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Full Length Research Article

Hydro-Priming and Re-Drying Effects on Germination, Emergence and Growth of Upland Rice (*Oryza sativa* L.)

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ABSTRACT: Experiments were conducted in the field and laboratory during the 2011 wet and dry seasons to investigate the effect of hydro-priming and drying duration on the germination, emergence and growth of seedlings of upland rice. Treatments consisted of four hydro-primed durations of 12, 24, 36 and 48 hrs at two and four hours of drying and unprimed (control) laid out in a completely randomized design (CRD) replicated three times. Results show that there was significant effect ($P<0.05$) of hydro priming on all the growth parameters except the plant height at 1, 2 and 3 weeks after sowing. It was therefore concluded that upland rice variety, NERICA 2 can successfully be hydro-primed for 12 hrs in order to obtain greater establishment and growth performance under Sokoto conditions. Hydrated seeds can be re-dried for four hours without loss of physiological advancement obtained from hydration phase.

Keywords: Hydro priming, drying, germination, seedling emergence, seedling growth, upland rice, *Oryza sativa*

INTRODUCTION

Rice (*Oryza sativa* L.) belongs to the grass family Poaceae, genus *Oryza* (L) of which two species are cultivated *O. sativa* (L) and *O. glaberrima* (Steud). It is normally grown as annual crop and can grow up to a height of 1 – 1.8m depending on the variety and soil fertility. In tropical areas it can survive as a perennial and can produce a ratoon crop for up to 30 years (IRRI, 2008). Rice cultivation is well suited to countries and regions with low labour costs and high rainfall as it is labour-intensive to cultivate and requires ample water. Rice is widely cultivated in most agro-ecological zones in Nigeria. The composition of rice differs with the variety, the nature of the soil, environmental conditions and the fertilizer applied (Juliano, 1964). The nutritional value per 100g of rice contains energy of about 1,527KJ (365Kcal), carbohydrate 80g, sugar 0.12g, dietary fiber 1.3g, fat 0.66g, protein 7.13g and water 11.61g.

Rice production and consumption in Nigeria have increased during the last quarter of the century. Notwithstanding, the increase in production was insufficient to match the consumption, thereby resulting to importation to make for the shortfall. With rice now being a structural component of the Nigerian diet and rice imports making up an important share of Nigerian agricultural imports, there is a well established and growing demand for rice in the country. However, only about half of that demand is met by domestic production -Nigeria importing 1.9 million metric tonnes of rice in 2002 valued at approximately US$ 500 million (USDA FAS, 2003). Given the size and value of the imports, there is considerable political interest in reducing rice imports.

As a cereal grain, it is the most important staple food for a large part of the world's human population especially in East and South Asia, the Middle East, Latin America and the West Indies. It is the grain with the second highest worldwide production after maize (corn) (FAOSTAT, 2006). Since a large portion of maize crops are grown for purposes other than human consumption, rice is the most important grain with regard to human nutrition and caloric intake, providing more than one fifth of the calories consumed worldwide by the human species (Smith, 1998). Rice is used as a staple food by more than 60% of the world population. Over boiled rice is used in Asia for starching clothes. Rice bran is used in confectionery products like biscuits, cookies e.t.c. The oil from the rice bran is used as edible oil, in soap and fatty acids manufacture. Rice straw is mainly used as animal feed and for mulching of horticultural crops. Commercial rice flour is prepared from broken parboiled rice, the resultant flour being essentially precooked flour (Hogan, 1967).

Rice cultivation requires a large amount of labour especially during transplanting which often results in its shortage and thereby increasing the cost of production. Alternate methods that require less labour without sacrificing productivity are therefore needed. Considering the cost, direct seeding is an appropriate

alternative. However, poor germination, uneven crop stand and high weed infestation are the main constraints to its adoption (Balasubramanian and Hill 2002).

Good crop establishment is vital in the production of annual crops from seed, because patchy stands result in low yields. Several approaches including seed priming, seed soaking and seed coating have been employed to precondition seeds to improve germination and seedling growth of various crops (Basra *et al*., 2003). Seed priming is a procedure in which seed is soaked in water and then dried back to its original water content (Harris *et al*., 2002). This is done to make the seed perform better. The beneficial effects of priming have being associated with various biochemicals, cellular and molecular events including synthesis of ribonucleic acid (R.N.A.) and proteins (Bray *et al*., 1989; Dell'Aquila and Bewley, 1989; Davison and Bray, 1991). A hydrated seed with water and re-drying them before they complete germination (hydro priming minimizes the use of chemicals and avoids discarding materials that may be undesirable to the environment (McDonald, 2000). Hydro priming practically ensures rapid and uniform germination accompanied with low abnormal seedling percentage (Singh, 1995; Shivankar *et al*., 2003).

Therefore, this experiment was conducted to study the effects of hydro priming and re-drying duration on germination, emergence and seedling growth of direct seeded upland rice (*Oryza sativa* L.) under Sokoto agro-ecological conditions.

MATERIALS AND METHODS

Experimental Site

Seed germination test was carried out in the Crop Science Laboratory of Usmanu Danfodiyo University, Sokoto. Emergence test was carried out in the Fruits and Vegetable Teaching and Research Farm of the Department of Crop Science, Usmanu Danfodiyo University, Sokoto. According to Ojanuga (2004), Sokoto state is situated between latitude 14˚N' and 15˚N' and longitude 4˚E and 5˚E. The state falls under Sudan savanna agro-ecology characterized by low rainfall of about 500-800 mm per annum and annual average temperature of 28.3°C. It has alternating rainy and dry seasons. The rainy season lasts from June to September while the dry season (which is characterized by very cold temperatures and dust laden winds) stretches from September to February. Sandy topsoil with clayey subsoil is common, except along the flood plains of the river valleys where alluvial soils predominate.

Experimental Materials

The following materials were used in conducting the experiment; petri-dishes, plastic containers (for priming), apron star (seed dressing chemical), filter paper and upland rice seeds of the variety NERICA 2 which were sourced from Sokoto Agricultural Development Project (SADP), Sokoto.

Treatment and Experimental Design

Treatments consisted of four hydro priming durations of 12, 24, 36, and 48 hrs at two periods of drying (two and four hours) and control (unprimed) making a total of nine treatments i.e. 2 x 4 plus control. The treatments were laid out in a completely randomized design (CRD) replicated three times.

Seed Hydro-Priming

The hydro priming was imposed as per treatments. The temperature of the water during priming was 26°C and the environmental temperature was 28°C for all hours of soaking. The quantity of water to the rice used was 600 seeds into 250 ml of water. After priming, the seeds were air-dried as prescribed by the treatments (two and four hrs).

Germination Test

One hundred (100) seeds were placed on moist medium filter paper (9 cm in diameter) in Petri-dishes and replicated three times. Droplets of distilled water were applied regularly on the filter paper to ensure adequate moisture for seed germination (protrusion of radical by 2mm). Germination count was taken daily for 6 days. The laboratory temperature at the time of the experiment was about 30°C. Germination percentage was computed using the following formula:

$$\text{Germination}(\%) = \frac{\text{Germinated Seeds}}{\text{Total Seeds Sown}} \text{x} 100$$

Field Emergence Test

Twenty seven plots of 30 cm × 30 cm were constructed on a well prepared land. The seeds were treated with apron star before sowing to control primary soil and seed-borne pathogens and insect pests during the experiment. Sowing was done by drilling 100 seeds at a depth of 2 cm on a sandy loam soil. No fertilizer was applied in the experiment. Water was applied at two

days interval after rain had stopped. Seedling emergence was recorded at 3, 5 and 7 days after sowing. This was done by counting the number of seedlings that emerged from the soil. Data were collected on the seedlings height at 7 days interval and dry matter accumulation at 3 weeks of sowing. Seedling height was measured using a ruler, while the dry matter was recorded by harvesting the plants and oven drying to a constant weight at 65°C in an electric oven and the dry weight was recorded by the use of an electronic weighing balance.

Data Analysis

Data were collected on seed germination and emergence, seedling height and dry matter accumulation, which were subjected to analysis of variance (ANOVA) for completely randomized design (CRD) using SAS (2003) software. Mean separation, where necessary was carried out using Duncan's New Multiple Range Test (DNMRT).

RESULTS

Seeds Germination

Table 1 shows that there was significant difference ($P<0.05$) between some treatments in hydro priming, except between 12 hrs and control after 24 hrs as primed seeds recorded higher germination percentage than the control probably due to faster water uptake by primed seeds compared to the control. A day after sowing, $P_{48}D_4$ and $P_{36}D_4$ recorded higher germination of 36.33 and 26.67, respectively. On the second day, all the primed treatments were significantly ($P < 0.05$) different from the control except $P_{48}D_4$ which recorded similar germination with the unprimed (control), perhaps due to the significant difference already observed after 24 hrs. The effect of hydro-priming appeared to decrease with time as primed seeds exposed for 12 hrs on third and fourth days after sowing were significantly similar to the control, however on the fifth day all treatments were statistically similar and lower than the control. There was no significant effect recorded on six days after sowing, as the effect could have diminished with time.

However, on the total germination percentage (Table 1), there was no significant difference the different hours of soaking, but only between the different hours and the control.

Seedling Emergence

The effect of seed hydro priming on the seeding emergence of upland rice is presented in Table 2. The highest emergence was observed in 24 hours priming and re-drying for four hours on third and fifth days after sowing which was significantly ($P < 0.05$) higher than the rest of the treatments, while on 7 days after sowing, many treatments were similar, except the control which had the lowest emergence.

Table 1: Seed germination of upland rice as affected by hydro priming and re-drying duration (hrs) during 2011 cropping season at Crop Science Laboratory, Usmanu Danfodiyo University, Sokoto

Treatments		Days after sowing						Germination
Hydro-priming	Re-drying duration(hrs)	1	2	3	4	5	6	percentage (%)
0(control)		0.00^{e}	3.33^{c}	28.33^{a}	13.00^{a}	10.00^{a}	4.33	59.00^{c}
12	2	6.00^{de}	32.33^{ab}	25.00^{a}	10.33^{a}	3.00^{b}	1.33	78.00^{a}
	4	0.00^{e}	31.67^{ab}	23.33^{a}	11.67^{a}	2.33^{a}	2.00	71.00^{abc}
24	2	14.67^{cd}	39.00^{a}	8.67^{bc}	1.00^{b}	3.00^{b}	1.67	68.00^{abc}
	4	21.67^{bc}	31.67^{ab}	11.67^{bc}	0.67^{b}	2.67^{b}	2.33	70.67^{abc}
36	2	18.67^{bc}	22.67^{b}	12.67^{bc}	3.33^{b}	1.33^{b}	1.33	60.00^{bc}
	4	26.67^{ab}	26.33^{b}	15.00^{b}	4.00^{b}	1.00^{b}	0.67	73.67^{ab}
48	2	23.67^{bc}	31.67^{ab}	10.33^{bc}	0.33^{b}	1.67^{b}	2.00	69.67^{abc}
	4	36.33^{a}	11.33^{c}	4.33^{c}	4.33^{b}	1.00^{b}	2.67	60.00^{bc}
SE(±)		3.564	3.536	2.689	1.305	1.111	ns	4.281
CV (%)		37.62	23.96	30.09	41.80	66.62	103.92	10.94
Significance		*	*	*	*	*	ns	*

Means in a column followed by the same letter are not significantly different using Duncan's Multiple Range Test at 5% level, *= significant at 5%, ns= not significant, P is priming and D is re- drying.

Table 2: Seedling emergence of upland rice as affected by hydro priming and re-drying duration (hrs) during 2011 cropping season at Crop Science Laboratory, Usmanu Danfodiyo University, Sokoto

Treatments		Days after sowing		
Hydro-priming rates(hrs)	Re-drying duration(hrs)	3	5	7
0(control)		7.00^{c}	20.67^{d}	31.7^{c}
12	2	12.67^{bc}	28.00^{bcd}	52.67^{b}
	4	12.00^{bc}	40.00^{bc}	64.33^{b}
24	2	19.67^{bc}	26.67^{bcd}	65.67^{b}
	4	48.00^{a}	68.00^{a}	82.33^{a}
36	2	21.33^{bc}	43.33^{b}	65.00^{b}
	4	18.67^{bc}	43.67^{b}	66.33^{ab}
48	2	24.67^{b}	42.67^{bc}	67.67^{ab}
	4	13.00^{bc}	23.67^{cd}	50.33^{b}
SE(±)		4.417	5.862	5.476
CV (%)		38.89	27.15	15.63
Significance		*	*	*

Means in a column followed by the same letter are not significantly different using Duncan's Multiple Range Test at 5% level, *= significant at 5%, P is priming and D is re- drying

Primed Seeds Unprimed seeds

Plate1: Germination test in the Laboratory showing primed and unprimed treatments of upland rice one day after sowing.

Primed seedlings

Unprimed seedlings

Plate 2: Effect of hydro-priming on the emergence and growth of NERICA 2 seedlings three weeks after sowing during 2011 rainy and seasons at Sokoto.

Seedling Growth

Effect of hydro-priming and drying duration on plant height and dry matter accumulation of upland rice seedlings are presented in Table 3. Results show that there was no significant difference of hydro-priming and drying duration on the plant height at 1, 2 and 3weeks after sowing. Dry matter accumulation at 3 weeks after sowing was significantly different ($P < 0.05$) between treatments, with 24, 36 and 48 hour of priming at two hours of re-drying recording similar results which were significantly ($P < 0.05$) higher than other treatments including the control (unprimed).

Table 3: Plant height and dry matter accumulation as affected by hydro priming and re-drying duration (hrs) during 2011 cropping season at Crop Science Laboratory, Usmanu Danfodiyo University, Sokoto

Treatments		Plant Height(cm)			
		Week(s) after sowing			
Hydro-priming rates(hrs)	Re-drying duration(hrs)	1	2	3	Drymatter accumulation(g) at 3WAS
0(control)		1.77	2.43	3.73	0.047^{b}
12	2	1.63	2.47	3.67	0.050^{b}
	4	1.67	2.77	4.13	0.057^{b}
24	2	1.90	2.67	4.37	0.070^{ab}
	4	1.70	3.23	4.20	0.057^{b}
36	2	1.77	2.57	4.33	0.073^{ab}
	4	1.67	2.33	4.23	0.050^{b}
48	2	1.80	3.17	4.63	0.093^{a}
	4	1.63	2.97	4.20	0.060^{b}
SE(±)					0.008
CV(%)		20.71	19.89	15.14	23.89
Significance		ns	ns	ns	*

Means in a column followed by the same letter are not significantly different using Duncan's Multiple Range Test at 5% level, *= significant at 5%, ns= not significant, P is priming and D is re- drying

DISCUSSION

Hydro-priming was found to have improved earlier and higher germination percentage in upland rice 24 hrs after sowing, probably because the seeds had already imbibed some water, which was retained. The results are in line with the findings of Birendra and Shambhoo (2011) who recorded earlier and higher germination percentage in rice seeds that were hydro-primed for 48 hrs. Moradi Dezfuli *et al.* (2008) also reported higher germination percentage in maize seeds that were hydro-primed for 36 and 48 hrs. Abbasdokht *et al.* (2010) reported that hydro-primed seeds could achieve earlier and more uniform germination than un-primed seeds. These positive effects are probably due to the stimulatory effects of priming on the early stages of germination process by mediation of cell division in germinating seeds (Szabolcs, 1994; Sivriteps *et al.,* 2003). Priming may improve germination by accelerating imbibitions, which in turn would facilitate the emergence phase and the multiplication of radicle cells (McDonald, 1999). This process is important because it allows the subsequent development of the embryo, especially in seeds characterized by a morphological dormancy (immature embryo), like *Chamaecyparis nootkatensis* seeds (Schimtz *et al*., 2001).

The present results showed faster emergence with primed seeds than unprimed as was evident on the third day after sowing. Enhanced germination ensures rapid emergence, as one stage leads to the other in a sequence. The results are in agreements with Harris *et al.* (2001) who reported that wheat seeds soaked in tap water resulted in earlier emergence, deeper root, earlier flowering and high yield. Ghassemi-Golezani *et al.* (2008a) reported that seeds of pinto bean that was hydro-primed enhanced earlier seedling emergence. The efficiency of seed hydro-priming for better seedling emergence was also reported in barley (Abdulrahmani *et al.,* 2007). Faster and uniform emergence may be due to improved α-amylase activity, which increased the level of soluble sugar in the primed seeds. Rapid establishment of seedlings could lead to the production of vigorous plants (Ghassemi-Golezani *et al.,* 2008a). A robust seedling establishment enhances competitiveness against weeds, improves tolerance to environmental stresses and maximizes both biological and grain yields (Ghiyasi *et al.,* 2008).

However, hydro-priming did not produce any significant ($P < 0.05$) increase in the plant height of upland rice, (NERICA 2) This was not in line with Kaya *et al.* (2006) and Basra *et al.* (2006) who reported that hydro-primed seeds of sunflower and wheat could germinate faster and produced taller seedlings when compared with untreated seeds. This may probably be due to the nature of the variety as it displays heterosis, the phenomenon in which the progeny of two genetically different parents grow faster, yield more, or tolerate stresses better than either of the parents. This in turn makes the primed seeds grow at the same rate with that of the unprimed. Tavili *et al.* (2009) reported taller seedling with hydro-primed seeds of *Bromusinermis* at two weeks after sowing.

Hydro-priming significantly increases dry matter accumulation in upland rice, because physiological activities start early enough and continue at faster rate up to the point of physiological maturity. The result agreed with that of Yari *et al.* (2011) who recorded higher dry matter yield with hydro-primed wheat seedlings than unprimed seedlings. Similar results were also reported by Farahani and Maroufi (2011) which recorded higher seedling dry weight with basil seeds hydro-primed for 12hrs. MoradiDezfuli *et al.* (2008) reported similar results with the maize inbred line MO17 which recorded higher dry weight with hydro-priming duration at 12, 36 and 48 hrs.

The positive influence of seed priming could be attributed to the well developed root system of the treated plants which might have improved the nutrient uptake by the plants which in turn improve the growth characters and hence dry matter production and yield.

CONCLUSION AND RECOMMENDATION

The experiment was conducted to study the effect of hydro priming and drying duration on germination, emergence and growth of upland rice, *Oryza sativa* L. NERICA 2 variety in Sokoto in Sudan savanna region of Nigeria. Treatments consisted of four levels of hydro priming period (12, 24, 36 and 48 hrs) at two levels of drying (2 and 4 hrs), and the control (unprimed). Treatments were laid out in a completely randomized design replicated three times. Results show significant effect of hydro priming on all the growth parameters taken except plant height which reveal no significant effect in all the weeks after sowing. Drying duration has no effect on the hydro primed treatments.

It could be concluded that upland rice variety, NERICA 2 can successfully be hydro primed for at least 12 hrs and re-dried for two hours to enhance seed

germination, seedling emergence and high dry matter accumulation. Hydrated seeds can be re-dried without loss of physiological achievement obtained from hydration phase. Hydro-priming could be a suitable, cheap and easy seed invigoration treatment for rice and thus can easily be adopted by resource-poor farmers in marginal areas of developing countries. It is therefore recommended that NERICA 2 rice variety can be hydro-primed for about 12 hrs in order to obtain greater establishment and performance on the field. Further study is required to investigate the effects of longer re-drying duration and condition after hydro-priming.

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