-priming maximized seedling vigour index (SVI)-II under AG condition. Therefore, seed priming treatments were higher seedling vigour index (SVI)-II than non-priming treatment under both conditions.

Table 1. Morphological traits of upland rice genotypes under control and AG conditions

Treatment	Survival %		DLTRS	Shoot length(cm)		Root length (cm)	
	Control	AG	AG	Control	AG	Control	AG
Factor A- Seed Priming							
Non-priming	85.135 c	63.141 d	11.694 a	28.392 c	27.827 d	8.296 c	7.937 d
Hydro-priming	94.330 a	65.361 c	9.500 c	33.657 a	30.891 c	9.226 b	9.278 c
On-farm priming	94.080 a	67.750 b	9.167 d	33.469 a	32.100 b	9.535 a	10.136 a
Osmo-priming	93.004 b	72.111 a	9.889 b	32.760 b	33.334 a	9.695 a	9.708 b
$LSD_{0.05}$	0.475	0.503	0.188	0.480	0.350	0.230	0.403
Factor B - Genotypes							
Pin To Yin	92.513 ab	75.583 a	9.000 d	33.112 c	33.102 b	9.441 b	9.995 a
San Shwe Ni	91.988 bc	72.383 b	9.042 d	35.558 a	32.513 c	9.996 a	9.369 b
Kha Lyein Khan-Lawe	92.941 a	62.625 e	9.417 c	33.977 bc	31.022 d	9.043 c	9.538 ab
Khao Mon HomKyae	91.740 c	69.094 d	8.833 d	35.217 ab	35.478 a	9.363 b	9.938 a
Khao Hlan On	91.667 c	71.483 c	11.542 b	28.555 d	28.720 e	8.981 c	8.753 c
Inpara-3	88.976 d	51.375 f	12.542 a	25.997 e	25.393 f	8.305 d	7.994 d

$LSD_{0.05}$	0.582	0.615	0.231	0.588	0.429	0.282	0.494
Pr>F							
Seed Priming	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Genotypes	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Seed Priming x Genotypes	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002
CV%	0.77	1.12	2.80	2.23	1.68	3.74	6.49

DLTRS= Days of leaf tip reached the flood water surface and AG= Anaerobic germination

Table 1. (Continued)

Treatment	SDW(g)		RDW(g)		SVI-I		SVI-II	
	Control	AG	Control	AG	Control	AG	Control	AG
Factor A- Seed Priming								
Non-priming	0.334 c	0.125 d	0.132 c	0.058 d	31.369 c	24.481 d	0.397 c	0.117 d
Hydro-priming	0.433 a	0.138 c	0.162 b	0.071 c	40.452 a	28.196 c	0.558 a	0.138 c
On-farm priming	0.409 b	0.151 b	0.160 ab	0.082 b	40.470 a	30.557 b	0.535 b	0.160 b
Osmo-priming	0.410 b	0.166 a	0.156 a	0.096 a	39.499 b	32.157 a	0.533 b	0.191 a
$LSD_{0.05}$	0.016	0.004	0.006	0.009	0.528	0.393	0.015	0.005
Factor B - Genotypes								
Pin To Yin	0.446 a	0.144 c	0.152 bc	0.084 b	39.329 d	32.699 a	0.556 ab	0.176 a
San Shwe Ni	0.464 a	0.163 a	0.145 cd	0.088 a	42.147 a	30.377 c	0.564 a	0.173 a
Kha Lyein Khan-Lawe	0.425 b	0.136 c	0.155 b	0.063 c	40.097 c	25.528 f	0.542 b	0.126 c
Khao Mon HomKyae	0.386 c	0.155 b	0.151bc	0.084 b	41.001 b	31.406 b	0.493 c	0.172 ab
Khao Hlan On	0.329 d	0.145 b	0.171 a	0.088 a	34.503 e	26.829 d	0.459 d	0.168 b
Inpara-3	0.329 d	0.127 e	0.145 d	0.055 d	30.608 f	26.248 e	0.420 e	0.094 d

$LSD_{0.05}$	0.020	0.005	0.007	0.006	0.646	0.482	0.019	0.003
Pr>F								
Seed Priming	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Genotypes	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Seed Priming + Genotypes	<0.0001	0.0109	0.0002	0.0183	<0.0001	<0.0001	<0.0001	<0.0001
CV%	6.13	4.65	6.02	5.69	2.07	2.03	4.55	3.50

SDW= Shoot dry weight, RDW= Root dry weight, SVI-I and SVI= Seedling vigour index (I and II)

Table 1. (Continued)

Treatment	Survival %		DLTRS	Shoot length(cm)		Root length (cm)	
	Control	AG	AG	Control	AG	Control	AG
Seed Priming + Genotypes							
Non-priming+ Pin To Yin	85.71 h	70.50 fgh	10.00 g	29.86 h	28.91 ij	9.19 b-f	8.62 ef
Non-priming+ San Shwe Ni	85.81 h	69.57 h	10.83 f	31.97 g	28.60 j	8.43 hi	8.32 fg
Non-priming+ Kha Lyein Khan-Lawe	85.71 h	57.83 l	12.17 cd	30.19 h	26.81 k	7.66 j	8.25 fg
Non-priming+ Khao Mon HomKyae	85.71 h	65.74 j	10.17 g	30.69 h	34.17 cde	8.63 ghi	8.67 ef
Non-priming+ Khao Hlan On	85.71 h	68.23 i	12.83 b	24.92 l	26.19 k	8.29 i	7.09 hi
Non-priming+ Inpara-3	82.14 i	46.97 o	14.17 a	22.72 m	22.29 m	7.58 j	6.68 i
Hydro-priming+ Pin To Yin	97.62 a	74.67 cd	9.00 h	35.29 def	33.50 de	9.52 bc	9.53 de
Hydro-priming+ San Shwe Ni	96.43 b	71.30 f	8.00 i	37.55 b	32.51 f	10.44 a	9.57 cde
Hydro-priming+ Kha Lyein Khan-Lawe	96.43 b	60.13 k	9.17 h	34.49 ef	30.70 g	8.64 f-i	9.48 de
Hydro-priming+ Khao Mon HomKyae	93.36 def	67.40 i	8.17 i	36.61 bc	35.53 b	9.01 c-g	10.06 cd
Hydro-priming+ Khao Hlan On	92.86 ef	69.83 gh	10.83 f	30.35 h	28.73 ij	9.25 b-e	9.48 de
Hydro-priming+ Inpara-3	89.29 g	48.83 n	11.83 de	27.67 ij	24.38 l	8.50 ghi	7.55 ghi
On-farm priming+ Pin To Yin	93.86 de	76.57 b	8.00 i	34.61 ef	34.52 c	9.61 b	10.37 bcd

On-farm priming+ San Shwe Ni	92.86 ef	73.70 de	8.33 i	36.46 bcd	33.45 e	10.53 a	10.09 cd
On-farm priming+ Kha Lyein Khan-Lawe	96.76 ab	64.60 j	8.17 i	35.58 cde	32.23 f	9.43 bcd	10.32 bcd
On-farm priming+ Khao Mon HomKyae	93.53 de	70.13 fgh	8.17 i	39.27 a	36.46 a	9.42 bcd	11.17 abc
On-farm priming+ Khao Hlan On	95.24 c	70.97 fg	10.67 f	28.60 i	29.56 hi	9.52 bc	10.55 abc
On-farm priming+ Inpara-3	92.24 f	50.53 m	11.67 e	26.29 k	26.39 k	8.71 e-i	8.30 fg
Osmo-priming+ Pin To Yin	92.86 ef	80.60 a	9.00 h	32.69 g	35.48 b	9.45 bcd	11.46 a
Osmo-priming+ San Shwe Ni	92.86 ef	74.97 c	9.00 h	36.26 cd	35.50 b	10.52 a	9.49 de
Osmo-priming+ Kha Lyein Khan-Lawe	92.86 ef	67.93 i	8.17 i	35.65 cde	34.35 cd	10.45 a	10.11 cd
Osmo-priming+ Khao Mon HomKyae	94.36 cd	73.10 e	8.83 h	34.29 f	35.75 ab	10.39 a	9.85 cd
Osmo-priming+ Khao Hlan On	92.86 ef	76.90 b	11.83 de	30.35 h	30.40 gh	8.93 d-h	7.89 fgh
Osmo-priming+ Inpara-3	92.24 f	59.17 k	12.50 bc	27.31 jk	28.52 j	8.43 hi	9.44 de
$LSD_{0.05}$	1.164	1.232	0.463	1.176	0.859	0.565	0.989

Table 1. (Continued)

Treatment	SDW(g)		RDW(g)		SVI-I		SVI-II	
	Control	AG	Control	AG	Control	AG	Control	AG
Seed Priming + Genotypes								
Non-priming+ Pin To Yin	0.36 gh	0.12 ij	0.14 ef	0.06 ij	33.48 ij	26.46 jk	0.43 ij	0.13 jk
Non-priming+ San Shwe Ni	0.36 gh	0.13 ghi	0.12 gh	0.07 gh	35.24 h	25.69 kl	0.41 ik	0.14 i
Non-priming+ Kha Lyein Khan-Lawe	0.33 h	0.12 jk	0.13 fg	0.05 k	32.44 ij	20.27 o	0.39 k	0.09 m
Non-priming+ Khao Mon HomKyae	0.45 def	0.14 fgh	0.13 fg	0.07 hi	33.70 i	28.16 gh	0.49 fg	0.13 ijk
Non-priming+ Khao Hlan On	0.27 i	0.13 ghi	0.17 a	0.07 hi	28.46 k	22.71 n	0.38 k	0.14 ij
Non-priming+ Inpara-3	0.24 i	0.11 k	0.11 h	0.04 l	24.89 l	23.60 mn	0.28 l	0.07 o
Hydro-priming+ Pin To Yin	0.52 a	0.13 ghi	0.15 de	0.08 f	43.21 bc	32.13 d	0.66 a	0.16 gh
Hydro-priming+ San Shwe Ni	0.51 ab	0.15 de	0.15 cde	0.08 f	46.27 a	29.99 ef	0.65 a	0.17 fg
Hydro-priming+ Kha Lyein Khan-Lawe	0.44 ef	0.13 hij	0.17 abc	0.06 jk	41.59 de	24.16 m	0.58 cd	0.11 l
Hydro-priming+ Khao Mon HomKyae	0.42 f	0.15 de	0.15 cde	0.08 fg	42.59 b-e	30.73 e	0.53 e	0.16 h
Hydro-priming+ Khao Hlan On	0.33 h	0.14 fg	0.17 ab	0.08 ef	36.77 g	26.68 ij	0.46 ghi	0.16 h
Hydro-priming+ Inpara-3	0.38 g	0.13 hij	0.14 ef	0.05 k	32.29 j	25.47 l	0.46 ghi	0.09 n
On-farm priming+ Pin To Yin	0.44 def	0.14 efg	0.15 cde	0.09 de	41.50 e	34.37 b	0.56 de	0.18 de
On-farm priming+ San Shwe Ni	0.48 bcd	0.16 cd	0.15 cde	0.09 de	43.64 b	32.09 d	0.59 cd	0.19 cd
On-farm priming+ Kha Lyein Khan-Lawe	0.47 cde	0.14 efg	0.17 a	0.07 gh	43.55 b	27.48 hi	0.63 ab	0.14 ij

On-farm priming+ Khao Mon HomKyae	0.33 h	0.18 ab	0.16 bcd	0.09 de	45.54 a	33.40 c	0.45 hi	0.19 c
On-farm priming+ Khao Hlan On	0.38 g	0.15 ef	0.17 a	0.09 cd	36.30 gh	28.47 g	0.53 ef	0.17 ef
On-farm priming+ Inpara-3	0.35 gh	0.13 ghi	0.15 de	0.06 ij	32.28 j	27.53 ghi	0.46 ghi	0.09 m
Osmo-priming+ Pin To Yin	0.46 cde	0.18 ab	0.16 a-d	0.11 ab	39.13 f	37.84 a	0.58 cd	0.23 a
Osmo-priming+ San Shwe Ni	0.49 abc	0.17 bc	0.16 bcd	0.11 a	43.44 bc	33.73 bc	0.61 bc	0.21 b
Osmo-priming+ Kha Lyein Khan-Lawe	0.463 cde	0.16 cd	0.15 cde	0.08 fg	42.81 bcd	30.20 ef	0.57 cd	0.16 gh
Osmo-priming+ Khao Mon HomKyae	0.35 gh	0.19 a	0.17 a	0.10 bc	42.17 cde	33.33 c	0.49 fg	0.21 b
Osmo-priming+ Khao Hlan On	0.34 h	0.16 cd	0.17 ab	0.11 ab	36.48 gh	29.45 f	0.47 gh	0.21 b
Osmo-priming+ Inpara-3	0.35 gh	0.14 efg	0.16 a-d	0.07 gh	32.97 ij	28.38 gh	0.47 gh	0.13 k
$LSD_{0.05}$	0.040	0.011	0.015	0.003	1.294	0.963	0.038	0.007

4. CONCLUSION

The present study exhibited that seed priming treatments markedly increased most of the traits compared to non-priming treatment under both conditions. Hydro-priming and on-farm priming showed higher survival percent, shoot length (cm) and vigour index (SVI)-II under control condition. Under AG condition, osmo-priming and on-farm priming treatments resulted higher values in most of traits compared to non-priming treatment. Regarding to genotypes, Pin To Yin, San Shwe Ni, Kha Lyein Khan-Lawe and Khao Mon HomKyae showed higher survival percent, shoot length (cm), root length (cm) and seedling vigour index (SVI)-I and earlier DLTRS under both conditions compared to tolerant check, Khao Hlan On. The maximum survival percent was observed in Pin To Yin with hydro-priming treatment under control condition and Pin To Yin with osmo-priming treatment under AG condition. Therefore, these findings highlighted the effectiveness of primingtreatments enhanced survival percent, accelerated days of leaf tip reached the flood water surface (DLTRS), shoot and root length, shoot and root dry weight and higher vigour index under both conditions. The present study suggested that combining of genetic tolerance with proper seed priming treatment before sowing could effectively be used for better crop in direct seeding areas especially under AG condition during germination.

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