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Impact of Thermotherapy on the Seed Quality of Pusa Basmati 1121

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ABSTRACT: Nearly half of world population consumes rice as the principal food crop. Rice is affected by several seed borne pathogens. Seed treatment with chemical will pose adverse effects on the environment. The excessive use of fungicides has raised concerns such as a decrease in the fungicide sensitivity of the pathogens. For this reason, alternative methods are being investigated to control the disease. To reduce the inoculum level of seedborne pathogens in rice seeds and to improve the germination speed of the seed. Hot water treatment is one of the non chemical method can be used as an alternative strategy to control seedborne pathogens of rice but it may adversely affect germination and seedling vigour. Hence, we tested the thermotherapy at different temperatures and different times of exposures. The parameters such as germination percentage, plumule length, radicle length, total seedling length and seed vigour were recorded. Hot water treatment at 55°C for 15 minutes was physiologically safe for rice seed. The hot water treatment at 65°C for 20 minutes consistently decreased seed quality in all parameters and is considered an unsafe treatment for rice variety.

Keywords: Hot water treatment, seed borne pathogens, seed germination, seed vigour.

INTRODUCTION

Rice (*Oryza sativa* L.) is the principal food crop for majority population of the world. It is a major food source along with wheat and maize throughout the world. Rice belongs to the order Poales of the grass family Poaceae (Graminae). About 80 million hectare of world's rice area comes under irrigated conditions, which contributes 75 per cent of world's rice production. As a primary staple crop, rice caters to 21% calorie and 15% protein requirements of the world population (Mahender *et al.*, 2016). Rice is an excellent source of carbohydrates and provides instant energy. It also contains protein, fat, thiamine, riboflavin, zinc and niacin in minimal amounts (Philip *et al.*, 2018).

About 90% of the world's total rice production is produced and consumed in Asia (Nirmala, 2017). India ranks first in area under paddy cultivation with 44 million hectares (mha) and second in position with a yearly production of 112.91 million tonnes of milled rice. India has to increase its rice productivity by 3 per cent annually to maintain present food self-sufficiency and to meet future food requirements, but the there is little possibility of expanding the area under rice in near future (Kaur *et al.*, 2015).

In India, area under rice cultivation is 45.07 million hectares with a production 122.27 million tonnes with an average productivity of 2713 kg ha^{-1}. In India, rice is cultivated in almost all the states *viz.,* West Bengal, Uttar Pradesh, Madhya Pradesh, Bihar, Odisha, Andhra Pradesh, Assam, Tamil Nadu, Punjab, Maharashtra and Karnataka. With regards to production, West Bengal stands first followed by Uttar Pradesh in India. In Uttar Pradesh, rice is grown in the entire 72 districts with about 5.68 M ha area comprising 12.60 % of total rice area in India with a production of 15.66 million tones (Anonymous, 2021).

Based on isozyme markers, rice genotypes have been characterized into six clusters *viz*., indica, japonica, aus, basmati, deep water rices, and javanica (Glaszman, 1987).Basmati rice is a unique product of Indo-Gangetic plains of Himalaya comprising good quality characters and aroma. The name 'Basmati' is derived from the Sanskrit word, *bas* from *'vasay'* meaning aroma; and *mati* from *mayup* meaning ingrained from the beginning. The regular usage might have resulted in change of *vas* to *bas* resulting in Basmati (Singh and Singh, 2009). The unbeaten quality and aroma characters made the Basmati rice as one of the important export commodities among food grains from India. India is one of the top exporters of rice, both basmati and non-basmati rice, and the annual Indian rice exports over around 10-13 million MT. India exports Basmati rice to almost 132 countries across the world every year and the major export destinations for

Indian Basmati rice are Central Asian Countries *viz*., Iran, Saudi Arabia, UAE and Iraq (APEDA, 2019).

PB 1121 is a semi-dwarf rice variety with a plant height ranges from 110 to 120 cm. The variety has a yield potential of up to 5.5 t ha^{-1} with a crop duration of about 140–145 days. It can produce 18–20 tillers per plant at a spacing of 20 cm× 15 cm and around 350–400 panicles per m^2. It produces long panicles, ranging from 26 to 28 cm. The number of filled grains per panicle ranges from 105 to 110 and the 1000-grain weight of the fully mature grains is 27.0–28.0 g (at 14% moisture). It has extra-long slender grains with a milled rice kernel length averaging 9.00 mm, breadth of 1.90 mm and an L/B ratio of 4.74 (Singh *et al.*, 2018).

With the commercial release of Pusa Basmati (PB) 1121, the international trade of Basmati rice increased the momentum with the foreign exchange earning reaching to an all-time high of Rs. 29,850 crores during 2020-21. In the fiscal year 2001-02, India exported 0.67 mt of Basmati rice, and it has grown to 4.63 mt during 2020-21.

Most of the seed borne diseases like brown leaf spot, rice blast, bakanae and bacterial leaf blight are caused by the pathogens like *Drechsleraoryzae*, *Pyriculariaoryzae*, *Fusarium fujikuroi* and *Xanthomonas campestris pvoryzae* are the main causes of rice yield reduction. To prevent the seed borne diseases, thermotherapy (hot water treatment) is an alternative eco-friendly method but may affect the seed quality. Hence the work mostly emphasised to develop the effective temperature and time of immersion which effect the germination and seed vigour positively.

MATERIAL AND METHODS

Hot water treatment method was performed at different temperatures and time of exposures. The seeds were dipped in hot water bath at temperatures 50^{O}C, 55^{O}C, 60^{O}C and 65^{O}C for 5, 10, 15 and 20 minutes. Then the germination of seeds were observed.

Standard Blotter Method. Sterilized blotter papers were cut into 9 cm diameter circle and three circles of blotter paper were placed at the bottom of each sterilized Petri plate aseptically and moistened by sterile distilled water. Twenty five seeds were placed at equal distance in each Petri plate and the plates were incubated at 26 ± 1^{0}C. The experiment was conducted in Completely Randomized Design (CRD) with three replications for each temperature level and time of exposure. The observations such as number of germinated seeds, percentage of germinated seeds (%), Plumule length (cm), radicle length (cm), total seedling length (cm), seed vigour index were recorded at 5 days after treatment. Data were analyzed statistically following LSD.

RESULTS

The number of seeds germinated had varied across the treatments considered in the study. The maximum seeds (25) with germination were observed in treatments with 55°C with an exposure time of 10 and 15 minutes. The least seeds with germination (5.67) were observed in treatments with 65°C with an exposure time of 20 minutes. The treatments with 60°C and above with exposure time of 20 minutes had badly affected the number of germinated seeds.

The trend of the germination increased with the temperature from 50 to 55 °C until the highest germination was observed (100%) in treatments at 55°C with 10 and 15 minutes exposure durations. Temperatures above 55°C showed a decline in the germination trend with a least germination observed (22.67%) in treatments with a temperature of 65°C and a duration of 20 minutes. The plumule length had greatly varied across the treatments in the current study. Generally, the length linearly increased with exposure duration until 15 minutes and then decreased in 20 minutes. The following observation was observed across all the treatments except in 65°C with an exposure time of 15 minutes had shown a decline in the plumule length. The maximum plumule length (4.72 ± 0.08 cm) seeds were observed in treatments with 55°C with an exposure time of 15 minutes. The shortest plumule length (0.74 ± 0.19 cm) were observed in treatment with 65°C with an exposure time of 20 minutes.

Typically, at a given temperature, the radicle length decreased linearly with exposure period. The highest radicle length (4.65 ± 0.05 cm) seeds were seen in treatments with 60°C with an exposure time of 5 minute. While the smallest radicle length (0.69 ± 0.35 cm) was recorded in a treatment with 65°C and a 20 minutes exposure interval. The comprehensive results of the experiments are with the parameters total seedling length (cm) and seed vigour index. The total seedling length generally, increased with exposure duration until 15 minutes and then decreased in 20 mins for a particular temperature. The most superior results were obtained from treatment with 55°C and with an exposure time 15 minutes (8.52 ± 0.11). Whereas, the least results (1.43 ± 0.22) were obtained from treatment with 65°C and with an exposure time 20 minutes.

The seed vigour index generally increased with exposure duration until 15 minutes and then decreased in 20 minutes for a particular temperature. The most superior results were obtained from treatment with 55°C and with an exposure time 15 minutes (852). Whereas, the least results (32.41) were obtained from treatment with 65°C and with an exposure time 20 minutes.

Table 1: Effect of hot water treatment on seed germination of basmati rice variety PB 1121 after 5 days.

Time of exposure (minutes)	Number of germinated seeds	Germination (%)	Plumule length (cm)	Radicle length (cm)	Total seedling length (cm)	Seed vigour index
At temperature 50^{o}C						
5	23.67± 0.58^{*a}	94.67	2.32 ± 0.19^{gh}	4.60 ± 0.23^{a}	6.92 ± 0.42^{abcd}	655.11
10	24.33 ± 0.58^{a}	97.33	4.01 ± 0.16^{bcd}	4.46 ± 0.19^{ab}	8.47 ± 0.34^{ab}	824.38
15	24.67 ± 0.58^{a}	98.67	4.63 ± 0.18^{ab}	3.88 ± 0.30^{abcd}	8.51 ± 0.46^{a}	828.31
20	24.33 ± 0.58^{a}	97.33	5.06 ± 0.04^{a}	3.39 ± 0.15^{bcd}	8.45 ± 0.12^{ab}	822.47
At temperature 55^{o}C						
5	24.33 ± 0.58^{a}	97.33	3.31 ± 0.65^{def}	4.27 ± 0.19^{abc}	7.58 ± 0.51^{abcd}	737.79
10	25.00 ± 0.00^{a}	100.00	4.20 ± 0.14^{bc}	4.10 ± 0.46^{abc}	8.30 ± 0.57^{abc}	830.00
15	25.00± 0.00^{a}	100.00	4.72 ± 0.08^{ab}	3.81 ± 0.03^{abcd}	8.52 ± 0.11^{a}	852.00
20	24.00 ± 0.00^{a}	96.00	3.63 ± 0.15^{cde}	3.70 ± 0.19^{abcd}	7.34 ± 0.32^{abcd}	704.64
At temperature 60^{o}C						
5	24.67 ± 0.58^{a}	98.67	2.61 ±0.19^{fgh}	4.65 ± 0.05^{a}	7.26 ± 0.21^{abcd}	716.32
10	23.67 ± 1.53^{a}	94.67	3.67 ± 0.15^{cde}	4.46 ± 0.19^{ab}	8.14 ± 0.32^{abc}	770.59
15	23.33 ± 1.53^{a}	93.33	4.61 ± 0.25^{ab}	3.80 ± 0.19^{abcd}	8.41 ± 0.43^{ab}	796.15
20	8.67 ± 2.08^{d}	34.67	3.00 ± 0.25^{efg}	3.14 ± 0.19^{cd}	6.14 ± 0.43^{de}	212.87
At temperature 65^{o}C						
5	24.00 ± 1.00^{a}	96.00	3.37 ± 0.16^{fgh}	3.96 ± 0.19^{abc}	7.33 ± 0.34^{cd}	703.68
10	20.00 ± 2.65^{b}	80.00	2.41 ± 0.17^{gh}	3.46 ±0.03^{bcd}	5.87 ± 0.19^{de}	496.60
15	14.67 ± 4.04^{c}	58.67	2.01 ± 0.20^{h}	2.76 ± 0.16^{d}	4.77 ± 0.31^{e}	279.84
20	5.67 ±1.53^{d}	22.67	0.74 ± 0.19^{i}	0.69 ±0.35^{e}	1.43 ± 0.22^{f}	32.41
Control	23.33 ± 0.58^{a}	93.33	4.46 ± 1.26^{bc}	2.28 ± 0.62^{abcd}	6.74 ± 1.87^{bcd}	629.07

***** Mean ± Standard Deviation

Mean with respective standard deviation indicated in a column by same letters were not significantly different from one another as per DMRT

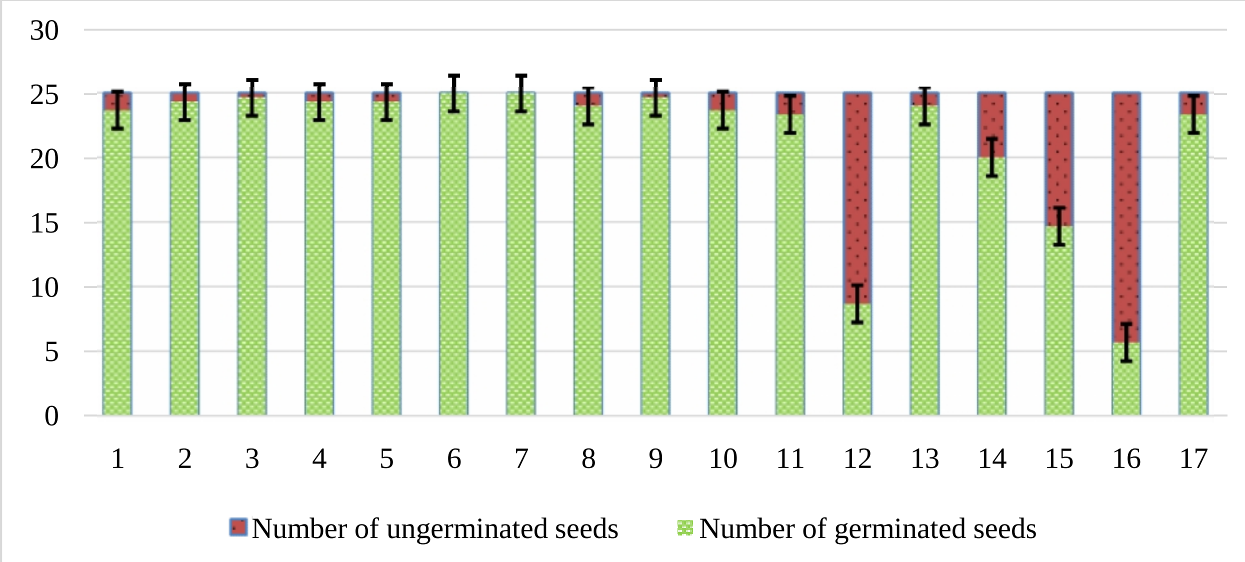

Fig. 1. Effect of hot water treatment on the seed germination in variety PB1121.

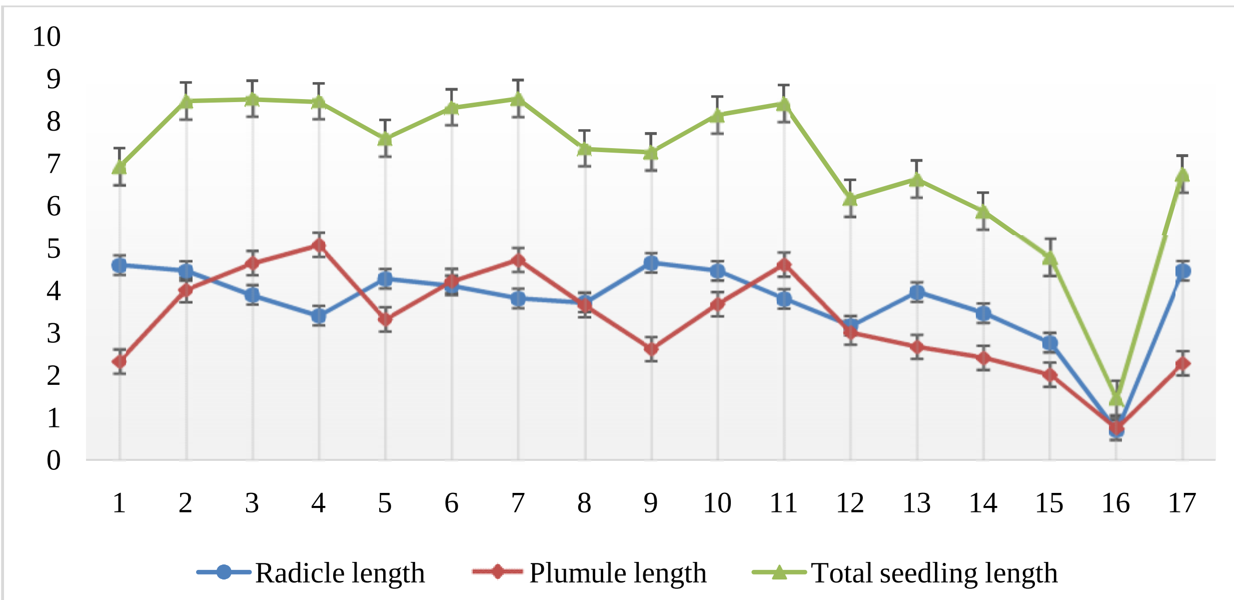

Fig. 2. Effect of hot water treatment on the seedling length in variety PB1121.

DISCUSSION

The number of germinated seeds showed great significance across the treatments. The maximum germinated seeds (25 were recorded in treatments with 55°C with an exposure time of 10 and 15 minutes. The least seeds with germination (5.67) were observed in treatments with 65°C with an exposure time of 20 minutes.

The plumule length and radicle length had greatly varied across the treatments in the current study. The maximum plumule length (4.72 ± 0.08 cm) seeds were observed in treatments with 55°C with an exposure time of 15 minutes. The highest radicle length (4.65 ± 0.05 cm) seeds were seen in treatments with 60°C with an exposure time of 5 minute. While the smallest plumule length (0.74 ± 0.19 cm) and radicle length (0.69 ± 0.35 cm) were recorded in a treatment with 65°C and a 20 minutes exposure interval. The total seedling length generally, increased with exposure duration until 15 minutes and then decreased in 20 mins for a particular temperature. The most superior results were obtained from treatment with 55°C and with an exposure time 15 minutes (8.52 ± 0.11). Whereas, the least results (1.43 ± 0.22) were obtained from treatment with 65°C and with an exposure time 20 minutes.

The germination trend increased with the temperature from 50 to 55 °C until the highest (100%) germination was observed in treatments at 55°C with 10 and 15 minutes exposure durations.

According to Ventura and Garrity (1987), the hot water treatment at 52°C for 15 rain was safe for rice seed regardless of cultivar, storage condition after treatment, or whether presoaking was practiced before the treatment. The 52°C for 15minutes treatment increased field seedling vigor and tiller number over the untreated control. The hot water treatment at 57°C for 30minutes consistently decreased seed quality and was considered an unsafe treatment for rice seed. Matic *et al.* (2014) also reported that seed priming with *P. guilliermondii R9* and *M. pulcherrima R23* in combination of thermotherapy at 60°C for 10 minutes decreased the bakanae disease index below 5% and improved the seed germination rate. Hossain *et al.* (2016) recorded the seed germination which were not significantly differed up to 25 minute when exposed at 53 and 55°C and found better performance compared to other temperatures and exposure time.

The result of Eğerci *et al.* (2022) also revealed thatthe highest seed germination rate of 86.25% was observed in the hot water treatments at 50 °C, followed by 52 ° C (75%), 55 °C (40%) and 57 °C (9%), respectively. In pot trial tests, the highest germination rate was observed in hot water treatments at 50 °C (74%).

The results were in close proximity with reports of Hossain *et al.* (2016) recorded the seed germination which were not significantly differed up to 25 minute when exposed at 53 and 55°C and found better performance compared to other temperatures and exposure time. Seed treatment at 550 C for 10 minutes gave 4.5% infection as compared to 1% at 60^0 C for 10 minutes. Seed treated at 55^0 C for 15 minutes gave 4% infection. Seed-borne infection was 1.5% when the seeds were treated at 58^0 C for 5 minutes

CONCLUSION

Thermotherapy is an alternative method to prevent the seed borne pathogens of rice. The treatment at 55°C and with an exposure time 15 minutes showed better performance in germination percentage and seed vigour index. The treatment at 60°C and with an exposure time 20 minutes decreased the seed germination and seed vigour index and found inferior among all the treatments.

FUTURE SCOPE

To provide good nutritional quality and safe fodder for the livestock effective strategy to manage seed borne pathogens. It is best non chemical method which not helps in controlling the seed borne pathogens but also improves the seed germination rate. This work mainly suggests that thermotherapy effects seed germination and seed vigour.

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