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Efficacy of Dormancy Breaking Methods in *Indica* Rice Varieties

KOTA JANAIAH, K. KANT AND M. DADLANI
Division of Seed Science and Technology, Indian Agricultural Research Institute,
New Delhi- 110012
kotajanaiah@yahoo.com

ABSTRACT Freshly harvested seeds of 44 rice varieties were used to test the efficacy of eight dormancy breaking methods. Among all the eight dormancy breaking methods tried in the 19 strong dormant varieties, dry heat treatment was most effective and the effectiveness of the other treatments was optimal. In four varieties, Kanak, Malaviya Dhan 36, Swarna and Intan, having strong dormancy, none of the treatments could improve germination beyond 70%. In the weak dormancy group dry heat treatment was most effective followed by moist heat and GA_3 (100ppm and 500 ppm). HNO_3 (0.1N) treatment improved germination significantly in all the varieties with weak dormancy except in cv. Kasturi. Similarly H_2O_2 and KNO_3 seed treatments were not able to improve germination in cvs Kasturi, Pusa 44 and Narendra 359.

Keywords: Rice, *Oryza sativa*, dormancy breaking

Occurrence of seed dormancy in rice varies significantly among cultivars. In general, cultivars belonging to tropical *Indica* subspecies show greater dormancy than the *Japonica* and *Javanica* subspecies [1 and 2]. On the other hand, wild species of rice [3] and cultivated species of African rice (*Oryza glaberrima*) exhibit stronger dormancy than the *Indicas* [4]. Presence of seed dormancy in rice is both problematic as well as advantageous. It is problematic for post harvest seed testing [5]; in the production of two or three crops a year [6] and in plant breeding [7] where a number of times off-season crops are taken. However, it is advantageous in avoiding viviparous germination in tropical cultivars grown during monsoon season [8]. Widely applicable dormancy breaking methods are necessary in the routine seed testing, to asses the exact planting value in the laboratory for certification purpose and to the plant breeders to raise two to three crops in a year. Though ISTA [9] and several workers [10-16] have suggested treatments to break seed dormancy in rice, it is not necessary that one method may be able to break dormancy available in all the rice cultivars. Therefore, the present investigations were undertaken to observe the efficacy of dormancy breaking methods on the *Indica* rice varieties having different intensity of dormancy.

MATERIALS AND METHODS

Freshly harvested seeds (*Kharif* 2002) of 44 rice varieties were used in the present investigation. Based on initial germination (%), varieties were grouped into strong (<25% germination) and weak dormancy groups (>25% germination). The following eight seed treatments were given on the both dormancy groups.

Seeds were treated with (1) 100 and (2) 500 ppm GA_3, (3) 0.1 N HNO_3 (4) 0.1N H_2O_2, (5) 0.01M KNO_3, (6) 0.2 % KNO_3 for 24h. After the treatments seeds were dried at room temperarture. For KNO_3 treatment germination substrate was saturated with the solution, (7) moist heat treatment (seeds were kept in small cloth bags and kept on wire mesh in desiccator for 2 days maintained at 100% RH and 43°C) and (8) dry heat treatment (seeds were kept in Petri dishes and transferred to the incubators by adjusting the temperature to 50°C for one week)

The treated seeds were kept for germination at 25°C in two replications of 100 seeds each and germination percentage was evaluated into normal, abnormal seedlings, dead and fresh ungerminated seeds as per ISTA [9].

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Table 1 . Per cent seed germination as affected by various treatments in rice varieties

Variety	Germination (%)								
	Control 1	GA_3 (100 ppm) 2	GA_3 (500 ppm) 3	HNO_3 (0.1N) 4	H_2O_2 (0.1 M) 5	KNO_3 (0.2%) 6	KNO_3 (0.01 M) 7	Moist heat* 8	Dry heat ** 9
Varieties with strong dormancy									
Ratna	8.5	21.5	40.5	39.5	29.0	33.5	28.5	88.5	91.5
	(16.9)	(27.6)	(39.5)	(38.9)	(32.5)	(35.3)	(32.2)	(70.2)	(73.0)
ADT-37	13.5	78.0	85.5	60.0	59.5	73.5	64.5	82.0	92.5
	(21.5)	(62.0)	(67.4)	(50.7)	(50.4)	(59.0)	(53.4)	(64.9)	(74.1)
Pant Dhan-10	21.0	88.5	92.0	59.5	76.0	66.5	62.0	83.0	97.0
	(27.2)	(70.2)	(73.6)	(50.4)	(60.6)	(54.6)	(51.9)	(65.6)	(80.1)
HKR 126	25.0	95.5	93.5	92.0	91.0	91.5	90.0	91.5	97.0
	(29.9)	(77.7)	(75.5)	(73.6)	(72.5)	(73.0)	(71.5)	(73.1)	(80.1)
HKR 120	18.5	82.0	86.5	68.0	50.0	51.0	45.5	74.5	94.0
	(25.4)	(64.9)	(68.4)	(55.5)	(45.0)	(45.5)	(42.4)	(59.6)	(75.8)
Basmati 370	5.5	45.5	62.0	40.0	7.5	9.0	6.0	29.5	96.0
	(13.5)	(42.4)	(51.9)	(39.2)	(15.1)	(17.4)	(14.1)	(32.8)	(78.5)
Kanak	7.5	22.0	24.0	13.5	8.5	14.0	6.5	20.0	56.0
	(15.1)	(27.9)	(29.3)	(21.5)	(16.9)	(21.9)	(14.7)	(26.5)	(48.4)
Malviya Dhan 36	2.0	6.0	12.0	9.5	2.5	2.5	1.5	22.0	59.5
	(7.8)	(14.1)	(20.2)	(17.9)	(9.0)	(9.0)	(6.9)	(27.9)	(50.4)
Vijetha	5.5	15.0	44.5	31.5	20.0	12.5	10.5	29.5	90.0
	(13.4)	(22.7)	(41.8)	(34.1)	(26.5)	(20.6)	(18.8)	(32.8)	(71.5)
Mandya vijaya	4.0	3.5	13.5	20.0	2.5	4.0	2.0	49.0	90.0
	(11.4)	(10.7)	(21.5)	(26.5)	(9.0)	(11.4)	(8.1)	(44.4)	(71.5)
Vajram	15.5	63.5	62.5	49.5	44.5	16.5	21.5	52.5	89.5
	(23.0)	(52.8)	(52.2)	(44.7)	(41.8)	(23.9)	(27.6)	(46.4)	(71.0)
Swarna	6.0	38.0	54.5	12.5	6.0	16.5	16.0	30.0	57.5
	(14.1)	(38.0)	(47.5)	(20.7)	(14.1)	(23.9)	(23.5)	(33.1)	(49.3)
Swarna Dhan	11.0	25.5	60.0	67.0	31.5	20.0	13.5	72.5	96.0
	(19.3)	(30.3)	(50.7)	(54.9)	(34.1)	(26.5)	(21.5)	(58.3)	(78.5)
Chaitanya	19.5	56.0	53.5	65.0	55.5	26.0	20.0	69.0	97.5
	(26.1)	(48.4)	(47.0)	(53.7)	(48.1)	(30.6)	(26.5)	(56.1)	(81.3)
IET 7191	11.5	16.0	39.5	35.5	16.5	15.5	19.0	72.5	91.0
	(19.8)	(23.5)	(38.9)	(36.5)	(23.9)	(23.1)	(25.8)	(58.3)	(72.5)
Intan	2.5	7.0	6.5	18.0	8.5	2.5	3.5	50.5	69.0
	(9.0)	(14.7)	(14.7)	(25.0)	(16.9)	(9.0)	(10.7)	(45.2)	(56.1)
Krishnaveni	4.0	10.0	4.5	24.0	4.5	13.0	4.5	3.5	86.00
	(11.4)	(18.4)	(12.2)	(29.3)	(12.2)	(21.1)	(12.2)	(10.7)	(68.0)
Prathiba	16.0	86.5	80.5	71.5	49.5	55.0	55.5	49.5	71.0
	(23.5)	(68.4)	(63.8)	(57.7)	(44.7)	(47.8)	(48.1)	(44.7)	(57.4)
IR-20	1.0	38.0	34.0	12.5	63.0	52.0	52.5	67.0	87.5
	(5.9)	(38.0)	(35.6)	(20.7)	(52.5)	(46.1)	(46.4)	(54.9)	(69.3)
Mean	**10.4**	**41.7**	**50.3**	**41.5**	**32.9**	**30.3**	**27.5**	**54.5**	**84.7**
Varieties with weak dormancy									
Annada	59.0	96.5	97.00	95.5	94.0	95.0	97.5	96.0	96.0
	(50.1)	(79.2)	(80.16)	(77.7)	(76.1)	(77.0)	(80.9)	(78.6)	(78.5)
Red triveni	63.5	94.5	96.50	85.0	92.5	91.0	93.0	93.5	95.5
	(52.8)	(76.4)	(79.24)	(67.2)	(74.1)	(72.6)	(75.0)	(75.2)	(77.7)
Pusa 834	29.0	82.0	78.50	79.0	76.5	96.0	89.0	90.5	95.0
	(32.5)	(64.9)	(62.37)	(62.5)	(61.0)	(78.4)	(70.6)	(72.0)	(77.3)
Pant Dhan 11	59.5	92.0	93.00	83.0	93.5	87.5	89.0	85.5	97.5
	(50.4)	(73.6)	(74.81)	(65.6)	(75.2)	(69.3)	(70.6)	(67.6)	(80.9)

Table 1 . Contd.

Variety	Germination (%)								
	1	2	3	4	5	6	7	8	9
				Varieties with weak dormancy					
IR 50	69.0	91.5	87.00	82.5	91.5	89.0	91.5	91.0	92.0
	(56.1)	(73.1)	(69.30)	(65.3)	(73.1)	(70.6)	(73.1)	(72.6)	(73.6)
Rasi	79.5	90.5	89.00	84.0	90.5	93.0	95.0	96.0	94.0
	(63.0)	(72.1)	(70.64)	(66.4)	(72.0)	(74.6)	(77.1)	(78.5)	(76.0)
Pusa 169	58.0	94.0	94.00	84.5	81.0	84.5	91.0	96.5	96.5
	(49.6)	(76.0)	(75.86)	(66.8)	(64.1)	(66.8)	(72.5)	(79.2)	(79.4)
Krishna Hamsa	75.5	96.0	97.0	96.5	88.5	97.5	95.5	96.0	97.5
	(60.3)	(78.5)	(80.16)	(79.2)	(70.2)	(80.9)	(77.7)	(78.5)	(80.9)
IR 36	59.5	92.5	95.00	84.0	74.0	88.5	88.0	87.5	91.5
	(50.4)	(74.1)	(77.14)	(66.4)	(59.3)	(70.2)	(69.7)	(69.3)	(73.0)
Pusa 677	69.0	92.0	96.00	97.5	97.0	96.0	96.0	88.5	95.5
	(56.1)	(73.6)	(78.46)	(80.9)	(80.1)	(78.5)	(78.5)	(70.2)	(77.7)
Vikas	61.0	92.5	94.50	75.5	96.5	85.5	95.5	88.0	93.5
	(51.3)	(74.1)	(76.56)	(60.3)	(79.2)	(67.6)	(77.7)	(69.7)	(75.3)
Pusa 205	51.5	76.5	77.50	81.5	85.5	68.5	85.5	90.5	91.5
	(45.8)	(61.0)	(61.96)	(64.5)	(67.6)	(55.8)	(67.6)	(72.0)	(73.1)
Kasturi	35.0	91.0	(87.50	39.0	57.5	53.5	58.0	88.0	84.5
	(36.2)	(72.5)	(69.38)	(38.6)	(49.3)	(47.0)	(49.6)	(69.7)	(66.8)
Pant Dhan 12	69.0	96.0	89.0	94.5	89.0	86.5	89.5	93.0	97.0
	(56.1)	(78.6)	(70.6)	(76.5)	(70.6)	(68.4)	(71.0)	(74.5)	(80.1)
Pusa 44	30.0	66.0	71.0	68.5	28.5	31.5	34.0	82.0	92.5
	(33.2)	(54.3)	(57.4)	(55.8)	(32.2)	(34.1)	(35.3)	(64.9)	(74.1)
IR 64	71.0	89.0	81.5	91.0	78.5	87.0	84.5	94.0	98.0
	(57.7)	(70.6)	(64.5)	(72.5)	(62.3)	(68.9)	(66.8)	(76.0)	(82.1)
Pant Dhan 4	27.0	89.0	84.0	90.5	78.0	69.0	66.5	88.0	96.0
	(31.3)	(70.6)	(66.4)	(72.0)	(62.0)	(56.1)	(54.6)	(69.8)	(78.4)
Pusa Basmati 1	69.0	81.5	84.0	92.5	74.5	85.5	85.5	95.5	96.5
	(56.1)	(64.5)	(66.4)	(74.1)	(59.6)	(67.6)	(67.6)	(77.7)	(79.2)
Narendra 359	54.0	74.5	77.5	84.5	49.0	57.5	54.5	92.0	95.5
	(47.2)	(59.6)	(61.7)	(66.8)	(44.4)	(49.3)	(47.5)	(73.6)	(77.7)
ADT 38	52.0	93. 5	84.5	92.5	86.0	79.5	72.5	90.5	88.5
	(46.1)	(75.2)	(66.8)	(74.1)	(68.0)	(63.0)	(58.3)	(72.0)	(70.2)
Phalguna	66.5	88.0	75.0	93.5	76.5	79.5	72.5	89.5	94.0
	(54.6)	(69.7)	(60.0)	(75.2)	(61.0)	(63.0)	(58.3)	(71.1)	(75.8)
ADT 39	45.0	94.0	95.5	95.0	91.5	90.5	89.0	91.0	94.5
	(42.1)	(75.8)	(77.7)	(77.1)	(73.0)	(72.0)	(70.6)	(72.5)	(76.5)
Sona Mahsuri2	8.5	88.5	95.5	70.5	61.0	64.5	63.5	81.5	94.5
	(32.2)	(70.2)	(77.9)	(57.1)	(51.3)	(53.4)	(52.8)	(64.5)	(76.4)
Sarjoo 52	62.0	85.0	86.0	96.0	72.0	74.0	76.0	97.5	98.0
	(51.9)	(67.2)	(68.0)	(78.6)	(58.0)	(59.3)	(60.6)	(80.9)	(81.8)
Tarorai Basmati	40.5	92.5	93.5	91.5	80.0	63.0	70.5	82.0	99.0
	(39.5)	(74.3)	(75.2)	(73.1)	(63.4)	(52.5)	(57.1)	(64.8)	(85.9)
Mean	**55.3**	**88.4**	**88.2**	**85.1**	**79.3**	**79.2**	**80.9**	**90.5**	**94.5**
CD (P=0.05)									
Varieties (V)		1.64							
Treatments (T)		0.80							
V×T		4.39							

* Moist heat (43 ^{0}C, 100% RH, 2 days)

** Dry heat (50 ^{0}C, 7 days)

Arc sine values in parenthesis

RESULTS AND DISCUSSION

When various treatments were compared for their efficacy to break the dormancy of strong dormancy group, it was observed that in strong dormancy group dry heat treatment was most effective (mean germination, 84.7%) as compared to control (10.4%). The other treatments were only partially effective. Out of 19 varieties of strong dormancy group in only 14 varieties, the dry heat treatment could improve germination (%) above Indian Minimum Seed Certification Standards (IMSCS), while in the rest five varieties it ranged from 56 to 71% only (Table 1). In cv. HKR 126, all the dormancy breaking seed treatments improved germination (>90%) as compared to control (25%). On the other hand in four varieties, i.e. Kanak, Malaviya Dhan 36, Swarna and Intan, having strong dormancy, none of the treatments could improve germination beyond 70%.

In five varieties, i.e. ADT 37, Pant Dhan 10, HKR 126 and HKR 120 and Pratibha, GA_3 500 ppm was also effective in improving the germination. In two of these varieties the initial germination exceeded 20%.

In the weak dormancy group dry heat treatment was most effective (mean germination 94.6%), followed by moist heat (90.6%), GA_3 100ppm (88.5%) and GA_3 500 ppm (88.3%). In 10 varieties (Annada, Red Triveni, Pant Dhan 11, IR 50, Rasi, Pusa 169, Krishna Hamsa, Pusa 677, Pant Dhan 12 and ADT 39) all the treatments improved germination (%) above the IMSCS.

HNO_3 (0.1N) improved the germination (%) significantly in all the varieties with weak dormancy, except in Kasturi, when compared to control. H_2O_2 and KNO_3 did not improve the germination in Kasturi, Pusa 44 and Narendra 359.

The interaction effect (variety x treatment) was significant, showing that the treatments are not effective in all the varieties in improving germination (Table 1).

Roberts [17] suggested that oxidation reactions should proceed to a certain level before germination can take place. The conditions within the seed are relatively anaerobic and the seed covering structures act as barriers to the inward diffusion of oxygen; consequently breaking of dormancy is normally a slow process. Any treatment which leads to an increase in the rate of oxidation reaction results in a more rapid loss of dormancy i.e. puncturing the covering structures, storage in oxygen, application of hydrogen peroxide, or storage at high temperature. Respiration competes strongly for the available oxygen in affecting the dormancy breaking reaction.

Cytochrome oxidase, a terminal oxygen acceptor in electron transport system of respiration has very high affinity for oxygen and is therefore a strong competitor for the available oxygen. Therefore any treatment which decreases the competition for respiration oxygen also speeds up the breaking of dormancy e.g., the application of inhibitors of cytochrome oxidase, or the provision of alternative hydrogen acceptors which can be used in respiratory process such as nitrate, nitrite or methylene blue. Inhibition of cytochrome oxidase would remove the competition for respiration and make available more oxygen for the oxidation reaction necessary for breaking dormancy. Active cytochrome oxidase is not necessary for the initiation of germination in rice, since energy required for the earliest germination process is probably provided by fermentation.

Possible reasons for the occurrence of seed dormancy in rice are non availability of oxygen to the embryo due to the impermeability of the hull and the pericarp [7,17] or presence of high peroxidase activity [18]and growth inhibitors such as ABA and phenols [19, 20] as well as in the embryo [21] or high levels of short chain saturated fatty acids (SCSFAs) [22].

Dry heat treatment possibly helped in overcoming the restriction of the availability of oxygen to the embryo by increasing cracks in the hull [23] or reducing the peroxidase activity in the seed covering structures thereby promoting the degradation and evaporation of SCSFAs from the dormant seeds [24] increasing the germinability.

Similarly, the strong oxidizing agents like KNO_3 or H_2O_2 might have promoted the break down of the germination inhibiting substances such as polyphenols and SCSFAs.

The possible reason for improvement in germination due to moist heat treatment may be the increase in high metabolic rate. Thus it may be concluded that out of the eight dormancy breaking methods tried, only dry heat treatment was effective in varieties with strong dormancy. However, all the methods were effective in breaking dormancy and improving germination in varieties with weak dorymancy (>25% germination).

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