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RESEARCH ARTICLE

Pre-sowing seed hardening enhancement treatment on seed quality and seed yield in rice ADT 36

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SUMMARY

Rice is one of the main staple food of man and is grown in almost all the tropical and subtropical regions of the world. An experiment was carried out to investigate the effect of pre-sowing seed hardening treatment with different chemicals such as 1% $CaCl_2$, 1% KCl, 1% KNO_3 and 1% NaCl and organics such as 10% cow dung and 3% panchagavya on seed quality and seed yield in rice cv. ADT 36. In general seed hardening treatment of rice before sowing significantly increased the seed quality characteristics and yield attributing characters when compared to untreated seeds. From the result, it was observed that 1% $CaCl_2$ seed hardening treatment improved the seed quality characters such as germination percentage, speed of germination, shoot length, root length, seedling length, dry matter production, vigour index and yield attributing characters such as number of productive tillers per plant, number of seeds per panicle and seed yield per plant. Hence, rice seeds hardened with 1% $CaCl_2$ may be recommended to get higher seed yield and seed quality.

Key Words : Rice, Seed hardening, $CaCl_2$, Seed quality, Seed yield

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Rice (*Oryza sativa* L.) is one of the staple food crops in South and Southeast Asia. More than 90% of the world's rice is grown and consumed in Asia, where 60% of the world's population lives. In world, rice ranks second next only to wheat in terms of area harvested, but in terms of importance as a food crop, rice provides more energy per hectare than any other cereal crops. Major rice producing countries are China, India, Indonesia, Bangladesh, Vietnam, Thailand, Burma, Philippines, Brazil and Japan. India ranks first in area and second in production. In India, major rice producing states are West Bengal, Uttar Pradesh, Andhra Pradesh, Punjab and Tamil Nadu. In Tamil Nadu, area under rice cultivation is 21 lakh hectares with a production of 93 L.MT and productivity of 4.43 metric tons per hectare (Urban Development and Agriculture, Policy Note 2015-16). In Cuddalore district during 2014-15, rice

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is cultivated in a total area of 117000 hectares with a production of 513406 metric tonnes and the productivity is 4125 kg ha^{-1} (Anonymous, 2017).

Quality seeds play a major role in crop production along with improved pre-sowing seed treatment and cultural package of practices to enhance productivity. The low productivity is due to use of poor quality seeds, improper selection of pre-sowing seed treatment and treating agent and improper crop management. Rapid and uniform field emergences of seedlings are the two essential pre-requisites to increase yield and quality in a number of field crops (Krishnotar *et al.*, 2009). Seed hardening is conditioning of seed to withstand adverse environment and adaptive conditions. It is a creation of resistance in the seed for better outgrowth of seedling. Such physiological reorganization is induced by hydration and dehydration process (De Lespinay *et al.*, 2010).

Seed hardening will give an beginning nourishment for germinating seeds and hardened seedling can put forth better root and shoot growth. This enhances the drought tolerance of the plants resulting in increased yield and increased seed quality of the resultant seeds. The favourable effect of chemical and organic seed hardening was decisively recommended by several scientists for various crops to improve the seed yield and quality. With this background experiment was designed to study the effect of pre-sowing seed hardening enhancement treatment on seed quality and seed yield in rice cv. ADT 36.

MATERIAL AND METHODS

The present investigation was carried out both in the laboratory as well as in the field condition. The laboratory experiment was conducted at the Seed Technology Laboratory, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University and the field experiment was carried out at Plant Breeding Farm, Faculty of Agriculture, Annamalai University during the year 2016-2017. Genetically and physically pure seeds of rice cv. ADT 36 were hardened with the following chemicals and organics *viz.*, T_0 – Control, T_1 – 1% $CaCl_2$, T_2 –1% KCl, T_3 – 1% KNO_3, T_4 – 1% NaCl, T_5 – 10% cow dung, T_6 –3% panchagavya. The lab experiment was conducted with the above treatment (CRD) with three replications. During pre-sowing seed treatment, seeds were soaked in the respective chemical solution and organics for 12 hours at the ratio of 1:1 of the seeds. After soaking, seeds were dried back to original moisture content and then evaluated for seed quality characteristics *viz.*, germination percentage (ISTA, 1999), speed of germination (Maguire, 1962), root length (ISTA, 1999), shoot length (ISTA, 1999), dry matter production (Gupta *et al.*, 1993) and vigour index I and II (Abdul-Baki and Anderson, 1973).

The field experiment was conducted with the same treatment (RBD) with three replications. Observation on growth and yield parameters such as number of productive tillers per plant, plant height, panicle length, leaf length, leaf breadth, number of seeds per panicle, 100 seed weight, seed length, seed breadth, seed yield per plant, fresh weight, dry weight and harvest index. The recommended package of practices was adopted for raising the crop. The data collected were subjected to statistical analysis described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Pre-sowing hardening is one of the best methods that results in modifying the physiological and biochemical nature of seed so as to get the characters that are favourable for drought resistance. Pre-sowing hardening is the result of extensive physiological reorganization induced by hydration and dehydration process (Sujatha *et al*., 2013).

During hardening process, a number of physico-chemical changes occur that modify the protoplasmic characters, increasing the embryo physiological activity and associated structures, eventually leading to higher absorption of water, increase in the elasticity of the cell and development of a stronger and efficient root system. The hardening resulting from pre-sowing treatments is due to a number of phyto-chemical changes within the cytoplasm including greater hydration of colloids, higher vicosity and elasticity of the protoplasm, increase in hydrophilic and decrease in lipophilic colloids, increase in the temperature required for protein coagulation and increase in bound water content. Root plays a major role as far as moisture extraction and nutrient absorption are concerned.

From the experiment results, among the pre-sowing seed hardening treatment in rice ADT 36, it was observed that T_1 (1% $CaCl_2$) recorded the highest germination percentage and speed of germination when compared to T_0 (control). Treatment (T_1) 1% $CaCl_2$ hardened seeds recorded higher root length, shoot length and dry matter production when compared to other hardening treatments and untreated seeds. Improved vigour index was also recorded by T_1 over the T_0 (Table 1).

In the field experiment plant height was maximum in T_1 followed by T_2 when compared to control T_0 and other treatments. Same trend was observed in case of number of productive tillers per plant and panicle length (Table 2). In case of yield attributing characters more number of seeds per panicle was observed in T_1 when compared to other treatments and control. Increased 100 seed weight noticed in T_1 followed by T_2 and the inferior was recorded by T_0. The same trends were observed in seed yield per plant in T_1 when compared to other treatments and control (Table 3).

Hardening with $CaCl_2$ recorded the best seed quality *viz.*, germination percentage, speed of germination, root length, shoot length, seedling length, dry matter production and vigour index I and II from the resultant seeds among the seed treatments when compared to the control (Table 4).

The reason for higher germination percentage and speed of germination may be due to greater hydration of colloids, higher viscosity and elasticity of protoplasm, offer an increase in bound water content, lower water deficit and increased metabolic activity (Maitraa *et al.*, 1999). The improvement in germination by $CaCl_2$ hardened seeds may be attributed to stimulation of hydrolytic enzyme activity known to be induced by $CaCl_2$ agents. Since, calcium in $CaCl_2$ improves cell water status and also act as cofactors in the activities of numerous enzymes during reserve metabolization and radical protrusion (Taiz and Zieger, 2002).

Higher seedling length including root and shoot length (Plate 1) may due to the enhanced metabolic activity and enzyme activity which hydrolysis the stored reserved food material and make available high energy bio molecules and vital components to growing points and also due to the presence of growth promoting substance GA_3, auxin, IAA which induces elongation of cells there by increasing root and shoot length (Ganesh *et al.*, 2013).

Table 1 : Effect of pre-sowing seed hardening enhancement treatment on initial seed quality parameters in rice cv. ADT 36

Treatments	Germination percentage (%)	Speed of germination	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Dry matter production (g/10 seedling)	Vigour index I	Vigour index II
T_0	82 (64.90)	26.07	15.63	10.40	26.03	0.3400	2134.46	27.88
T_1	92 (73.58)	34.34	17.90	12.06	29.96	0.3767	2756.32	34.04
T_2	90 (71.55)	33.85	17.06	11.80	28.86	0.3667	2597.40	32.40
T_3	87 (68.87)	30.87	16.00	10.90	26.90	0.3567	2340.30	30.45
T_4	88 (69.73)	31.99	16.66	11.30	27.96	0.3467	2460.48	29.92
T_5	85 (67.21)	33.14	16.06	10.60	26.66	0.3500	2266.10	29.75
T_6	84 (66.42)	27.80	16.40	11.00	27.40	0.3567	2301.60	29.40
Mean	87 (68.89)	30.72	16.53	11.15	27.68	0.3562	2408.09	30.54
S.E.±	0.2974 (0.2893)	0.1803	0.0755	0.0702	0.1202	0.0040	7.3489	0.1483
C.D. (P = 0.05)	0.6394 (0.6220)	0.3876	0.1623	0.1510	0.2584	0.0086	15.8001	0.3188

Table 2 : Effect of pre-sowing seed hardening enhancement treatment on number of productive tillers per plant, plant height, panicle length, leaf length and leaf breadth in rice cv. ADT 36

Treatments	Number of productive tillers per plant	Plant height (cm)	Panicle length (cm)	Leaf length (cm)	Leaf breadth (cm)
T_0	14.13	73.74	21.23	30.23	1.01
T_1	17.70	80.53	22.93	33.99	1.64
T_2	16.80	80.34	22.58	33.57	1.15
T_3	15.80	76.93	21.85	31.23	1.08
T_4	16.67	78.49	22.50	33.32	1.10
T_5	15.50	74.34	21.83	30.94	1.06
T_6	15.80	75.59	22.58	30.77	1.05
Mean	16.06	77.13	22.08	32.01	1.15
S.E.±	0.0526	0.5225	0.0044	0.1484	0.0040
C.D. (P = 0.05)	0.1148	1.1390	0.0095	0.3235	0.0087

Plate 1 : Effect of pre-sowing seed hardening enhancement treatment on initial seed quality in rice cv. ADT 36

The increased dry matter production recorded by T_1 over the control might be due to simultaneous effect of repair mechanism induced by hardened and synchronized earlier germination that makes seedling entry into the autotrophic state well in advance to produce more photo assimilate from source to sink there by increases the dry matter production. This was in conformity with earlier work of Shah (2007).

Higher seedling vigour index recorded by T_1 over control was due to the increased germination percentage, root length, shoot length and dry matter production of seedlings. In $CaCl_2$ treatment, seeds increased the synthesis of protein and soluble sugar in the first phase of germination, which have advantages for earlier germination and in turn produces longer seedlings there by increased the vigour of seedling (Mulsanti and Wahyuni, 2011).

Among the treatments, T_1 registered the more value for panicle length, leaf length and leaf breadth over other treatments and control. The improvement in vegetative growth parameters (number of productive tillers per plant, plant height, panicle length, leaf length and leaf breadth) might be due the cumulative effect of hardening and $CaCl_2$ could have triggered the biosynthesis of nucleic acids, proteins and the consequential enhancement of cell division besides the enhanced metabolic activity of

Table 3 : Effect of pre-sowing seed hardening enhancement treatment on number of seeds per panicle, 100 seed weight, seed length, seed breadth, seed yield per plant, fresh weight, dry weight and harvest index in rice cv. ADT 36

Treatments	Number of seeds per panicle	100 seed weight (g)	Seed length (mm)	Seed breadth (mm)	Seed yield per plant (g)	Fresh weight (g)	Dry weight (g)	Harvest index
T_0	105.40	1.88	6.63	2.79	21.63	85.00	44.05	30.60
T_1	129.83	2.00	6.83	2.96	25.97	136.50	64.40	46.27
T_2	126.67	1.97	6.81	2.95	24.93	123.00	59.80	44.20
T_3	110.17	1.90	6.79	2.88	23.60	103.00	54.55	41.00
T_4	124.50	1.93	6.75	2.88	24.80	98.00	55.55	41.70
T_5	109.08	1.93	6.79	2.92	23.48	115.00	54.60	39.03
T_6	107.60	1.90	6.75	2.92	22.83	121.00	53.60	35.53
Mean	116.17	1.93	6.78	2.90	23.89	111.64	55.22	39.76
S.E.$\pm$	0.9916	0.0073	0.0104	0.0145	0.0424	0.5648	0.2935	0.4907
C.D. (P = 0.05)	2.1617	0.0160	0.0226	0.0316	0.0923	1.2313	0.6398	1.0697

Table 4 : Effect of pre-sowing seed hardening enhancement treatment on resultant seed quality in rice cv. ADT 36

Treatments	Germination percentage (%)	Speed of germination	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Dry matter production (g/10 seedling)	Vigour index I	Vigour index II
T_0	83 (65.65)	27.02	15.83	10.96	26.79	0.3500	2223.57	29.05
T_1	93 (74.66)	35.02	18.13	12.40	30.53	0.3867	2839.29	35.34
T_2	91 (72.54)	34.69	17.43	12.00	29.43	0.3700	2678.13	33.67
T_3	89 (70.63)	32.50	16.26	11.03	27.29	0.3600	2428.81	32.04
T_4	90 (71.56)	33.20	17.13	11.46	28.59	0.3567	2573.10	31.50
T_5	92 (73.57)	31.37	16.33	10.76	27.09	0.3600	2492.28	33.12
T_6	88 (69.73)	29.93	16.60	11.13	27.73	0.3633	2440.24	31.68
Mean	89 (71.19)	31.96	16.82	11.39	28.21	0.3638	2525.06	32.34
S.E.$\pm$	0.2456 (0.2102)	0.1523	0.1084	0.1018	0.3154	0.0031	6.1396	0.0650
C.D. (P = 0.05)	0.5281 (0.4520)	0.3290	0.2330	0.2189	0.6781	0.0066	13.2001	0.1397

the plant resulting in the increased uptake of nutrients which are associated with improved crop growth (Pawar *et al.*, 2003).

Improved vegetative growth parameter might be due to the role of calcium involvement increased cell division strengthening of cell wall and cell enlargement which have a plant growth promoting capabilities and often applied as exogenous plant growth enhance (Muhammad *et al.*, 2014).

The treatment (T_1) 1% $CaCl_2$ recorded the more number of productive tillers per plant which might be due improved mobilization of nutrient and moisture supply from hardened seeds and might have resulted enhanced fertilization, which ended in lower number of sterile spikelet's as reported by Rehman *et al.* (2011); Patil *et al.* (2014) and Roohul Amin *et al.* (2016).

In case of the untreated seeds (T_0) the plant registered the reduced plant height. The mechanism of reduction in plant height may be due to the reduced cell size, cell thickening, reduced rate of enzyme activity and poor availability of nutrients to the growing seedlings which favours delayed emergence and reduces vigour (Kamala Thirumalaiswamy and Sakharam Rao, 1977; Karivaratharaju and Ramkrishnan, 1985).

The probable reasons for improvement in yield attributes (number of seeds per panicle, seed yield per plant and harvest index) might be due to the hardening chemicals ($CaCl_2$) which accelerate the synthesis of protein and nucleic acid bound water content and repair germination and growth of seedling resulting in increasing uptake of nutrients and ability of treated plants to unfavourable condition when compared to control.

Improvement in 100 seed weight might be due to the increased mobilization of nutrient towards the panicle which resulted in lower number of chaffy seeds and increase in normal seed might be due uniform distribution of photo assimilates within the seeds.

In contrast, the control registered the minimum values for yield attributing characters might be due to the slow starch hydrolysis and in efficient mobilization and utilization of seed resources (Kanwar *et al.*, 2015). From the present study, it was evident that the control plants have a poor plant establishment, poor vegetative growth and which results in lesser photosynthesis and reduced translocation of photo assimilate from sources to sink.

In laboratory condition resultant seed quality of T_1 1% $CaCl_2$ recorded significantly higher values for all the seed quality parameters namely germination percentage (%), speed of germination, root length (cm), shoot length (cm), seedling length (cm), dry matter production (g/10 seedlings), vigour index I and II, which might be due to the enhanced crop stands, growth and yield characters that ultimately results in the improvement of seed quality (Vijayan, 2005; Susmitha, 2006; Rehman *et al.*, 2011; Patil *et al.*, 2014 and Roohul Amin *et al.*, 2016). The improved seed quality of resultant seeds might also due to the more food reserved materials in seeds and reduced stress condition during seed maturation and development which favoured this positive effect (Plate 2).

Plate 2 : Effect of pre-sowing seed hardening enhancement treatment on resultant seed quality in rice cv. ADT 36

Conclusion :

Hence, from the present study it was revealed that 1% $CaCl_2$ hardening treatment improves the seedling quality and seed yield compared to control due to the cumulative effect of hardening and $CaCl_2$.

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