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Effect of polymer coated CORH 3 hybrid rice seeds on physiological parameters at vegetative and reproductive stages under moisture stress conditions

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ABSTRACT

An experiment was carried out to found the effect of polymer seed coatings (Genius coat 171, Genius coat 172, Arcus, Myconate and Quick roots) on physiological parameters of CORH 3 hybrid rice seeds at vegetative and reproductive stages under various moisture stress conditions viz., *stress at panicle initiation stage, grain filling stage and both panicle initiation and grain filling stages. The results revealed that the seeds coated with Quick roots was found to be significantly superior in maintaining all the physiological parameters* viz., *leaf area index, relative water content, chlorophyll stability index, soluble protein content and nitrate reductase activity both under normal irrigation and moisture stress at various growth stages.*

Key words: *Polymer coating, hybrid rice, moisture stress, physiological parameters*

Rice, one of the most important food crop for over half of the world's population accounts for around 23% of the global calorie intake (Li *et al*., 2011; Bernier *et al*., 2008).The demand for rice is increasing tremendously with the projected population growth of 9 billion people by 2050 (Kajala *et al.*, 2011). However, increasing the rice production is becoming more difficult because of biotic and abiotic stresses and continuing decrease of cultivated rice areas due to the expansion of population and decreasing in water level. In order to provide adequate food in the future, rice yields in Asia needs to be increased by 60% by 2050. It is estimated that 50% of the world rice production is affected by drought (Bouman*et al.*, 2005) and losses is about 18 million tonnes annually (O'Toole, 2004). In Asia alone, it is estimated that a total of 23 million hectares of rice fields are drought prone (Pandey and Bhandari, 2009).Thus drought is a formidable foe. This affects world's food security (Bray *et al.*, 2000).

Rice is a great consumer of water, requiring around 5,000 litres of water to produce one kg of rice and is less efficient in the way it utilizes water than wheat or maize (Shen*et al.*, 2001). Drought is a major limiting factor for rice production. It is not simply the lack of water that lowers yield potential, but also the timing and duration of drought stress related to phonological processes (Jongdee*et al.*, 2002). Water stress during the growth cycles of plants adversely affects many physiological growth processes like leaf area index, relative water content and nitrate reductase activity (Fageria*et al.*, 2006). Soil water deficits during critical growth stages such as panicle initiation (Rahman *et al*., 2002) and grain filling stage (Sarvestani *et al*., 2008) can significantly affects the physiological parameters such as leaf area index, relative water content, chlorophyll stability index, soluble protein content and nitrate reductase activity.

The application of polymers to seed serves as an extra exterior shell in order to give the desired seed characteristics *viz.*, quick water uptake and enhanced germination that would be beneficial for better emergence and establishment in the given condition (Taylor *et al.*, 1998). In order to overcome moisture stress encountered during seed germination in the field, polymer seed coating is recommended now-a-days which is a promising technique for maintaining a high water potential around the germinating seeds and thereby ensuring the soil water content not to fall below the critical level. The fine particles in the coating act as a ‘‘wick” or moisture attracting material to improve seed soil contact. Therefore the present study was undertaken to evaluate the performance of polymer coated CORH 3 hybrid rice seeds on physiological parameters at vegetative and reproductive stages under moisture stress conditions.

MATERIALS AND METHODS

The field experiment was conducted at Paddy Breeding Station, Tamil Nadu Agricultural University (TNAU), Coimbatore. Genetically pure seeds of CORH 3 hybrid rice were obtained from the Paddy Breeding Station and sent to the Integrated Coating Technology Pvt. Ltd., (INCOTEC), Ahmedabad, Gujarat for coating through machine with different polymers *viz.*, Genius coat 171, Genius coat 172, Arcus, Myconate and Quick roots. The polymer coated rice seeds were raised under various moisture stress conditions by skipping the irrigation at panicle initiation stage, grain filling stage and both panicle initiation and grain filling stages along with normal irrigation as check. The effect of moisture stress onleaf area index, relative water content, chlorophyll stability index, soluble protein and nitrate reductase activity were studied at two different stages of plant growth *viz.* vegetative stage and reproductive stage. The experiment was set up adopting Split Plot Design with three replications.

RESULTS AND DISCUSSION

Water stress during different stages of plant growth cycle adversely affects many physiological growth processes like leaf area index, relative water content, chlorophyll stability index, soluble protein and nitrate reductase activity (Fageria*et al.*, 2006). Leaf area index (LAI) is an important source in manufacturing photoassimilates for determining crop yield and a reduction was observed due to decrease in water supply. Bunce (1977) observed a linear relationship between elongation rate and turgidity of stressed leaves. Water stress at reproductive stage arrested all growth parameters observed and it was very sensitive stage to the rice plant. The results are conformity with the findings of Stone *et al.* (2001) in sweet corn; Pandey *et al.* (2000) in maize and Usman *et al.* (2010) in cotton. Highest leaf area index was recorded at maturity stage irrespective of moisture stress conditions when seeds were coated with Quick roots. The rice seeds coated with Quick roots recorded highest leaf area index (3.0 and 4.4) irrespective of moisture stress when compared to untreated control seed (2.3 and 4.0) at vegetative and reproductive stages, respectively. Among the moisture stress, skipping irrigation at grain filling stage (4.2) recorded highest leaf area index compared to stress at early stages (4.1) (Table 1). Polymer coated sugar beet seeds increases the rate of imbibitions where the fine particles in the coating act as “wick” or moisture attracting material. This may be the reason for increase in leaf area index of the rice plant.

Table 1. Effect of polymer coated CORH3 hybrid rice seeds on leaf area index under moisture stress conditions

Polymer treatments(S)	Moisture stress conditions (M)									
	Vegetative stage					Reproductive stage				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
Untreated	2.3	2.3	2.3	2.3	2.3	4.1	4.0	4.1	4.0	4.0
Genius coat 171	2.4	2.4	2.4	2.4	2.4	4.2	4.1	4.2	4.1	4.1
Genius coat 172	2.7	2.7	2.7	2.7	2.7	4.3	4.2	4.3	4.2	4.2
Arcus	2.5	2.5	2.5	2.5	2.5	4.2	4.2	4.2	4.2	4.1
Myconate	2.8	2.8	2.8	2.8	2.8	4.3	4.3	4.3	4.3	4.2
Quick roots	3.0	3.0	3.0	3.0	3.0	4.5	4.3	4.5	4.3	4.4
Mean	2.6	2.6	2.6	2.6		4.2	4.1	4.2	4.1	
	M	S	M x S	S x M		M	S	M x S	S x M	
SEd	1.683	0.004	1.683	0.009		0.004	0.006	0.013	0.013	
CD (P<0.05)	NS	0.009**	NS	NS		0.011*	0.137*	0.273*	0.275*	

M_1-Normal irrigation; M_2- Skipping irrigation at panicle initiation stage; M_3- Skipping irrigation at grain filling stage; M_4- Skipping irrigation at panicle initiation and grain filling stages

Relative Water Content (RWC) is the appropriate measure of plant water status in terms of the physiological consequence of cellular water deficit. Relative water content had a significant influence on photosynthesis by reducing the net photosynthesis by more than 50 per cent when relative water content was less than 80 per cent. As observed by Slatyer (1955), a reduction by 5% in RWC led to reduction in photosynthesis by 40 to 50%. Reduction in RWCunder water stress is a general phenomenon (Anaytullah*et al*., 2007). The seeds coated with Quick roots (86 and 87%) recorded higher RWC irrespective of moisture stress when compared to untreated control (77 and 75%) at vegetative and reproductive stage, respectively. Among the moisture stress, skipping irrigation at grain filling stage (84%) recorded higher RWC compared to moisture stress at both panicle initiation and grain filling stage (80%) (Table 2). The polymer coated seeds maintained relatively higher RWC in the leaf cells irrespective of the water regimes tested. The polymer has a great importance for its role in the increase of water absorption capacity and enhanced lipid utilization through glyoxalate cycle.

Chlorophyll Stability Index (CSI) is an indicator of stress tolerance capacity of plants and is a measure of integrity of membrane (Murthy and Majumdar, 1962). Water stress generally reduced the values of CSI with distinct variation among the irrigation regimes. CSI has been used as an indicator of stress tolerance in rice as reported by Michael Gomez and Rangasamy, 2002and Yogameenakshi, 2002. The increased values of CSI had endowed better drought tolerance capacity to the plants. A higher CSI also meant better availability of chlorophyll (Meghanatha Reddy *et al*., 2007) leading to increased photosynthetic rate (soluble protein content). The decrease in CSI was noticed in the plants moisture stressed at panicle initiation and grain filling stage. The seeds coated with Quick roots recorded maximum CSI(82 and 79%) irrespective of moisture stresses compared to untreated control seed (78 and 69%) at vegetative and reproductive stages, respectively (Table 3). Among the moisture treatments, skipping irrigation at grain filling stage (75%) recorded higher CSI compared to stress at both panicle initiation and grain filling stage (73%). This might be due to the increased consumptive water use efficiency and accumulation of more photosynthesis in the leaf produced prior to major reproductive development.

Soluble protein is the most abundant protein in green tissue, containing the enzyme RUBISCO, involved in CO_2 assimilation. As RuBisCO forms nearly 50% of the soluble protein in many plants, the enhancement in soluble protein content might have a direct impact on photosynthetic capacity of the crop plants (Joseph *et al.*, 1981). The capacity of protein synthesis decreases considerably in response to water stress. Martignone *et al*. (1987) elucidated that soluble protein was the first nitrogenous compound lost during water deficit conditions. Similar situation was observed when water deficit occurred during the panicle initiation and grain filling stage. Meghanatha Reddy *et al.* (2007) also observed similar sensitivity of rice cultivars for reduction in soluble protein content under water stress. This reduction in soluble protein content might be attributable to the down regulation of PS II activity under water stress resulting in an imbalance between the generation

Table 2. Effect of polymer coating on relative water content (%) of CORH 3 hybrid rice seeds under moisture stress conditions

Polymer treatments(S)	Moisture stress conditions (M)									
	Vegetative stage					Reproductive stage				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
MeanUntreated	77	77	77	77	77	80	75	80	75	78
Genius coat 171	78	78	78	78	78	82	76	82	76	79
Genius coat 172	79	79	79	79	79	85	81	85	81	83
Arcus	81	81	81	81	81	83	79	83	79	81
Myconate	84	84	84	84	84	87	83	87	83	85
Quick roots	86	86	86	86	86	89	85	89	85	87
Mean	80	80	80	80		84	80	84	80	
	M	S	M x S	S x M		M	S	M x S	S x M	
SEd	1.24	0.28	1.53	0.57		0.19	0.17	0.37	0.35	
CD (P<0.05)	NS	0.58	NS	NS		0.48**	0.35**	0.81**	0.71**	

Table 3. Effect of polymer coating on chlorophyll stability index (%) of CORH 3 hybrid rice seeds under moisture stress conditions at vegetative and reproductive stages

Polymer treatments(S)	Moisture stress conditions (M)									
	Vegetative stage					Reproductive stage				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
MeanUntreated	78	78	78	78	78	71	68	71	68	69
Genius coat 171	79	79	79	79	79	73	71	73	71	72
Genius coat 172	81	81	81	81	81	76	75	76	75	75
Arcus	79	79	79	79	79	75	73	75	73	74
Myconate	81	81	81	81	81	77	76	77	76	76
Quick roots	82	82	82	82	82	80	78	80	78	79
Mean	80	80	80	80		75	73	75	73	
	M	S	M x S	S x M		M	S	M x S	S x M	
SEd	1.211	0.336	1.358	0.673		0.28	0.20	0.38	0.41	
CD (P<0.05)	NS	0.68**	NS	NS		0.69*	0.41*	0.78*	0.83*	

and utilization of electron apparently, which caused changes in the quantum yield. These changes in the photochemistry of chloroplasts of the water stressed leaves could generate active oxygen species (AOS), which were potentially dangerous to the plants under water deficit situations (Peltzer *et al.*, 2002). These AOS also initiated degradation of RUBISCO (Meghanatha Reddy *et al.*, 2007). The seeds coated with Quick roots (6.90 and 9.97 mg g^{-1}) recorded higher soluble protein irrespective of moisture stress compared to untreated control seed (6.10 and 9.71 mg g^{-1}) at vegetative and reproductive stage, respectively (Table 4). Among the moisture stress treatments,stress at grain filling stage (10.18 mg g^{-1}) recorded higher soluble protein compared to stress at both panicle initiation and grain filling stages (9.47 mg g^{-1}) (Table 4). Polymer coating increased the absorption of water, gases, micronutrients and the activity of hormones which help to maintain higher chlorophyll stability index. These polymers are having the capacity to absorb water about 100 to 1000 times of their weight from the surrounding rhizosphere which act as a local reservoir over a period of time and water from this reservoir is released gradually to the soil and thereby to plants based on need (Iqbal and Srinivasan, 1987).

Nitrate reductase (NRase), a key enzyme in nitrogen metabolism in plants, is highly sensitive to environmental fluctuations. Anaytullah *et al.* (2007) indicated that the drought tolerant rice genotypes possessed minimum percentage of reduction for NRase activity under water stress situations. The results are also in concordant with Chen *et al.*, (2004) who stated that water stress at critical stages leads to significant decrease in all physiological characters in hybrid rice. Similar trend in the results of nitrate reductase activity was observed and it increased gradually upto flowering and declined towards maturity. For these parameter also, the seeds coated with Quick roots performed well both under normal and moisture stress conditions. The seeds coated with Quick roots (0.645 and 0.755µmol NO$_2$g^{-1} h^{-1}) recorded higher NRase activity irrespective of moisture treatments compared to untreated control seed (0.611 and 0.711µmol NO$_2$g^{-1} h^{-1}) at vegetative and reproductive stages, respectively (Table5). The moisture stress at grain filling stage (0.773µmol NO$_2$ g^{-1} h^{-1}) recorded higher soluble protein compared to stress at both panicle initiation and grain filling stage (0.695µmol NO$_2$ g^{-1} h^{-1}) (Table 5). The polymer has a great importance for its role in increase of water absorption capacity and decrease of bad effects of drought stress. Henderson and Hensley (1987) reported that seed coating with polymer could provide protection against water stress and the hydrophilic polymers are mostly used to enhance the rate of water uptake thereby ensuring the soil water content not to fall below the critical level. The polymer coating stimulated vigorous seedling establishment and stronger root system which in turn derived the available soil moisture and nutrients enabling better plant growth and physiological parameters (Gray, 2003).

Among the moisture stress at different stages of plant growth, plant physiological parameters are strongly affected by moisture stress at both panicle initiation and grain filling stages which are the sensitive stage to

Table 4. Performance of polymer coating on soluble protein (mg g^{-1}) of CORH 3 hybrid rice seeds under moisture stress conditions at vegetative and reproductive stages

Polymer treatments(S)	Moisture stress conditions (M)									
	Vegetative stage					Reproductive stage				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
Untreated	6.10	6.10	6.10	6.10	6.10	10.05	9.37	10.05	9.37	9.71
Genius coat 171	6.40	6.40	6.40	6.40	6.40	10.09	9.40	10.09	9.40	9.74
Genius coat 172	6.60	6.60	6.60	6.60	6.60	10.23	9.52	10.23	9.52	9.87
Arcus	6.50	6.50	6.50	6.50	6.50	10.16	9.45	10.16	9.45	9.80
Myconate	6.70	6.70	6.70	6.70	6.70	10.27	9.51	10.27	9.51	9.89
Quick roots	6.90	6.90	6.90	6.90	6.90	10.31	9.60	10.31	9.60	9.97
Mean	6.53	6.53	6.53	6.53		10.18	9.47	10.18	9.47	
	M	S	M x S	S x M		M	S	M x S	S x M	
SEd	1.258	0.001	1.258	0.002		0.033	0.003	0.340	0.007	
CD (P<0.05)	NS	0.002**	NS	NS		0.081*	0.007*	0.083*	0.015*	

Table 5. Effect of polymer coating on NRase activity (μmol $NO_2 g^{-1} h^{-1}$) of CORH 3 hybrid ric seeds under moisture stress conditions at vegetative and reproductive stages

Polymer treatments(S)	Moisture stress conditions (M)									
	Vegetative stage					Reproductive stage				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
Untreated	0.611	0.611	0.611	0.611	0.611	0.752	0.670	0.752	0.670	0.711
Genius coat 171	0.615	0.615	0.615	0.615	0.615	0.762	0.689	0.762	0.689	0.725
Genius coat 172	0.624	0.624	0.624	0.624	0.624	0.772	0.701	0.772	0.701	0.736
Arcus	0.618	0.618	0.618	0.618	0.618	0.767	0.695	0.767	0.695	0.731
Myconate	0.631	0.631	0.631	0.631	0.631	0.788	0.705	0.788	0.705	0.746
Quick roots	0.645	0.645	0.645	0.645	0.645	0.797	0.713	0.797	0.713	0.755
Mean	0.624	0.624	0.624	0.624		0.773	0.695	0.773	0.695	
	M	S	M x S	S x M		M	S	M x S	S x M	
SEd	0.622	0.001	0.622	0.003		0.004	0.0006	0.003	0.001	
CD (P<0.05)	NS	0.003**	NS	NS		0.009*	0.001*	0.009*	0.002*	

the CORH 3 hybrid rice. CORH 3 hybrid rice seeds coated with Quick roots polymer recorded better physiological parameters *viz*., high leaf area index, relative water content, chlorophyll stability index, soluble protein and nitrate reductase activity both under normal irrigation as well as moisture stress conditions.

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