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Research Article

Seeds Enhancement Technique as Tool to Improve Rice Germination and Seedling Establishment in High soil Temperature Stress

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Abstract

Background and Objective: Rapid germination is very important for better plant growth and development under stress condition. The increase in soil and water temperature reduces seed germination ability, germination speed and hence resulting into poor seedling vigor and plat growth. This study was conducted to investigate to what extent the seed enhancement technique helped to improve the rice seed germination and seedling establishments on the effect of high soil temperature stress. **Methodology:** Four rice seeds varieties were primed with PEG 6000, hydropriming and non-primed seeds were used as a control. After priming, germination test under soil temperature stress of 36°C (room-control), 40, 43 and 46°C was performed in greenhouse condition to evaluate the stress effect on germination and seedling quality. **Results:** The results showed highly significant difference on maximum germination (max G, %), mean germination time (MGT%), time to attained 50% germination (T50%), germination energy (GE), shoot and root growth and development at different soil temperature stress between primed and non-primed seeds. **Conclusion:** Primed seed promote rapid germination as well as shoot and root growth under high soil temperature (40-43°C). However, growth and development were ceased at above 43°C. Furthermore, high soil temperature and priming techniques promoted root and shoot growth than to non-primed seeds.

Key words: Soil temperature stress, rapid germination, poor seedling vigor, seed enhancement, priming techniques, rice seed germination

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Rice is temperature sensitive crop, it originated in tropical regions then adapted to subtropics[1]. It is cultivated in area where optimal growth temperature is about 20-28°C. However, it can also adapt in a wide range from 17°C, in some area of Japan and up to 33°C in area like Punjab. However, rice is highly affected by the increase in both soil and air temperature[2]. In seedling stage, rice growth and development can be reduced by high air temperature and consequently lower the final yield. High temperature affects both quality and quantity of rice[3]. In tropical and subtropical region where rice is mostly cultivated; temperature affects rice productivity by reducing the grain weight and quality[3]. It reduces seed setting rate by 65%, 1000 grain weight and yield. Many field researches along Asian countries[4-6], reports the effect of temperature and carbon dioxide (CO_2) on rice growth, development and yield. Increase in air temperature and CO_2 concentration due to climate change had negative results on rice growth, development and final yield. The effect of temperature on yield and grain quality indicated that the rate of immature grain is higher at higher temperature during grain filling stage. According to Lur *et al.*[5] indicates that high quality grain was obtained when the optimal temperature is 23°C. On the other hand, high temperature increase rice palatability as it lowers amylose contents. According to the Intergovernmental Panel on Climate Change, severe storms, flooding and drought are the result of rising in world temperature or a global warming[7]. The adverse effect of increasing in air temperature due to climate change not only affects rice portion above the ground but also bellow the ground. Increase in soil water temperature affects seed germination and also may affect the rate of water and nutrient uptake. High soil temperature disrupts water ions and organic soluble movement across plant membrane which will interfere the photosynthesis and respiration[2,8]. During germination process, high soil temperature can reduce the percentage of germination and germination speed, hence resulting in poor seedling vigor[2]. Sensitivity to temperature stress of rice plant depends on growth stage, cultivar and duration of temperature[4].

Seed germination and vigor establishments are the key point for successive yield but germination is very sensitive under abiotic stress. The stresses such as soil temperature, drought acidic and salinity delay seed set. This leads to reduce the germination speed, plant health and final yield[9]. Many scientific research on seed treatments indicated that seed priming technique had high ability to facilitate better seed germination and vigor establishments under stress condition[10-12]. Seed priming is a process in which seeds are soaked in water or osmotic solution or combination of solid matrix and water in specific proportion followed by drying before radical emergence[13]. Several researches on the effect of temperature stress had been conducted but most of this research focus on air temperature, while the effects of increase in soil temperature has been given little attention in most of the researches. This research therefore aimed to investigate critically the effect of seed priming techniques on rice seeds germination under high soil temperature stress.

MATERIALS AND METHODS

The research was factorial in complete randomized design (CRD) which consists of three factors with three replications. The factors were; seed enhancement techniques (seed priming), rice varieties and soil temperatures stress. Four rice seeds varieties: PTT1, RD31, RD43 and Suphan Buri 1 were primed using PEG 6000 solution at the concentration of 10% w/v giving the osmotic potential around[14] -0.85 MPa. Another seed sample was primed by deionized water or hydro-priming, osmotic potential around 0.0 MPa, while non-primed seeds was used as a control.

Priming process: About 50 g of rice seeds from each variety were soaked in oxygen aerated 500 mL of deionized water for 24 h and another 50 g in PEG 6000 for 48 h. This soaking period has been conducted by previous researchers and practiced by different researchers[15,16]. Then the seed was placed into germinator (Seedburo Achieva Precision Table Top Germinator, SEEDBURO Equipment Company, Illinois, USA) at 25°C in darkness. After the soaking, the primed seeds were rinsed in tap water for 5 min and dried on top of bench for 24 h and then stored for 2 days before sown into pots for germination test under temperature stress experiments.

Soil preparation: Loam soil was grinded and sieved with 0.5 mm^2 wire mesh sieve size then compost and cow dung manure was mixed in each pot at the rate of 781.25 kg ha^{-1} and 12 t ha^{-1} equivalent to 0.57 and 71 g per pot respectively. Water was added in every pot to make the soil moisture content (SMC) at saturated level, then the soil was left to stand for 14 days waiting for the release of nutrients before planting seeds.

Seed germination test under high soil temperature stress: Germination test was conducted under controlled soil temperature stress. The soil temperature was maintained at constant of 40, 43 and 46°C (±0.5°C) and the control (room soil temperature) which was recorded as an average of 36°C as modified from Arai-Sanoh *et al.*[17]. A rectangular pot measuring 1.00×0.06×0.05 m was partitioned into four and 100 seeds of each variety was sown in each part. Three pot each containing PEG 6000 primed seeds, hydropriming and non-primed seeds were immersed into a water bath with a dimension of 1.40×0.25×0.15 m. water bath was filled with tap water then the water was heated to warm the soil inside the pot at required temperature using thermostat electric heater. The soil temperature was maintained for 10 h a day from 07:00 to 17:00 h for consecutive 21 days. At night the soil was allowed to cool to its normal room temperature inside greenhouse the room temperature was recorded as an average of 31.9°C. Relative humidity was 48.3 and 73.1% on a day and night time respectively. All measurement was made in three replication and the germination normal seedling was determined after every 24 h intervals. Seedling quality, roots, shoot, growth and development was evaluated for 21 days.

Data collection: Germination indices determined includes: maximum germination (max G, %), germination energy (GE, %), mean germination time (MGT, day) and time taken to attain 50% (T50, %). Furthermore, roots data were studied to analyses growth and development under different soil temperature stresses.

Statistical analysis: Data collected were presented as mean values of three replications and subjected to GERMINATOR software package for high-throughput scoring and curve fitting of seed germination to determine value of maxG, MGT and T50%. Then one way analysis of variance (One way-ANOVA) was used to compare mean up to three interaction items among treatments using statistical computer software (statistix 8.0) version. The significance differences among the means were compared using Less Significant Difference (LSD) *post hoc* tests at 5% probability level ($p<0.05$).

RESULTS AND DISCUSSION

Effect of seed priming techniques on rice seeds germination: The effect of seed priming technique on rice seeds germination and germination indices was shown in Table 1. Seed primed technique using PEG 6000 and that hydropriming showed high germination percentage over non primed seeds. The short period taken by seed lots on germination time (MGT) and to attain 50% germination (T50), indicated that primed rice seed reduce MGT and T50 by half of time of non-primed Table 1. On the other hand highly significant different at $p<0.05$ level was observed on germination energy between primed and non-primed seed. The result showed that primed seedling produce many roots and stimulate more shoot growth than non-priming seedling (Table 1).

Effect of seed priming techniques on soil temperature stress: The effect of seed priming on germination under high soil temperature stress was shown in Table 2. However Seed priming techniques seemed to promote seed germination even at high soil temperature stress than non-primed seeds, high soil temperature stress had serious effect on seed germination, seedling establishment, seedling growth and

Table 1: Effect of seed priming technique on germination and root-shoot growth and development

Treatment	maxG (%)	MGT (days)	T50 (days)	GE (%)	NR	TLR (cm)	TSL (cm)
Control	44.0^c	3.1^a	3.1^a	19.4^c	9.0^b	9.8^a	21.9^b
PEG 6000	76.5^a	1.3^b	1.6^b	74.1^a	11.0^a	10.1^a	26.1^a
Hydro	65.9^b	1.4^b	1.6^b	63.6^b	10.7^a	10.1^a	24.9^a
LSD	**	**	**	**	**	ns	**
CV	16.7	14.8	14.0	19.2	18	16.6	14.5

**Highly significant at $p<0.05$, maxG: Maximum germination, MGT: Mean germination time, T50: Time to attain 50 % germination, GE: Germination energy, TNR: Total number of root, RL: Root length and SL: Shoot length. Values for the parameter marked with same letters are not significantly difference at $p<0.05$ level by Fishers least square different (LSD) test

Table 2: Effect of soil temperature stresses on germination and root-shoot growth and development

Temperature (°C)	maxG (%)	MGT (days)	T50 (days)	GE (%)	TNR	LR (cm)	SL (cm)
36 (room)	74.5^a	2.3^a	2.3^a	54.8^b	8.7^c	9.1^c	21.6^c
40	72.2	1.8^{bc}	1.9^c	63.8^a	11.2^a	10.1^b	25.6^b
43	55.3	1.7^c	2.1^b	48.3^{bc}	11.1^a	10.9^a	27.4^a
46	46.5	1.9^b	1.9	42.4^c	9.8^b	9.9^b	22.5^c
LSD	**	**	**	**	**	*	**
CV	16.7	14.8	14	19.2	18	16.6	14.5

*Significant at $p<0.05$, **Highly significant at $p<0.05$, maxG: Maximum germination, MGT: Mean germination time, T50: Time to attain 50% germination, GE: Germination energy, TNR: Total number of root, RL: Root length and SL: Shoot length, Values for the parameter marked with same letters are not significantly difference at $p<0.05$ level by Fishers least square different (LSD) test development. The high soil temperatures of 46°C decreases rice seed germination percentage compared to room soil temperature-control (36°C). The significant different on maxG, MGT and T50 was observed between 46, 43, 40 and 36°C (Table 2). High soil temperature reduces seedling germination energy. The result from this study showed that at severe stress of 43 and 46°C, GE decrease compared to control (36°C). High soil temperature of 40°C looks to promote seedling GE than low soil temperature of 36°C. The soil temperature of below 40 and that of above 43°C reduce number of roots per plant where at 40 and 43°C promote more number of roots. Surprisingly, at 43°C soil temperature indicate to accelerate more shoot and root growth compared to 46, 40 and 36°C (Table 2).

Interaction between seed enhancement techniques with soil temperature stress: Primed seeds sown at normal soil temperature (the control -36°C), medium stress of 40°C, and severe stress of 43 and 46°C show high germination percentage than those from non-priming seeds. The result from the study showed at temperature of 43 and 46°C non primed seeds obtained very low germination percentage and some replication fails to attain 50% germination. Even at 36°C and 40°C the non-primed seeds took long period to attain T50 than primed seeds. It was observed that at high soil temperature stress of 40, 43 and 46°C under seed enhancement technique promote increases number of roots, promote shoot and root growth over non-primed. Even under room soil temperature 36°C, the non-primed seed observed to have less number of roots per plant compared to room temperature of primed (Table 3). Unexpectedly at 46°C, PEG 6000 seedling showed better performance on development of root system than hydropriming and non-primed. At 43°C, all three seed enhancement technique shows shoot growth is stronger. However, for priming technique indicates better stimulation with soil temperature.

Interaction between seed treatment technique with rice variety: There was no significant different between PEG 6000 and hydropriming on MGT for all varieties. The PEG 6000 osmopriming give long seedling shoot on PTT1 variety followed by RD31 whereas less growth was observed on RD43 and Suphan Buri 1. Likewise under hydropriming treatment the RD31 was best than PTT1 on shoots length (Table 4) while again RD43 and Suphan Buri showed less growth.

Growth effect on the interaction between soil temperature stresses with rice variety: Under very high soil temperature stress of 46°C the RD31 variety observed to have more number of roots per plant. Generally, under all soil temperature stress condition the RD31 is the best on producing more number of roots per plant compared to other varieties. PTT1 variety shows less number of root per plant fewer than 43 and 46°C. However the 43°C shows to stimulate more shoot and root growth on RD31, but the PTT1 variety was observed to perform better for all temperature conditions. Furthermore at 43 and 46°C, the RD43 and SuphanBuiri 1 varieties shows very week roots development (Table 5).

Table 3: Interaction effect of seed priming and soil temperature stress germination root-shoot growth and development

Treat	Temperature	maxG (%)	MGT (days)	T50 (days)	GE (%)	NR	TLR (cm)	TSL (cm)
Control	Room	69.5^{abc}	3.3^{a}	4.1^{b}	18^{e}	7.5^{f}	9.3^{cd}	18.7^{f}
	40	62.9^{bcd}	2.7^{b}	4.5^{b}	43.3^{d}	10.3^{cd}	10.8^{ab}	23.5^{cd}
	43	13.0^{f}	3.4^{b}	8.3^{a}	4.5^{e}	9.9^{de}	10.6^{abc}	25.2^{bc}
	46	31.0^{f}	2.8^{b}	8.3^{a}	12^{e}	8.4^{ef}	9.9^{bc}	20.2^{ef}
	LSD	**	ns	ns	ns	*	*	**
PEG 6000	Room	80.3^{a}	1.6^{cd}	1.8^{c}	76.8^{a}	9.9^{de}	9.6^{bcd}	25.7^{bc}
	40	78.0^{a}	1.3^{de}	1.5^{c}	73.8^{ab}	10.3^{cd}	9.4^{cd}	25.2^{bc}
	43	72.5^{abc}	1.3^{de}	8.3^{a}	72.5^{ab}	12.3^{ab}	11.3^{a}	27.3^{ab}
	46	75.3^{ab}	1.2^{e}	8.3^{a}	73.3^{ab}	11.6^{abc}	10.2^{abc}	25.5^{bc}
	LSD	**	ns	ns	ns	*	*	**
Hydro	Room	73.8^{abc}	1.7^{c}	1.9^{c}	69.8^{ab}	8.6^{ef}	8.4^{d}	20.9^{def}
	40	76.0^{a}	1.5^{cde}	1.7^{c}	74.5^{ab}	12.9^{a}	10.2^{abc}	27.7^{ab}
	43	54.0^{d}	1.3^{de}	8.3^{a}	50.3^{cd}	11.4^{bc}	10.9^{ab}	29.2^{a}
	46	59.7^{cd}	1.1^{e}	8.3^{a}	59.8^{bc}	9.7^{de}	9.6^{bcd}	21.7^{de}
	LSD	**	ns	ns	ns	*	*	**
CV		16.7	14.8	14	19.2	18	16.6	14.5

*Significant at $p<0.05$, **Highly significant at $p<0.05$, ns: Not significant, maxG: Maximum germination, MGT: Mean germination time, T50: Time to attain 50% germination, GE: Germination energy, TNR: Total number of root, RL: Root length and SL: Shoot length, Values for the parameter marked with same letters are not significantly difference at $p<0.05$ level by Fishers least square different (LSD) test

Table 4: Interaction effect of seed priming and rice variety on seed germination, root-shoot growth and development

Treatments	Variety	maxG (%)	MGT (days)	T50 (days)	GE (%)	TNR	LR (cm)	SL (cm)
Control	PTTTI	38.8^{d}	2.5^{a}	7.2^{a}	23.°C	10.7^{d}	18.1^{b}	32.8^{ab}
	RD31	47.3^{cd}	3.5^{ab}	6.1^{ab}	16.3^{c}	14.8^{a}	13.0^{c}	34.2^{a}
	RD43	49.5^{cd}	3.0^{b}	6.1^{ab}	24.8^{c}	6.7^{h}	1.5^{g}	6.2^{e}
	SUP1	40.5^{cd}	3.4^{ab}	5.9^{b}	13.8^{c}	7.3^{e}	2.9^{f}	13.5^{d}
	LSD	ns	*	*	ns	**	**	**
PEG 6000	PTTTI	81.0^{a}	1.4^{d}	4.9^{b}	78.8^{a}	10.4^{d}	23.3^{a}	33.6^{ab}
	RD31	74.3^{a}	1.3^{d}	4.9^{b}	68.5^{a}	13.8^{ab}	12.8^{c}	32.7^{ab}
	RD43	74.5^{a}	1.4^{d}	4.9^{b}	74.0^{a}	8.9^{e}	3.8^{def}	18.5^{c}
	SUP1	76.3^{a}	1.2^{d}	5.0^{b}	75.0^{a}	11.6^{cd}	4.8^{d}	20.3^{c}
	LSD	ns	ns	ns	ns	**	**	**
Hydro	PTTTI	71.3^{a}	1.4^{d}	5.1^{b}	68.8^{a}	10.8^{d}	19.0^{b}	31.2^{b}
	RD31	69.3^{a}	1.6^{d}	5.2^{b}	69.5^{a}	12.5^{bc}	12.5^{c}	32.4^{ab}
	RD43	68.3^{ab}	1.4^{d}	5.1^{b}	67.8^{a}	8.3^{e}	3.4^{ef}	15.6^{d}
	SUP1	54.3^{bc}	1.4^{d}	5.0^{b}	48.3^{b}	11.1^{cd}	4.3^{de}	20.4^{c}
	LSD	ns	ns	ns	*	**	**	**
CV		16.7	14.8	14	19.2	18	16.6	14.5

*Significant at p<0.05, **Highly significant at p<0.05, ns: Not significant, maxG: Maximum germination, MGT: Mean germination time, T50: Time to attain 50% germination GE: Germination energy, TNR: Total number of root, RL: Root length and SL: Shoot length, Values for the parameter marked with same letters are not significantly difference at p<0.05 level by Fishers least square different (LSD) test

Table 5: Interaction effect of soil temperature stress and rice varieties on seed germination root-shoot growth and development

Temperature	Variety	maxG (%)	MGT (days)	T50 (days)	GE (%)	TNR	LR (cm)	SL (cm)
36	PTTTI	67.3^{abcdef}	2.2^{abc}	2.5^{c}	53.0^{bcde}	11.3^{def}	20.7^{a}	33.2^{a}
	RD31	82.0^{a}	2.2^{abc}	2.3^{c}	63.6^{abc}	13.2^{abc}	11.2^{c}	33.7^{a}
	RD43	70.7^{abc}	2.5^{a}	2.9^{bc}	44.7^{def}	3.3k	1.3^{g}	7.3^{g}
	SUP1	78^{ab}	2.5^{a}	2.8^{bc}	58.0^{abcd}	6.7^{ij}	3.3^{fg}	13.4^{ef}
	LSD	ns	ns	ns	*	*	*	**
40	PTTTI	71.0^{abcd}	1.7^{cde}	3.9^{b}	68.0^{ab}	10.9^{def}	19.9^{a}	32.3^{a}
	RD31	72.3^{abcd}	2.2^{abc}	2.6^{bc}	52.7^{bcde}	13.9^{ab}	12.8^{b}	33.2^{a}
	RD43	69.0^{abcd}	1.7^{cde}	1.9^{c}	63.0^{abc}	8.2^{hi}	3.8^{def}	17.5^{cd}
	SUP1	76.3^{abc}	1.6^{de}	1.8^{c}	72.7^{a}	11.8^{cde}	3.9^{de}	19.5^{c}
	LSD	ns	ns	ns	ns	*	*	**
43	PTTTI	61.3^{abcdef}	1.7^{cde}	8.3^{a}	59.0^{abcd}	9.9^{fg}	20.7^{a}	33.0^{a}
	RD31	44.3^{fgh}	2.4^{a}	8.3^{a}	39.3^{ef}	13.1^{abc}	13.9^{b}	34.5^{a}
	RD43	38.0^{h}	2.0^{abcd}	8.3^{a}	31.3^{f}	9.1^{gh}	4.1^{de}	18.8^{cd}
	SUP1	42.3^{gh}	1.8^{bcd}	8.3^{a}	40.0^{ef}	12.6^{bcd}	5.1^{d}	23.4^{b}
	LSD	ns	ns	ns	*	*	*	**
46	PTTTI	55.0^{defg}	1.5^{e}	8.3^{a}	47.3^{cdef}	10.3^{efg}	20.5^{a}	31.7^{a}
	RD31	56.3^{defg}	1.7^{cde}	8.3^{a}	50.0^{cde}	14.4^{a}	13.1^{b}	32.1^{a}
	RD43	50^{efgh}	1.7^{cde}	8.3^{a}	44.7^{def}	6.0^{j}	2.5^{fg}	10.0^{fg}
	SUP1	59.7^{cdef}	1.8^{bcde}	8.3^{a}	51.3^{bcde}	8.9^{gh}	3.7^{def}	16.1^{de}
	LSD	ns	ns	ns	ns	*	*	**
CV		16.7	14.8	14	19.2	18	16.6	14.5

*Significant at p<0.05, ns: Not significant, nd: Not defined (the seed lot not attain T50% at all germination time), maxG: Maximum germination, MGT: Mean germination time, T50: Time to attain 50%, germination GE: Germination energy, TNR: Total number of root, RL: Root length and SL: Shoot length

Effect of seed priming techniques on rice seeds germination: The MGT and T50 on seed germination is very important to determine the seedling vigor. The shorter time indicates higher seedling vigor than long time (Table 1). Primed seeds obtained shorter time than non-primed seeds, a similar result obtained by McDonarld[18] that primed seeds exhibit a faster and more synchronized germination to abiotic stresses than unprimed seeds. The higher GE on primed seed over that of non-primed was due to faster protein synthesize activity in seed embryo which was initiated during priming process. On the other hand low GE on non-prime seed might be due to low protein synthesis in the embryo of non-primed seed. It was reported by Sivritepe and Dourado[19] that high germination is the result of high protein synthesis in germination embryo.

Effect of seed priming techniques on soil temperature stress: Even though, other literatures reported that soil temperature over 40°C could reduced germination[20,21], this was found to be true for non-primed seeds only. When non - primed seeds subjected to severe soil temperature stress only few seeds germinate and survived after 21 days (Table 2).

Contrast to Cooper[20], seed priming techniques improved growth and development of seedling and GE even above 40°C (40-43°C)[22], however, further study needed to be conducted to find the relationship between seed priming technique and growth mechanism under high temperature stress. Surprisingly, the study found that 43°C promote root elongation compared to other soil temperature stress. Some literature pointed out that above 40°C the root growth is ceased. Kar *et al.*[21] reported that the maximum root growth attained at soil temperature between (37-40°C). Kar *et al.*[21] finding disagreed with this result for which the maximum root and shoot growth was attain at 43°C for primed seedling however above 43 growths declined. The root growth and development activity at soil temperature stress of 40-43°C, might be due to efficient carbon and protein metabolism by root thermal tolerance mechanisms[23]. The root thermo-tolerance in some of perennial grass was associated with a greater capacity to control respiratory costs through respiratory acclimation, lowering carbon investment in maintenance for protein turnover and efficiently partitioning carbon into different metabolic pools and alternative respiration pathways[24]. The soil temperature of 40 and 43°C it looks to accelerate plant growth after adaptation of temperature stress at germination stage due to root thermo-tolerance mechanism.

Interaction between seed enhancement techniques with soil temperature stress: The study revealed that, seed priming technique promote number of roots per plant under high soil temperature stress than normal soil temperature (Table 3). The increase in number of root, shoot and root growth for prime seedling over non-primed seed under prove that high soil temperature promote more roots in plants[22]. The increase in number of root due to high soil temperature will probably increase water and nutrient absorption so more fertilizer might be required for future production under global warming. According to Huang[24], the soil temperature and root metabolism is due to efficient carbon and protein metabolism that enhance root temperature tolerance by lowering carbon investment in maintaining the protein turnover and partitioning carbon into different metabolic pools and alternative respiration pathways. Under such situation roots are able to maintain growth and activity during high soil temperature stress condition by activating stress defense proteins such as heat shock protein and antioxidant defense[24]. Dewar *et al.*[25] suggested that plant adaptation to increasing soil temperatures depends mainly on the internal allocation of carbohydrates for protein synthesis.

Interaction between seed treatment technique with rice variety: The priming techniques affect growth and development of seedling however the effect differ from one variety to the other. For shoot/root growth RD43 and suphan Buri 1 grow longer for over 60% of non-primed seed (Table 4). This result concurred with the finding of Sivritepe and Dourado[19] that the stimulation of protein synthesis activity during priming process enhance fast seed growth and development.

Growth effect on the interaction between soil temperature stresses with rice variety: This result showed that there was no statistical significant different for maxG, MTG and T50 at 43 and 46°C, on RD43 and Suphan Buiri 1 varieties showed very week roots development (Table 5). Then the study suggested that the ability of seedling growth and development under high soil temperature stress condition is also depends highly on rice genotype[26].

CONCLUSION

The soil temperature stress above 40°C has effect on seed germination, germination energy, T50 and MGT on non-primed seed. The primed seeds promote more seed germination, shoot and root growth after stress adaptation. The PTT1 rice variety was the best when considering in maxG, GE, MGT and T50 followed by Suphanburi 1. Both PEG 6000 osmopriming and hydropriming technique performs better. Thus seed enhancement might be the promising solution for threatening effect increasing in soil temperature stress.

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SIGNIFICANCE STATEMENT

This study discovers that at soil temperature of 43°C the seed priming technique (PEG 6000 and hydropriming) was enable rice seed to germinate, grow and develop well provided all other growth conditions (including water and nutrients) are maintained. For rice crop the soil temperature of 43°C is over known optimal range required for seed germination (i.e., 18-40°C). This study will help the researcher to uncover the critical areas of relationship between seed priming technique and root/shoot growth mechanism and genetic expression under high temperature stress over non-priming technique that many researchers were not able to explore. Thus a new theory on the relation of seed priming technique and extra stress tolerance mechanism may be arrived at.

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