PRE-SOWING TREATMENT FOR IMPROVING SEED QUALITY IN WEST AFRICAN RICE VARIETIES II. SEEDLING EMERGENCE AND SEEDLING GROWTH.

BY

Adebisi, M. A., Ajala, M. O., Daniel, I. O., and Fasan, K.O.
Department of Plant Breeding and Seed Technology,
University of Agriculture, P. M. B. 2240, Abeokuta, Nigeria
email: mayoadebisi(@yahoo.com.uk, wole_mike@yahoo.com.

ABSTRACT

The influence of dry heat pre-sowing treatment was investigated to improve rate and level of field emergence and eventually seedling growth in ten new West African rice varieties. The varieties were exposed to different dry heat temperatures (40, 45, 50, 55 and 60°C) and control (32°C) for 24 hours. Variations in dry heat intensities and varieties modulated field emergence and seedling growth. Influence of dry heat treatment on field emergence and seedling growth occurred at all the heat intensities. Dry heat intensities (50, 55 and 60°C) accelerated field emergence and low temperatures (40°, 45° and 50°C) had higher promotion tendency on seedling growth than other heat intensities. Field emergence of ITA 230, TOX 4004-43-1-2-1, SIPI 692023 and WITA 12 had remarkable improvement across all the heat intensities. Promotion of field emergence increased seedling height in TOX 4004-43-1-2-1 and stimulation of seedling height enhanced seedling dry weight in WAB 189-B-B-B-HB. Field emergence of BW348-1, WITA 1 and CISADANE seeds had distinct reduction across all dry heat treatments. Dry heat at 55° and 60°C had considerable improvement in field emergence of TOX 4004-43-1-2-1 above other varieties. At pre-sowing dry heat of 50° and 55°C, field emergence of BW 348-1 and WITA 1 seeds was significantly promoted and a wider range of heat intensities at 45° to 60°C enhanced field emergence of SIPI 692033 seeds. Dry heat treatments did not have promotion tendency in the seedling growth of BW 348-1, WITA 1, WAB 99-1-1 and WAB 189-B-B-B-HB.

Key Words: *Field emergence, heat intensity, pre-sowing, seed quality, seedling growth.*

INTRODUCTION

A primary objective of rice seed production programme is to provide farmers with seeds of high physiological quality which guarantee the establishment of a uniform stand of healthy seedlings even under less favorable field conditions. Dry heat treatments were earlier found promising in breaking seed dormancy and protecting the seeds from infection and gave encouraging results in a variety of crop seeds (Dell-Quila and Di-Turi, 1996; Herranz *et al.,* 1998; Jeffery *et al.* 1988; Meng *et al* 1999; Dadlani and Seshu 1990; Grondeau *et al.*, 1992 and Zhang, 1990).

Lee *et al.* (2002) observed that at high temperatures of 85 and 90°C, percentage emergence, plant height and dry weight of Korean rice varieties were significantly reduced compared to the control. They also observed that lower temperatures (70 80°C) had no adverse effects on these traits and reported varietal differences in seedling emergence, plant height and dry weight at 90°C temperature.

Most publications deal with laboratory studies and there is dearth of information on the efficacy of pre-sowing heat treatment on seedling emergence and seedling growth of new West African rice varieties. Besides, there exists contradictory results in literature concerning the improvement of field emergence and subsequent seedling growth by means of pre-sowing treatments. Moreover, since the ultimate criterion of seed vigour is the ability to establish a stand in the field, it is imperative to investigate the efficacy of a pre-sowing treatment from sowing to field establishment. In this paper, the influence of dry heat pre-sowing treatment was investigated to improve rate and level of field emergence and eventual seedling growth in seeds of new West African rice varieties. Additionally, the study set out to determine the extent of varietal differences in field emergence and seedling growth of West African rice varieties following dry heat treatment.

MATERIALS AND METHODS

Seed preparation

Seeds of 10 new West African rice varieties were sourced, soon after harvest, from the West Africa Rice Development Association (WARDA) in 2003 early cropping season. The seeds were stored at room temperature for five months (October 2003 to February, 2004) to break seed dormancy. The ten rice varieties were prepared for various dry heat treatments.

Dry heat treatment

Seeds were pre-treated to reduce moisture content at 35°C for 48 hours in paper bags before treatment. Water content of seeds was about 10% after pre-drying Hundred gramme seeds each of the ten rice varieties were subjected to different dry heat temperatures (40, 45,50, 55 and 60°C) for 24 hours. Control treatment was included at ambient room temperature. After treatment, seeds were kept at room temperature for 5 days. Thereafter, seeds were assessed for seedling emergence and seedling growth in the screen house thus:

Seedling emergence: To determine seedling emergence, 100- seeds in three replicates of each treatment were sown in plastic pots (16 cm radius) at 1.5 cm depth. The seedlings of 2.0cm length of each plot were counted at 8 days after emergence and divided by the sowing density.

Seedling height: This was determined in centimeters from the soil level to the terminal end of the seedling at 30 days after sowing.

Seedling dry weight: After 30 days, ten seedlings from each treatment were dried for 24 hours in a heated oven at 70°C and later measured in grammes after cooling for two hours.

Data analysis

Data analyses were performed using SAS (2003) statistical soft ware (version 8). Analysis of variance was computed for each trait and treatment means were separated using Duncan's (1955) multiple range test at 5% level of probability.

RESULTS

The results of the analysis of variance are presented in Table 1. Heat, variety and interaction effects of heat x variety were highly significant (P 0.01) for the three seed quality traits examined.

Results presented in Table 2 show that seedling emergence, seedling height and seedling dry weight under different heat regimes considerably differed. Percentage seedling emergence ranged from 51% (for control) to 70% and 70% (for 50°C temperatures). Seedling emergence was significantly increased at high temperatures of 50-60°C with emergence of 62% and above. The seedling height was significantly highest (8.2 cm) when heat-treatment was carried out at 45°C whereas similar seedling height was observed at other heat intensities and control. Seedling dry weight was significantly increased at low temperature (40 and 45°C) while other heat intensities recorded similar dry weight. In Table 3, significant differences were observed among the varieties for all the traits. Percentage seedling emergence was ranked highest with TOx 4004-43-1-2-2 and ITA 230 and with 81% and 79% respectively, closely followed by SIPI 692033 (70%) and WITA 12 (71%). Conversely, BW 348-1, CISADANE, WAB 189-B-B-B-HB and WITA 1 recorded low seedling emergence, ranging between 19 and 30%. Seedling height was ranked highest with WAB 189-B-B-B-HB with 11.25cm, followed by FARO 11 with 8.59cm. Seedling dry weight was significantly ranked highest with TOx 4004-43-1-2-1 and WAB 189-B-B-B-HB with 3.88g and 3.82g respectively, followed by CISADANE (3.68g) and WITA 12 (3.10g). Three varieties (BWB 348-1, WAB 99-1-1 and WITA-1) were ranked lowest in seedling dry weight.

The results presented in Table 4 show that seedling emergence of ITA 230 was highest at control, 40, 45 and 50°C with the range of 78-89%, indicating for this variety and FARO 11 and CISADANE a decrease in seedling emergence with increasing heat-treatment temperatures. While some varieties(WITA12 and FARO 44) were indifferent, others (TOx 4004-43-1-2-1 , WAB 189-B-B-B-HB, BW 348-1-) were decreasing in seedling emergence with increasing heat-treatment temperatures. Similarly, TOx 4004-43-1-2-1 recorded significant highest seedling emergence (81-87%) at 55 and 60°C.

Results in Table 5 reveal that seedling height of WAB 189-B-B-B-HB consistently ranked highest at all the dry heat intensities which ranged from 9.57cm (for control) to 12.69cm (for 45°C), followed by FARO 11 with between 8.14 (for control) and 8.77cm (for 55°C). Conversely, BW348-1, WITA 1, and CISADANE were among varieties with low seedling height at each of the heat intensities. In Table 6, seedling dry weight of CISADANE was significantly highest at low temperature (40, 45°C and control with 4.79-6.32g. TOx 4004-43-1-2-1 recorded high seedling dry weight at higher temperatures (45 and 50°C) but a drastically low value at the highest heat intensity (60°C). At high temperature of 60°C, WITA 12 (13.82g), followed by BW 348-1 (3.52g) had high significant seedling heights whereas CISADANE (1.23g), FARO 11 (1.64g), ITA 230 (1.83g) and TOx 4004-1-2-1 (2.50g) recorded significantly low seedling weight, coinciding with decreasing seedling emergence of CISADANE, FARO11 and ITA 230 (Table 4). Except at 60°C , the seedling dry weights of BW 348-1, WAB 99-1-1 and WITA 1 were generally low at each of the heat intensities.

DISCUSSION

Variations in dry heat treatments and varieties influenced the field emergence, seedling height and seedling dry weight of West African rice seeds. The influence of dry heat treatments on the seed quality traits of the rice varieties depended on dry heat intensity. Similar findings were reported by Lee *et al.* (2002) in Korean rice varieties. On the basis of earlier laboratory studies , it was expected that the pre-sowing treatment would lead to an acceleration of seedling emergence (Ajala, 2003). This proved to be true as dry heat treatments at 50, 55 and 60°C stimulated field emergence when compared with other heat intensities, while low temperatures (40 and 45°C) failed to promote seedling emergence above the control treatment. Seed pre-sowing treatment at low temperature (45°C) for 24 hours considerably enhanced seedling height but failed to increase seedling dry weight.

The study revealed that percentage seedling emergence of ITA 230, TOx 4004-43-1-2-1, SIPI 692023 and WITA 12 had remarkable improvement across all the heat intensities. Promotion of seedling emergence increased seedling height of TOx 4004-43-1-2-1 while stimulation of seedling height increased seedling dry weight of WAB 189-B-B-B-HB. From the work of Zeigler *et al* (1987), heat and chemical therapy may play a positive role in controlling seed-borne infection, thereby enhancing germination. The seedling emergence of BW 348-1, WITA 1 and CISADANE seeds had distinct reduction across all heat treatments. This suggests the exhibition of secondary dormancy. As Nugraha and Soejadi (1991) used pre-drying and soaking as an effective method to overcome dormancy in IR-64 rice seeds, this implies that for some genotypes, pre-drying accumulates some deleterious chemicals which presumably removed by leaching / soaking . This further indicates that efficacy of pre-sowing treatment to improve seedling emergence and seedling growth may be related to certain chemical factors and dormancy-enhancing features in the seeds. Lee *et al.* (2002) reported that varietal differences in seedling emergence of Korean rice seeds were not related to grain size but closely related to ecotype, dormancy and endosperm characters.

In this study, heat intensities of 55 and 60°C had significant increase in seedling emergence of TOx 4004-43-1-2-1 above other varieties. However, percentages of seedling emergence of CISADANE and WAB 189-B-B-B-HB seeds were generally low at all dry heat intensities. Very noteworthy is the fact that at temperatures of 50 and 55°C, field emergence of BW 348-1 and WITA 1 seeds was significantly stimulated while temperatures of 45 to 60°C enhanced seedling emergence of SIPI 692033 seeds.

There were significant varietal differences in plant heights at all the dry heat treatments. Varieties WAB 189-B-B-B-HB and FARO II had a consistent and significant seedling height at all the heat intensities including control. However, all the heat treatments remarkably increased the seedling height of WAB 189-B-B-B-HB but low temperature (40, 45 and 50°C) had higher promotion tendency than other heat intensities. Pre-sowing dry heat treatments did not have promotion tendency in seedling height of BW 348-1, CISADANE, WAB 99-1-1, WITA 1 and WITA 12. The study further revealed that low heat intensities (40 and 45°C) promoted seedling dry weight of CISADANE while varieties TOx 4004-1-2-1 and WAB 189-B-B-B-HB had superior seedling dry weight at all the heat intensities. Moreover, irrespective of the degree of dry heat intensities, seedling dry weight was largely reduced in BW 348-1, SIPI 692033, WAB 99-1-1 and WITA 1.

The study demonstrated that pre-sowing dry heat treatments improved seedling emergence and seedling growth in new West African rice varieties, although, some varieties were sensitive to dry heat intensities. The normal dry heat treatments for new West African rice seeds was 45 to 55°C for improved seedling emergence level and enhanced seedling development.

Table 1: Analysis of variance (ANOVA) of three seed quality characters evaluated

Sources of Variation	Df	Seedling emergence (%)	Seedling height (cm)	Seedling dry weight (g)
Heat	5	94.892**	12.930**	11.463**
Genotype	9	2127.327**	24.936**	7.854**
Heat x Genotype	45	24.887**	3.630**	2.173**
Error	120	1360	0.761	0.373
Total	180			

** Significant at P = 0.01

Table 2: Effect of dry heat treatment on seedling emergence and seedling growth of rice.

Dry Heat / Temperature (^0C)	Seedling emergence (%)	Seedling height (cm)	Seedling dry weight (g)
Control	46[b]	7.59[b]	2.53[b]
40	46[C]	7.92[b]	3.04[a]
45	48[b]	8.01[a]	3.30[a]
50	57[a]	7.97[b]	2.66[b]
55	57[a]	7.68[b]	2.40[b]
60	60[a]	7.80[b]	2.60[b]
Mean	52	7.8	2.76

Values within a column followed by a common letter are not significantly different according to Duncan's multiple range test at P = 0.05.

Table 3: Effect of variety on seedling emergence and seedling growth after heat treatment.

Variety	Seedling emergence (%)	Seedling height (cm)	Seedling dry weight (g
BW 348-1	26^{f}	6.94^{d}	1.97^{d}
CISADANE (FARO 51)	12^{h}	6.3^{d}	3.68^{b}
FARO 11 (056)	60^{d}	8.59^{b}	2.33^{c}
ITA 230 (FARO 50)	79^{a}	7.79^{c}	2.56^{c}
SIPI 692033 (FAR0 44)	70^{b}	7.56^{d}	2.54^{c}
TOX 4004-43-1-2-1	81^{a}	7.97^{c}	3.88^{a}
WAB 99-1-1	66^{c}	7.43^{d}	1.96^{d}
WAB 189-B-B-B-HB	19^{g}	11.25^{a}	3.82^{a}
WITA 1	30^{e}	6.85^{d}	1.72^{d}
WITA 12	71^{b}	7.20^{c}	3.10^{b}
Mean	51	7.80	2.76

Values within a column followed by a common letter are not significantly different according to Duncan's multiple range test at P = 0.05.

Table 4: Influence of dry-heat treatment on percentage seedling emergence of 10 rice varieties.

Variety	Dry Heat / Temperature (⁰C)						Mean
	Control	40	45	50	55	60	
	Percentage Seedling Emergence						
BW 348-1	2^{i}	3^{h}	4^{h}	60^{f}	66^{d}	18^{g}	26
CISADANE (FARO 51)	17^{f}	15^{f}	15^{f}	10^{i}	9^{g}	9^{h}	12
FARO 11 (056)	63^{d}	64^{d}	63^{d}	62^{e}	55^{e}	54^{e}	60
ITA 230 (FARO 50)	89^{a}	89^{a}	89^{a}	78^{a}	65^{d}	53^{d}	79
SIPI 692033 (FAR0 44)	63^{d}	63^{d}	77^{b}	76^{b}	74^{b}	68^{c}	70
TOX 4004-43-1-2-1	78^{b}	79^{b}	79^{b}	79^{a}	81^{a}	87^{a}	81
WAB 99-1-1	55^{e}	56^{e}	62^{d}	65^{d}	71^{c}	85^{b}	66
WAB 189-B-B-B-HB	12^{g}	15^{f}	15^{e}	17^{h}	26^{f}	49^{f}	19
WITA 1	4^{h}	6^{g}	7^{g}	47^{g}	54^{e}	49^{d}	30
WITA 12	74^{c}	74^{c}	74^{c}	73^{c}	73^{b}	55^{e}	71
Mean	46	46	48	57	57	55	

Values within a column followed by a common letter are not significantly different according to Duncan's multiple range test at P = 0.05.

Table 5:Influence of dry-heat treatment on seedling height of 10 rice varieties.

Variety	Dry Heat / Temperature (⁰C)						Mean
	Control	40	45	50	55	60	
	Seedling Height (cm)						
BW 348-1	6.42[e]	6.44[f]	6.90[g]	9.92[f]	7.40[e]	7.57[d]	6.94
CISADANE (FARO 51)	6.48[e]	6.98[e]	6.44[h]	6.25[g]	6.01[g]	5.88[g]	6.34
FARO 11 (056)	8.14[a]	8.54[b]	8.60[b]	8.67[b]	8.77[b]	8.84[b]	8.59
ITA 230 (FARO 50)	7.68[c]	7.87[c]	7.93[d]	8.13[c]	8.03[c]	7.08[f]	7.79
SIPI 692033 (FAR0 44)	7.19[d]	7.51[d]	7.55[e]	7.60[e]	7.60[d]	7.91[c]	7.56
TOX 4004-43-1-2-1	8.05[b]	8.31[b]	8.33[c]	7.98[d]	7.61[d]	7.52[d]	7.97
WAB 99-1-1	7.60[c]	7.65[c]	7.49[e]	7.42[e]	7.25[e]	7.19[e]	7.43
WAB 189-B-B-B-HB	9.57[a]	12.37[a]	12.69[a]	12.65[a]	10.25[a]	9.98[a]	11.25
WITA 1	6.51[e]	6.84[e]	6.86[g]	6.90[f]	6.82[f]	7.14[e]	6.85
WITA 12	8.10[b]	6.69[e]	7.31[f]	7.21[e]	7.03[e]	6.86[g]	7.20
Mean	7.92	7.92	8.01	7.97	7.68	7.60	

Values within a column followed by a common letter are not significantly different according to Duncan's multiple range test at P = 0.05.

Table 6:Influence of dry heat treatment on seedling dry weight of ten rice varieties.

Variety	Dry Heat / Temperature (⁰C)						Mean
	Control	40	45	50	55	60	
	Dry Weight (g)						
BW 348-1	1.64^{h}	1.65^{e}	1.65^{h}	1.68^{g}	1.68^{f}	3.52^{b}	1.97
CISADANE (FARO 51)	4.79^{a}	6.03^{a}	6.32^{a}	2.06^{f}	1.65^{f}	1.23^{j}	3.68
FARO 11 (056)	2.96^{d}	3.26^{c}	3.26^{e}	1.09^{i}	1.79^{d}	1.64^{i}	2.33
ITA 230 (FARO 50)	2.44^{e}	2.60^{d}	3.44^{d}	3.12^{c}	1.92^{d}	1.83^{h}	2.56
SIPI 692033 (FAR0 44)	1.48^{i}	2.57^{d}	2.60^{g}	2.69^{e}	3.50^{a}	2.38^{g}	2.54
TOX 4004-43-1-2-1	3.80^{b}	4.28^{b}	4.69^{b}	4.41^{a}	3.61^{a}	2.50^{f}	3.88
WAB 99-1-1	1.70^{g}	1.71^{f}	1.77^{f}	1.78^{g}	1.83^{d}	2.95^{d}	1.96
WAB 189-B-B-B-HB	3.67^{c}	4.18^{b}	4.57^{b}	3.93^{b}	3.28^{b}	3.27^{c}	3.82
WITA 1	0.74^{j}	0.96^{g}	1.00^{i}	2.88^{d}	1.91^{e}	2.81^{e}	1.72
WITA 12	2.12^{f}	3.11^{c}	3.69^{c}	2.99^{d}	2.85^{c}	3.82^{a}	3.10
Mean	2.53	3.04	3.30	2.66	2.40	2.60	

Values within a column followed by a common letter are not significantly different according to Duncan's multiple range test at P = 0.05.

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