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Influence of High Temperature on Seed Quality in Parental Lines of Rice Hybrids

HRISHIKESH SUTRADHAR*, SK CHAKRABARTY AND YOGENDRA SINGH

Division of Seed Science and Technology, ICAR-Indian Agricultural Research Institute, New Delhi 110 012
*hrishikesh_sutradhar@yahoo.com

ABSTRACT: A study was undertaken with the parental lines of three Indian rice hybrids *viz.*, DRRH-2, DRRH-3and PRH-10 during *Kharif* 2012-13 at ICAR-Indian Agricultural Research Institute, New Delhi. Parental lines were sown in three different sowing dates during the month of April (1st sowing), May (2nd sowing) and June (3rd sowing) to expose the plants to different range of temperatures and to understand its effect on seed quality. Seed quality parameters such as *per cent* mean germination at final count (83%, 87% and 92% in 1st, 2nd and 3rd sowing, respectively), mean seed vigour index I (1878.37, 2242.63 and 2591.98 in 1st, 2nd and 3rd sowing, respectively), mean seedling dry weight (9.5 mg, 10.1 mg and 10.7 mg in 1st, 2nd and 3rd sowing, respectively) and mean 1000 seed weight (17.95g, 18.67 and 19.18 g in 1st, 2nd and 3rd sowing, respectively) were significantly decreased by high temperature. It is concluded that higher temperature during seed development stage reduces the seed quality irrespective of genotypes.

Keywords: Hybrid rice, High temperature, Parental lines, Seed quality

Seed forms the basis of any agricultural activity and its ability to germinate and give an optimum plant stand depends on its quality. The growing environment affects the quality of seed which a genotype produces. Various environmental factors that affect seed viability and vigor during parental lines development are drought, freezing, nutrient deficiency, rainfall and temperature. Among these high temperatures is emerging as one of the main determinant in seed quality. With global warming, it is projected that the global mean temperatures would increase by 1·4-5·8°C [1]. Rice is grown in different agro-climatic zones and it feeds about 2.7 billion people in this world [2] and temperature is a critical factor in its cultivation. Heat stress is emerging as the most serious threat to hybrid rice seed production as a consequence of climate change. Studies conducted in japonica rice at high temperature throughout seed development and maturation revealed poor seed quality which did not become evident until seed filling had ended [3, 4]. It has later been reported that rice is more sensitive to high temperature mainly during early seed development stage than later stages of seed development and maturation [5]. Unfavourable environmental conditions in the field (high temperature, rainfall and relative humidity) as well as during harvesting, drying, cleaning and storage, affect the germination of a seed lot [6, 7]. So the present study was undertaken to evaluate the effect of different temperature regimes on the quality of seed produced in different parental lines of the three rice hybrids.

MATERIALS AND METHODS

This research work was undertaken at the research farm of ICAR-Indian Agricultural Research Institute (IARI), New Delhi. Experimental materials consisted of parental lines of three rice hybrids namely, DRRH 2, DRRH 3 and PRH-10. The seeds

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of the parental lines of hybrids, DRRH 2 and DRRH 3 were obtained from the ICAR-Indian Institute of Rice Research, Hyderabad and of the parental lines of PRH 10 from Division of Genetics, ICAR-IARI, New Delhi. The experiment was carried out using randomized complete block design with three replications. Sowing of seeds in the nursery was done in three periods/ dates viz.1st sowing: 26th march - 2nd April, 2nd sowing: 30th April - 7th May and 3rd sowing: 13th June- 20th June. Need based staggered sowing of seeds of the parental lines of the respective hybrid was done. Twenty five to thirty days old seedlings of all the parental lines were transplanted with single seedling per hill on 28th April, 8th June and 16th July for the 1st, 2nd and 3rd sowing, respectively. Three to four sets of R and A line in the ratio of 2:8 and four to six rows of B line were planted in each plot. Spacing between rows of pollen parent (R-line), R-line and seed parent (A-line) and between A-lines was 30cm, 20cm and 15cm, respectively. Fertilizer application, GA_3 application, supplementary pollination, roguing and plant protection measures were also undertaken. Seeds of all the parental lines were harvested at maturity. As freshly harvested paddy seeds exhibit dormancy so they were subjected to preheating following ISTA described procedure [8] for breaking their dormancy. Later on germination test was conducted using 'Between paper' method [8]. Four replicates of one hundred seeds from each genotype were placed equidistantly on moist germination paper. The rolled towels were incubated at 25°C for fourteen days. The final count of germinated seeds was recorded after fourteen days. The germination percentage was recorded on the basis of normal seedling only at the final count and expressed in percentage. Seedling vigour index I was calculated using recommended procedure [9] and expressed as whole number.

The 1000 seed weight of the seeds of different parental lines and sowing dates was recorded following the ISTA described procedure [8]. Pooled data were analyzed statistically to compare the effect of sowing dates on the characters recorded in the parental lines. The temperature data during the various growth stages and for the sowing dates (Table 1) were collected from the Division of Agricultural physics, ICAR-IARI, New Delhi.

RESULTS

Effect on Seed germination

There was a general decrease in germination of seeds of the parental lines in the first and second sowing compared to that in the third sowing (Table 2). The mean seed germination were 83, 87 and 92 in 1st, 2nd and 3rd sowing, respectively. However, in the 1st sowing, PRR 78 recorded the highest germination percentage of 86% among all the parental lines whereas DR 71412 R recorded the highest seed germination in 2nd and 3rd date of sowing (93% and 96%, respectively). Pusa 6A recorded the least mean germination percentage among all the parental lines (81%, 83% and 86% in 1st, 2nd and 3rd sowing, respectively).

Table 1. Temperature at various growth stages of the parental lines in the three dates of sowing

Sowings	Temp. (°C)	Sowing to Booting	Booting to 50% flowering	50% flowering to physiological maturity
1st sowing	Max.	39.3ºC	39ºC	35.6ºC
	Min.	24.5ºC	26.8ºC	26.8ºC
	Av.	31.5ºC	31.3ºC	31.3ºC
2nd sowing	Max.	34.6ºC	32.7ºC	33ºC
	Min.	26.7ºC	25.6ºC	24.6ºC
	Av.	30.7ºC	28.8ºC	28.8ºC
3rd sowing	Max.	33.5ºC	32.8ºC	33.6ºC
	Min.	26.5ºC	24.9ºC	21.5ºC
	Av.	29.5ºC	28.9ºC	27.4ºC

Table 2. Effect of sowing dates on percent germination at final count (%) in parental lines of rice hybrids

Parental lines	Sowing dates			Mean
	1st	2nd	3rd	
IR 68897 A	83 (67)*	87(69)	93(76)	87(71)
IR 68897 B	85 (69)	87(69)	91(74)	87(71)
DR71412 R	85 (64)	93(76)	96(78)	91(74)
APMS 6A	81 (67)	86(70)	92(75)	86(71)
APMS 6B	83(67)	85(69)	93(75)	87(70)
RPHR 1005	83(67)	90(72)	92(75)	88(71)
PUSA 6A	81(66)	83(67)	86(69)	83(67)
PUSA 6B	82(66)	89(73)	92(74)	88(71)
PRR 78	86(69)	87(70)	91(73)	88(71)
Mean	83(67)	87(70)	92(74)	
CD (p=0.05)	Parental line (P):1.092, Sowing date (S):0.63 and PxS:1.89			

*Figures in parenthesis are arc sine transformed values

Effect on seedling vigour Index I

Seedling vigour index I showed significant increase in all the parental lines from the 1st sowing to the 3rd sowing (Table 3). The mean seedling vigour index I were 1878, 2242 and 2591 in 1st 2nd and 3rd sowing, respectively. Among all the parental lines, mean seedling vigour index 1 was the highest in case of DR 71412 R (2161, 2506 and 2849 in1st, 2nd and 3rd sowing, respectively).

Effect on seedling dry weight

Seedling dry weight taken 14 days after seed germination also showed significant increase in all the parental lines from the 1st sowing to the 3rd sowing (Table 4). The mean seedling dry weight was 9.5 mg, 10.1 mg and 10.7 mg in 1st, 2nd and 3rd sowing, respectively. The mean seedling dry weight among all the parental lines was highest in case of PRR 78 (10.9mg, 11.8 mg and 12.9 mg in 1st, 2nd and 3rd sowing, respectively).

Effect on 1000 seed weight

The average thousand seed weight of the parental lines grown under the three different temperature

Table 3. Effect of sowing dates on seed vigour index I in parental lines of rice hybrids

Parental lines	Sowing dates			Mean
	1st	2nd	3rd	
IR 68897 A	2085	2144	2762	2330
IR 68897 B	1572	2364	2326	2186
DR71412 R	2161	2506	2849	2505
APMS 6A	1841	2204	2804	2283
APMS 6B	1717	2122	2493	2111
RPHR 1005	1810	2165	2477	2151
PUSA 6A	1756	2169	2224	2151
PUSA 6B	1803	2143	2600	2182
PRR 78	2157	2363	2788	2436
Mean	1878	2242	2591	
CD (p=0.05)	Parental line (P):237.17, Sowing date (S):136.93 and PxS: NS*			

*Non-significant

Table 4. Effect of sowing dates on seedling dry weight (mg) at 14 days after germination in parental lines of rice hybrids

Parental lines	Sowing dates			Mean
	1st	2nd	3rd	
IR 68897 A	8.7	9.0	9.6	9.1
IR 68897 B	10.2	11.3	11.6	11.0
DR71412 R	10.9	11.4	11.8	11.4
APMS 6A	9.1	9.6	9.8	9.5
APMS 6B	8.9	9.4	10.1	9.5
RPHR 1005	7.5	7.5	8.4	7.8
PUSA 6A	9.4	10.3	11.3	10.3
PUSA 6B	9.6	10.3	11.3	10.4
PRR 78	10.9	11.8	12.9	11.9
Mean	9.5	10.1	10.7	
CD (p=0.05)	Parental line (P):0.57, Sowing date (S):0.33 and PxS: NS*			

*Non-significant

regimes showed an increase from 1st sowing to the third sowing (Table 5). The A lines namely, APMS 6A and Pusa 6A showed higher 1000 seed weight compared to that in the respective B lines. Among all the parental lines 1000 seed weight was maximum for PRR 78 (23.44 g, 24.34 g and 25.04 g in 1st, 2nd and 3rd sowing, respectively).

DISCUSSION

Seed quality is very much sensitive to temperature during the seed filling period because of the fact that high temperature can differentially affect the various processes involved in seed filling and the chemical composition of the seeds may also be modified by increasing temperature. In the present study, seed germination was found to be reduced in the 1st and 2nd sowing as compared to the 3rd sowing. High temperatures during seed filling frequently disrupt normal seed development, which increases the proportion of seeds that are shrivelled, abnormal and are of lower quality [10]. High-temperature stress before the developing seeds achieve physiological or mass maturity is likely to inhibit the ability of the plant to supply

Table 5. Effect of sowing dates on 1000 seed weight (g) in parental lines of rice hybrids

Parental lines	Sowing dates			Mean
	1st	2nd	3rd	
IR 68897 A	18.67	19.10	19.94	19.24
IR 68897 B	19.43	20.26	21.17	20.29
DR71412 R	19.28	20.23	20.55	20.02
APMS 6A	16.67	17.04	17.55	17.08
APMS 6B	15.60	16.47	16.88	16.31
RPHR 1005	12.46	12.84	13.18	12.83
PUSA 6A	18.12	19.52	19.96	19.20
PUSA 6B	17.90	18.27	18.41	18.20
PRR 78	23.44	24.34	25.04	24.28
Mean	17.95	18.67	19.18	
CD (p=0.05)	Parental line (P):0.34, Sowing date (S):0.19 and PxS: NS*			

*Non-significant

the seeds with the assimilates necessary to synthesize the storage compounds required during the germination process [11] and/or the seeds suffer physiological damage [12] to the extent that the ability to germinate is lost.

Seedling vigour in the 1st and 2nd sowing was also found to be lower as compared to 3rd sowing. Seedling vigour is reduced by high-temperature stress before [7, 10] and also after physiological maturity [13]. High temperatures induce or increase the physiological deterioration of seeds. Limited evidence suggests that only short periods of high-temperature stress at critical seed development stages are required to reduce seed vigour. The loss in seed vigour is associated with physiological deterioration of the seed [14, 15] and lipid peroxidation is cited as the most frequent cause [16]. Lipid peroxidation results in cellular degeneration by the attack of free radicals on important cellular structures and molecules [16, 17]. A model [16] was suggested in which four types of cell damage was proposed, *viz.* enzyme inactivation, mitochondrial dysfunction, membrane degradation and genetic damage. It was reported that high-temperature stress of the parent plant may also cause mitochondrial degeneration, reduced energy levels, adenosine triphosphate (ATP) accumulation, and rates of oxygen uptake in imbibing wheat embryos, which provides clear evidence that metabolic changes do occur at the mitochondrial level in early seed germination during seed development and maturation in response to heat stress [18]. Seed storage accumulation is known to be affected by heat stress [19].

1000 seed weight is one of important parameter in seed quality. It relates to embryo size and seed storages for germination and emergence. The low 1000 seed weight in the first and second date of sowing as compared to third sowing establishes the fact that seed filling was not proper as the translocation of photosynthates might have been affected under high temperature stress. Thus, it is possible that heat stress after anthesis is particularly detrimental to subsequent seed development, due to the disturbance in the accumulation of seed storage products. As a result, the germination and vigour of the seedlings of parental lines produced under high temperature conditions were considerably reduced.

The environment during seed development and maturation can significantly reduce seed quality [6, 7, 20, 21] particularly seed vigour. Seed germination percentage may not be reduced drastically under high temperature stress but the vigour of such seeds are highly reduced. This may also lead to reduction in seed viability quickly after storage of such seeds. To minimize the risk of reductions in seed quality the seed industry need to, therefore, consider moving seed production in different areas or changing sowing dates so that seed filling occurs at mild temperatures in order to reduce the chances of environmental stress [7]. Sowing in June however was found to be better for good quality hybrid seed production of rice under Delhi conditions.

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