

Effect of maleic hydrazide on induction of seed dormancy and seed quality parameters in rice

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ABSTRACT Seed dormancy in rice is controlled by its genetic and environmental factors. It is necessary to prevent pre harvest sprouting which is more common. To induce seed dormancy a field experiment was conducted by using maleic hydrazide (MH) as a foliar spray with two different concentrations at the time of flowering in twenty non dormant rice cultivars. The induction of dormancy was tested by conducting germination test immediately after harvest up to the stage where the germination had reached to Indian minimum seed certification standard (80%). The dormancy duration was computed as the period from harvest till the germination reached to 80% in each entry. The germination percentage was recorded every 15 days, starting from 5 DFH (Days from harvesting) up to 35 DFH. The germination percentage was more in control (T_1) and lower values were observed in seeds treated with MH @ 20000 ppm followed by MH @ 10000 ppm. The shoot length, root length and seedling vigour index were found more in control and lower values were observed in MH @ 20000 ppm followed by MH @ 10000 ppm. It is concluded that, the foliar spray of MH @ 20000 ppm could induce seed dormancy that persisted from 30 to 35 days in 17 varieties with exceptions being RP Bio 226, Mahsuri and DRR Dhan 38.

Key words: Induction, seed dormancy, maleic hydrazide, germination, vigour index, rice

The changing climate demands climate resilient genotypes. Untimely rains and floods in the coastal ecosystems have been a common phenomenon in India. This is more pronounced due to changing climate in the recent past and as a result, the standing mature crop gets trapped in these untimely rains and in several instances caught in the floods/submergence. The genotypes which are non-dormant are the worst affected due to vivipary and deteriorate physically and physiologically as well.

Dormancy is one mechanism by which seeds maintain their viability during unfavourable conditions. Most of the popular rice cultivars in India are non dormant and harvesting these cultivars in rainy season poses the problem of sprouting in the field and subsequent deterioration in quality. This problem becomes more obvious if

harvesting, threshing and drying are delayed. Fortunately, there is a possible solution to this problem which can be overcome by incorporating dormancy in these cultivars. In spite of this advantage dormancy creates problems for seed analysts and seed producers, especially when the germination percentage of seed lot needs to be determined in a few weeks after harvesting. Sometimes even if the seeds germinate readily at harvest, due to unfavourable environmental conditions during storage or germination, secondary dormancy may develop. Farmers mistake this secondary dormancy as non-viability. Some of rice cultivars exhibit dormancy resulting in poor germination. On other hand non dormant varieties get quickly deteriorated due to vivipary.

Dormancy in cereals seeds has been reported by several workers over the years [1, 2]. Its intensity

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at harvest depends on numerous factors and varies significantly from one species to another [3, 4]. Basically, seed dormancy indicates the inability of the seeds to germinate even under favourable conditions. This condition may be due to any one or several causes [2, 5, and 6] such as immature embryos, seed coat impermeability to water and gases, inhibitors, physiological immaturity, light sensitivity and mechanical restriction by seed coats.

In recent years the presence of naturally occurring growth inhibitors have received increased attention which is supposed to play an important role in induction and termination of dormancy. A general model for seed dormancy is based on the assumption that the state of dormancy is determined by the balance between growth inhibitors and growth promoters [7]. Maleic hydrazide (Diethanolamine salt of 1,2-dihydroxy-3,6 pyridazine-dione), a growth inhibitor has been successfully used to induce dormancy thereby reducing sprouting losses in potato, sugarbeet, onion, carrot and rice. Differential seedling growth inhibitory effect of MH in different genotypes has been reported in rice [8].

In view to induce dormancy and reduce pre-harvest sprouting losses, the present experiment was undertaken.

MATERIAL AND METHODS

Twenty popular non dormant rice cultivars were obtained from the Directorate of Rice Research (DRR), Rajendranagar, Hyderabad. The field and laboratory experiments were undertaken at DRR farm, ICRISAT campus, Patancheru and Department of Seed Science and Technology, College of Agriculture, Hyderabad during the *Kharif* 2011-12 respectively. The field experiment was laid out by using Randomized Block Design with three replications. All the twenty genotypes were sown separately in the nursery on raised beds. 25 days old seedlings were transplanted in five rows of 6 m length by adopting a spacing of 15 cm between plants and 20 cm between rows. Recommended agronomic practices and plant protection measures for raising a healthy crop were followed during experiment.

Foliar application of maleic hydrazide (MH)

Ten gram of MH was dissolved in 10% NaOH to prepare the 10000 ppm (T_1) solution of MH and 20 gram was used to prepare 20000 ppm (T_2). The spray mixture was applied with knapsack sprayer @ 500 litres per ha to wet the panicles completely at the time of 100% flowering stage. The control (T_0) was maintained without foliar spray in each entry. Care was taken during spray to avoid the drift of solution to the adjoining plots. The crop was harvested and threshed separately; seeds were dried to 12-13% moisture content.

Dormancy duration-germination

The induction of dormancy was tested by conducting germination test immediately after harvest up to the stage where the germination reached to Indian minimum seed certification standards (80%). The dormancy duration was computed as the period from the harvest till the germination reached to 80% in each entry [9]. To determine the germination percentage one hundred seeds from each treatment in three replications were subjected to germination test by using Complete Randomized Design following the method as described [10].

Root length (cm)

The length of the roots was measured from collar region down to the tip of the longest root of each seedling and the average was expressed in centimetres.

Shoot length (cm)

Ten normal seedlings were randomly selected from each replication of the standard germination test on the 14th day and length of shoots was measured from collar region to the tip of top most leaf and expressed in centimetre.

Seedling vigour index

Vigour index of the seedlings obtained from the germination test was calculated using the formula [11].

$$\text{Vigour index} = \text{Seed germination percent} \times \text{seedling length (cm)}$$

RESULTS AND DISCUSSION

Germination percentage

The data on germination percentage indicated significant difference among the genotypes, treatments and their interaction. Significantly higher germination percentage was recorded in control (T_0) followed by T_1 (10000 ppm) and T_2 (20000 ppm) during all the periods of testing irrespective of the genotypes. However, the varieties RP Bio 226, Mahsuri and DRR Dhan 38 did not respond to the maleic hydrazide (MH) spray during any period of testing. From the data it is evident that, the germination percentages of all the varieties were significantly influenced by the interaction effect between the genotypes and concentration of maleic hydrazide.

a. Control (T_0) without MH spray: The varieties without MH spray recorded higher germination percentage. Among the varieties, Swarnadhan (83.66%) and Jaya (83.33%) had highest germination percentage followed by Sonasali (80%) and Sugandhamathi (80%) at 5 days from harvesting (DFH). The variety Phalguna (86.33%) and Suraksha (86.33%) exhibited highest germination percentage followed by Sonasali (82.33%) and Akshayadhan (82.33%) at 20 DFH. The variety Mugadasugandha recorded highest germination (98.33%) percentage and Mandyavijaya (86.33%) the lowest at 35 DFH (Table 1).

b. T_1 (MH @10000 ppm): The varieties when sprayed with 10000 ppm registered relatively less germination percentage as compared to the control (T_0). However, the variety DRR Dhan 38 (79%) had highest germination percentage and Sonasali (40.33%) recorded lowest germination percentage at 5 DFH. The variety RP Bio 226 (80.66%) and Mahsuri (80.66%) recorded maximum germination percentage and lowest germination percentage was found in Sonasali (49.66%) at 20 DFH. The variety DRR Dhan38 (97.66%) showed the highest germination percentage and Sona (78%) the lowest germination percentage at 35 DFH.

c. T_2 (MH @20000 ppm): The varieties sprayed with 20000 ppm MH also recorded relatively less germination percentage as compared to control (T_0) and (T_1). However, the variety Mahsuri (76.33%) and DRR Dhan 38 (76.33%) showed maximum

germination percentage and lowest germination percentage was found in Dhanrashi (32.33%) at 5 DFH. At 20 DFH, the variety Mahsuri (81.33%) had maximum germination percentage and lowest germination percentage was found in Akshayadhan (44%). Similarly at 35 DFH, the variety Akshayadhan (92.33%) exhibited highest germination percentage and lowest germination percentage was found in Sampada (80.66%). From the data it is evident that there was an increased trend with respect to germination percentage as the number of days after harvest increased.

Dormancy may block any of the sequential processes involved in the germination. The work of earlier scientists showed that the application of an inhibitor (MH) could bring about certain changes in the physiological and biochemical processes like alteration in promoter to inhibitor ratio, moisture content of the seed and water absorption capacity of the seeds which are responsible to make the seed dormant by way of arresting the growth of the embryo. Another important concept was that, dormant and non-dormant state of the seed was dependent on relative levels of inhibitors and promoters present in the seed [12, 13]. The inhibitory effect of maleic hydrazide (MH) (1, 2 dihydro-3-6 pyridazinedione) on the respiratory activity of plant cells and inducing ripening stages of various crops was reported by several authors. The bulbs of onion when treated with maleic hydrazide at different concentrations induced dormancy which in turn arrested the sprouting of onion bulbs [14]. The effect of MH was to inhibit mitosis in the meristematic region. Plant metabolic studies had shown that, besides its many physiological activities, MH acts as an antagonist of pyrimidine. Developed countries utilise this inhibitory effect of maleic hydrazide to prolong the storage of perishable agriculture produces [15]. It is evident from the present study that maleic hydrazide spray to rice crop prior to harvest, initially inhibited the emergence of radicle due to its inhibitory action on cells, while later, the cells resumed their normal growth after some period. MH-30 can be used for pre-harvest foliar application to reduce the losses due to viviparous germination in rice as the harvesting period coincides with rainy season in coastal regions. Maleic hydrazide (200 ppm and

Table 1. Effect of maleic hydrazide on germination percentage

Variety	5 DFH				20 DFH				35 DFH			
	T ₀	T ₁	T ₂	Mean	T ₀	T ₁	T ₂	Mean	T ₀	T ₁	T ₂	Mean
Mandyavijaya	81.66 (64.67)	51.66 (45.97)	42.00 (40.40)	58.44 (50.42)	83.66 (66.19)	56.33 (48.62)	45.66 (42.53)	61.88 (51.88)	86.33 (68.28)	82.66 (65.42)	81.33 (64.38)	83.44 (65.96)
Manasarovar	82.33 (65.12)	56.33 (48.62)	41.66 (40.22)	60.11 (50.83)	84.66 (66.97)	56.00 (48.45)	45.00 (42.13)	61.88 (51.88)	95.66 (78.03)	85.66 (67.78)	84.00 (66.42)	88.44 (70.09)
Akshayadhan	81.00 (64.16)	51.33 (45.75)	37.33 (37.64)	56.55 (48.73)	82.33 (65.12)	55.66 (48.27)	44.00 (41.55)	60.66 (51.18)	97.00 (80.02)	94.66 (76.69)	92.33 (73.89)	94.66 (76.69)
RP Bio-226	81.33 (64.38)	78.66 (62.51)	75.00 (60)	78.33 (62.24)	85.33 (67.45)	80.66 (63.94)	80.00 (63.44)	82.00 (64.90)	96.66 (79.53)	86.00 (68.03)	89.33 (70.91)	90.66 (72.24)
Suraksha	83.33 (65.88)	52.66 (47.12)	39.00 (38.65)	58.33 (49.78)	86.33 (68.28)	59.66 (50.59)	50.33 (45.17)	65.44 (53.97)	96.00 (78.46)	81.33 (64.38)	82.66 (65.42)	86.66 (68.61)
Sampada	83.00 (65.65)	46.33 (42.88)	36.33 (37.05)	55.22 (47.98)	83.33 (65.88)	56.33 (48.62)	45.66 (42.53)	61.77 (51.83)	97.33 (80.54)	81.66 (64.67)	80.66 (63.94)	86.55 (67.62)
Mahasuri	80.66 (63.94)	78.33 (62.24)	76.33 (60.87)	78.44 (62.31)	82.33 (65.12)	80.66 (63.94)	81.33 (64.38)	81.44 (64.45)	95.33 (77.48)	91.33 (72.84)	86.33 (68.28)	91.00 (72.54)
Vikramarya	82.00 (64.90)	51.33 (45.75)	42.33 (40.57)	58.55 (49.89)	85.66 (67.78)	59.00 (50.18)	48.66 (44.25)	64.44 (53.37)	92.33 (73.89)	82.66 (65.42)	82.00 (64.90)	85.66 (67.78)
Swarnadhan	83.66 (66.19)	49.33 (44.60)	37.66 (37.82)	56.88 (48.97)	84.66 (66.97)	53.66 (47.12)	47.00 (43.28)	61.77 (51.83)	91.33 (72.84)	86.33 (68.28)	81.33 (64.38)	86.33 (68.28)
Phalgun	83.33 (65.88)	51.33 (45.75)	40.33 (39.41)	58.33 (49.78)	86.33 (68.28)	56.33 (48.62)	49.66 (44.83)	64.11 (53.19)	94.33 (76.19)	81.66 (64.67)	81.00 (64.16)	85.66 (67.78)
Dhanarasi	82.00 (64.90)	52.00 (46.15)	32.33 (35.24)	55.44 (48.10)	86.00 (68.03)	58.66 (50.01)	46.33 (42.88)	63.66 (52.95)	97.66 (81.28)	80.66 (63.94)	81.00 (64.16)	86.44 (68.36)
Varadhan	81.66 (64.67)	51.66 (45.97)	40.00 (39.23)	57.77 (49.49)	85.66 (67.78)	56.33 (48.62)	49.00 (44.43)	63.66 (52.95)	96.00 (78.46)	96.00 (78.46)	90.00 (71.56)	94.00 (75.82)
Mugadha-sugandha	82.33 (65.12)	47.33 (43.45)	36.33 (37.05)	55.33 (48.04)	84.33 (66.66)	56.33 (48.62)	47.33 (43.45)	62.66 (52.36)	98.33 (82.51)	83.33 (65.88)	83.00 (65.65)	88.22 (69.91)
DRR Dhan 38	81.66 (64.67)	79.00 (62.72)	76.33 (60.87)	79.00 (62.72)	84.66 (66.97)	80.00 (63.44)	80.66 (63.94)	81.77 (64.75)	97.00 (80.02)	97.66 (81.28)	91.66 (73.26)	95.44 (77.61)
Jaya	83.33 (65.88)	58.33 (49.78)	40.33 (39.41)	60.66 (51.18)	85.66 (67.78)	63.66 (52.95)	49.33 (44.60)	66.22 (54.45)	98.00 (81.87)	81.33 (64.38)	82.00 (64.90)	87.11 (68.95)
Sugandhamati	80.00 (63.44)	59.66 (50.59)	44.33 (41.73)	61.33 (51.53)	83.33 (65.88)	63.33 (52.71)	48.33 (44.03)	65.00 (53.73)	92.33 (73.89)	86.33 (68.28)	85.33 (67.45)	88.00 (69.73)
Sona	80.33 (63.65)	40.66 (39.64)	38.33 (38.23)	53.11 (46.78)	84.66 (66.97)	50.00 (45)	46.00 (42.71)	60.22 (50.89)	94.00 (75.82)	78.00 (62.03)	81.00 (64.16)	84.33 (66.66)

Table 1 contd ...

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Sonasali	80.00 (63.44)	40.33 (39.41)	35.00 (36.27)	51.77 (46.03)	82.33 (65.12)	49.66 (44.83)	46.00 (42.71)	59.33 (50.36)	94.00 (75.82)	81.00 (64.16)	82.33 (65.12)	85.77 (67.86)
DRR Dhan 39	80.66 (63.94)	50.33 (45.17)	42.33 (40.57)	57.77 (49.49)	83.33 (65.88)	56.33 (48.62)	46.33 (42.88)	62.00 (51.94)	98.00 (81.87)	91.33 (72.84)	84.00 (66.42)	91.11 (72.64)
Jarava	80.33 (63.65)	49.66 (44.83)	35.33 (36.45)	55.11 (47.93)	83.66 (66.19)	59.00 (50.18)	48.33 (44.03)	63.66 (52.95)	93.66 (75.46)	85.00 (67.21)	81.66 (64.67)	86.77 (68.70)
Mean	81.73 (64.67)	54.81 (47.75)	44.43 (41.78)	60.32 (50.94)	84.41 (66.74)	60.38 (51)	52.25 (46.25)	65.68 (54.15)	95.06 (77.21)	85.73 (67.78)	84.15 (66.50)	88.31 (70.00)
	SEm	CD at 5%	SEm	CD at 5%	SEm	CD at 5%	SEm	CD at 5%	SEm	CD at 5%	SEm	CD at 5%
Treatment	0.281	0.55	0.29	0.58	0.25	0.50						
Variety	0.72	1.43	0.76	1.51	0.66	1.30						
Interaction	1.25	2.49	1.32	2.62	1.14	2.26						

(Figures in the parentheses are the *arc sine* transformed values)

500 ppm) sprayed rice seeds in the field prior to harvest did not germinate after two weeks of harvest and required more than a month to attain minimum seed certification standard (MSCS) level of seed germination [16, 17]. The results obtained in present investigation were in confirmation with the results observed in groundnut with MH @ 1000 ppm concentration inducing dormancy much better in non-dormant varieties [18, 19]. It is concluded from the present study that the foliar spray of MH @ 20000 ppm could induce seed dormancy which was maintained for 30 to 35 days in 17 varieties of rice, exceptions being RP Bio-226, Mahsuri and DRR Dhan-38.

Root length (cm)

The data on root length indicated significant difference among the genotypes (Table 2). Significantly higher root length was recorded in control (T_0) followed by T_1 (10000 ppm) and T_2 (20000 ppm) during any period of testing irrespective of the genotypes. From the data it is evident that, the root length of all the varieties was not influenced by the interaction effect at 5 DFH and 35 DFH, but significantly influenced at 20 DFH.

a. Control (T_0) without MH spray: The varieties without MH spray recorded higher root length

during all the periods of testing. Among the varieties Jarava (15.53) had highest root length and lowest was recorded in RP Bio-226 (12.20) at 5 DFH. The variety Jarava (15.80) had highest root length and lowest in RP Bio-226 (12.26) at 20 DFH. The variety Jarava (15.93) had highest root length and lowest in RP Bio-226 (12.36) at 35 DFH, respectively.

b. T_1 (MH @10000 ppm): The varieties when sprayed with 10000 ppm exhibited relatively less root length as compared to control (T_0). However, the variety Jarava and Vikramarya (14.93) exhibited highest root length and lowest in RP Bio-226 (11.80) at 5 DFH. Jarava recorded maximum root length (15.2) and lowest in RP Bio-226 (12.06) at 20 DFH. Jarava had highest root length (15.2) and lowest in RP Bio-226 (12), Mugadasugandha (12) at 35 DFH, respectively.

c. T_2 (MH @20000 ppm): The varieties sprayed with 20000 ppm MH exhibited relatively less root length as compared to control (T_0) and T_1 . However, the variety Jarava and Vikramarya (14.80) exhibited maximum root length and lowest was found in RP Bio-226 (11.60) at 5 DFH. At 20 DFH, the variety Jarava (15.06) had maximum root length and lowest in RP Bio-226 (11.86). Similarly, at 35 DFH, Jarava (14.93) had highest root length and lowest in RP Bio-226 (11.70).

Table 2. Effect of maleic hydrazide on root length (cm)

Variety	5 DFH				20 DFH				35 DFH			
	T ₀	T ₁	T ₂	Mean	T ₀	T ₁	T ₂	Mean	T ₀	T ₁	T ₂	Mean
Mandyavijaya	13.40	12.73	12.53	12.889	13.60	12.86	12.80	13.08	13.50	13.00	12.80	13.10
Manasarovar	14.40	13.53	13.26	13.733	14.40	13.60	13.40	13.80	14.16	13.53	13.56	13.75
Akshayadhan	14.66	13.80	13.73	14.067	14.80	13.93	13.80	14.17	14.80	14.06	13.83	14.23
RP Bio-226	12.20	11.80	11.60	11.867	12.26	12.06	11.86	12.06	12.36	12.00	11.70	12.02
Suraksha	13.40	12.93	12.80	13.044	13.60	13.20	13.20	13.33	13.40	13.00	12.93	13.11
Sampada	14.26	14.00	13.80	14.022	14.40	14.06	13.93	14.13	14.20	13.80	13.73	13.91
Mahasuri	15.00	14.53	14.40	14.644	15.06	14.80	14.53	14.80	14.80	14.53	14.40	14.57
Vikramarya	15.00	14.93	14.80	14.911	14.93	14.66	14.46	14.68	14.86	14.43	14.40	14.56
Swarnadhan	13.20	13.00	12.86	13.022	13.40	13.06	13.00	13.15	13.30	13.00	12.80	13.03
Phalguna	13.40	13.20	13.00	13.200	13.66	13.20	13.06	13.31	13.80	13.20	13.06	13.35
Dhanarasi	14.20	14.00	13.93	14.044	14.40	14.00	14.06	14.15	14.33	13.86	13.80	14.00
Varadhan	13.20	13.00	12.86	13.022	13.26	13.06	13.00	13.11	13.20	13.00	12.80	13.00
Mugadha-sugandha	12.40	12.13	12.00	12.178	12.60	12.26	12.40	12.42	12.40	12.00	12.00	12.13
DRR Dhan 38	12.26	12.20	12.13	12.200	12.60	12.40	12.26	12.42	12.60	12.40	12.33	12.44
Jaya	13.60	13.20	13.00	13.267	13.80	13.26	13.33	13.46	13.93	13.26	13.40	13.53
Sugandhamati	14.20	14.00	13.93	14.044	14.40	14.00	14.00	14.13	14.20	13.80	13.86	13.95
Sona	13.20	12.93	12.93	13.022	13.20	13.00	12.93	13.04	13.36	12.93	12.80	13.03
Sonasali	14.1	13.80	13.40	13.778	14.26	14.00	13.60	13.95	14.40	13.80	13.40	13.86
DRR Dhan 39	13.33	13.00	12.93	13.089	13.60	13.20	13.46	13.42	13.60	13.20	13.26	13.35
Jarava	15.53	14.93	14.80	15.089	15.80	15.20	15.06	15.35	15.93	15.20	14.93	15.35
Mean	13.75	13.38	13.23	13.457	13.90	13.49	13.41	13.60	13.85	13.40	13.29	13.51
	SEm		CD at 5%		SEm		CD at 5%		SEm		CD at 5%	
Treatment	0.04		0.07		0.03		0.07		0.03		0.07	
Variety	0.10		0.20		0.09		0.18		0.09		0.19	
Interaction	0.18		0.35		0.15		0.31		0.17		0.34	

Shoot length (cm)

Significant differences were recorded among the genotypes, treatments and their interactions for

shoot length (Table 3). Significantly higher shoot length was recorded in control (T₀) followed by T₁ (10000 ppm) and T₂ (20000 ppm) during all the

Table 3. Effect of maleic hydrazide on shoot length (cm)

Variety	5 DFH				20 DFH				35 DFH			
	T ₀	T ₁	T ₂	Mean	T ₀	T ₁	T ₂	Mean	T ₀	T ₁	T ₂	Mean
Mandyavijaya	12.26	11.60	11.53	11.80	12.26	11.80	11.60	11.88	12.20	11.53	11.60	11.77
Manasarovar	13.06	11.40	11.20	11.88	13.20	11.53	11.33	12.02	13.33	11.40	11.20	11.97
Akshayadhan	13.33	11.80	11.53	12.22	13.40	11.33	11.66	12.13	13.43	11.33	11.40	12.05
RP Bio-226	11.20	10.20	9.66	10.35	11.40	10.33	9.80	10.51	11.46	10.06	9.80	10.44
Suraksha	12.66	11.00	10.80	11.48	12.60	11.13	10.60	11.44	12.46	11.13	10.73	11.44
Sampada	13.26	12.00	11.86	12.37	13.40	11.80	11.60	12.26	13.33	11.80	11.66	12.26
Mahasuri	13.20	12.20	12.20	12.53	13.40	12.40	12.20	12.66	13.26	12.40	12.26	12.64
Vikramarya	13.33	12.33	12.20	12.62	13.33	12.13	12.20	12.55	13.33	12.13	12.20	12.55
Swarnadhan	12.60	11.60	11.40	11.86	12.60	11.46	11.20	11.75	12.66	11.53	11.40	11.86
Phalguna	12.33	11.53	11.40	11.75	12.53	11.40	11.46	11.80	12.53	11.40	11.46	11.80
Dhanarasi	13.20	11.86	12.40	12.48	13.46	12.26	12.33	12.68	13.40	12.40	12.40	12.73
Varadhan	12.46	11.80	11.46	11.91	12.46	11.26	11.40	11.71	12.40	11.40	11.26	11.68
Mugadha-sugandha	11.00	10.06	10.06	10.37	11.20	9.93	10.00	10.37	11.06	10.00	9.86	10.31
DRR Dhan 38	11.20	10.33	10.40	10.64	11.20	10.20	10.40	10.60	11.26	10.26	10.40	10.64
Jaya	12.66	11.73	11.60	12.00	12.73	11.53	11.40	11.88	12.73	11.46	11.40	11.86
Sugandhamati	13.00	12.13	11.93	12.35	13.20	12.40	12.20	12.60	13.20	12.40	12.20	12.60
Sona	12.20	11.00	10.93	11.37	12.20	11.00	11.00	11.40	12.20	11.00	11.00	11.40
Sonasali	13.00	11.26	11.33	11.86	13.00	11.20	11.20	11.80	13.00	11.20	11.20	11.80
DRR Dhan 39	12.60	11.26	11.20	11.68	12.60	11.13	11.00	11.57	12.60	11.13	11.00	11.57
Jarava	14.60	13.20	13.20	13.66	14.73	13.20	13.33	13.75	14.66	13.46	13.20	13.77
Mean	12.66	11.51	11.41	11.86	12.74	11.47	11.39	11.87	12.72	11.47	11.38	11.86
	SEm		CD at 5%		SEm		CD at 5%		SEm		CD at 5%	
Treatment	0.039		0.07		0.04		0.08		0.03		0.07	
Variety	0.10		0.20		0.10		0.21		0.09		0.19	
Interaction	0.17		0.34		0.18		0.37		0.16		0.33	

periods of testing irrespective of the genotypes. From the data it is evident that, the shoot lengths of all the varieties were significantly influenced by

the interaction effect between the genotypes and concentration of MH during all the periods of testing.

a. *Control (T_0) without MH spray*: The varieties without MH spray recorded higher shoot length during all the periods of testing. Among the varieties Jarava (14.60) had highest shoot length and lowest in Mugadasugandha (11) at 5 DFH. The variety Jarava (14.73) had highest shoot length and lowest in Mugadasugandha, DRR Dhan38 (11.2) at 20 DFH. The variety Jarava (14.66) had highest shoot length and lowest in Mugadasugandha (11.06) at 35 DFH, respectively.

b. T_1 (MH @10000 ppm): The varieties when sprayed with 10000 ppm exhibited relatively less shoot length as compared to control (T_0). However, the variety Jarava (13.20) had highest shoot length and lowest in Mugadasugandha (10.06) at 5 DFH. Jarava recorded maximum shoot length (13.20) and lowest in Mugadasugandha (11.93) at 20 DFH. Jarava (13.46) showed highest shoot length and lowest in Mugadasugandha (10) at 35 DFH.

c. T_2 (MH @20000 ppm): The varieties sprayed with 20000 ppm MH exhibited relatively less shoot length as compared to control (T_0) and T_1 . However, the variety Jarava (13.20) had maximum shoot length and lowest in RP Bio-226 (9.66) at 5 DFH on 20 DFH, Jarava (13.33) had maximum shoot length and lowest in RP Bio-226 (9.80). Similarly at 35 DFH, Jarava (13.20) had highest shoot length and lowest in RP Bio-226 (9.80).

The results obtained were in conformity with the findings of reported that root and seedling growths was suppressed and shoot to root ratio increased when MH was sprayed to the crop prior to harvest in rice [16]. Maleic hydrazide (MH) is a growth regulator, known to cause inhibition of seedling growth by inhibiting mitotic cell division in plants [20].

Seedling vigour index

A significant variation was recorded among the genotypes, treatments and their interactions for seedling vigour index (Table 4). Significantly higher seedling vigour index was recorded in control (T_0) followed by T_1 (10000 ppm) and T_2 (20000 ppm) during all the periods of testing irrespective of the genotypes. From the data it is evident that, the seedling vigour index of all the varieties were significantly influenced by the interaction effect

between the genotypes and concentration of MH except for RP Bio 226, Mahsuri and DRR Dhan 38 during all the periods of testing.

a. *Control (T_0) without MH spray*: The varieties without MH spray recorded higher seedling vigour index during all the periods of testing. Among the varieties Jarava (2421.13) exhibited highest seedling vigour index and lowest in RP Bio-226 (1903.06) at 5 DFH. The variety Jarava (2555) had highest seedling vigour index and lowest in Mugadasugandha (2006.66) at 20 DFH. The variety Jarava (2865.86) had highest vigour index and lowest in Mandyavijaya (2230) at 35 DFH.

b. T_1 (MH @10000 ppm): The varieties when sprayed with 10000 ppm exhibited relatively less seedling vigour index as compared to control (T_0). However, the variety Mahsuri (2093.66) had highest seedling vigour index and lowest in Sona (973.33) at 5 DFH. Mahsuri recorded maximum seedling vigour index (2194.40) and lowest in Sona (1200.13) at 20 DFH. Mahsuri had highest seedling vigour index (2459.86) and lowest in Mugadasugandha (1833.60) at 35 DFH.

c. T_2 (MH @20000 ppm): The varieties sprayed with 20000 ppm MH exhibited relatively less seedling vigour index as compared to control (T_0) and T_1 . However, the variety Mahsuri had maximum seedling vigour index (2030.46) and lowest in Mugadasugandha (801.60) at 5 DFH. At 20 DFH, Mahsuri had maximum seedling vigour index (2174.33) and lowest in Mugadasugandha (1060.06). Similarly, at 35 DFH, variety Akshayadhan had highest seedling vigour index (2329.86) and lowest in Mugadasugandha (1815.06).

From the data it has been noticed that there was an increased trend with respect to seedling vigour index as the number of days after harvest increased. Among the various concentrations of maleic hydrazide, the MH @20000 ppm acted effectively as growth retardant irrespective of genotypes for reducing the vigour index which might be a sign of induction of dormancy. The decline in seedling vigour index could be due to less germination as result of MH spray and it was in conformity with previous results [19].

Table 4. Effect of maleic hydrazide on seedling vigour index

Variety	5 DFH				20 DFH				35 DFH			
	T ₀	T ₁	T ₂	Mean	T ₀	T ₁	T ₂	Mean	T ₀	T ₁	T ₂	Mean
Mandyavijaya	2096	1257	1010	1454	2175	1389	1114	1559	2230	2028	1984	2080
Manasarovar	2261	1404	1019	1561	2337	1407	1112	1619	2630	2136	2080	2282
Akshayadhan	2268	1314	943	1508	2322	1406	1120	1616	2738	2404	2329	2491
RP Bio-226	1903	1730	1595	1742	2019	1807	1733	1853	2304	1897	1920	2040
Suraksha	2172	1260	920	1450	2262	1451	1197	1637	2483	1963	1956	2134
Sampada	2285	1204	932	1474	2316	1457	1165	1646	2679	2090	2048	2272
Mahasuri	2274	2093	2030	2133	2343	2194	2174	2237	2675	2459	2302	2479
Vikramarya	2323	1399	1143	1622	2421	1581	1298	1766	2603	2196	2181	2326
Swarnadhan	2158	1213	914	1428	2201	1316	1137	1551	2371	2118	1968	2152
Phalguna	2144	1269	983	1465	2262	1385	1218	1622	2484	2009	1987	2160
Dhanarasi	2246	1345	850	1481	2396	1541	1223	1720	2708	2118	2121	2316
Varadhan	2096	1281	973	1450	2204	1370	1195	1590	2457	2342	2166	2321
Mugadha-sugandha	1926	1050	801	1259	2006	1250	1060	1439	2307	1833	1815	1985
DRR Dhan 38	1916	1779	1720	1805	2015	1807	1828	1883	2315	2213	2083	2204
Jaya	2188	1454	992	1545	2272	1579	1220	1690	2613	2011	2033	2219
Sugandhamati	2175	1559	1146	1627	2300	1672	1266	1746	2529	2261	2224	2338
Sona	2040	973	915	1309	2150	1200	1101	1484	2403	1866	1927	2065
Sonasali	2170	1011	865	1349	2244	1251	1140	1545	2575	2025	2025	2208
DRR Dhan 39	2092	1221	1021	1445	2183	1370	1133	1562	2567	2222	2038	2276
Jarava	2421	1397	989	1602	2555	1675	1372	1867	2865	2436	2297	2533
Mean	2158	1361	1088	1535	2249	1505	1290	1682	2527	2131	2074	2244
	SEm		CD at 5%		SEm		CD at 5%		SEm		CD at 5%	
Treatment	8.22		16.28		8.65		17.13		7.36		14.58	
Variety	21.23		42.04		22.35		44.25		19.01		37.64	
Interaction	36.78		72.83		38.71		76.65		32.93		65.20	

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