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The Effect of the Use of Temperature on the Breakage of Dormancy and the Subsequent Performance of Rice (*Oryza* spp.)

Grace Denny Doku[1], Mawutor K. Glover[1, *], Edinam K. Glover[2], Kofi P. A. Dartey[3]

[1]Department of Agro Enterprise, Faculty of Applied Sciences, Ho Polytechnic, Ho, Ghana
[2]Faculty of Law, University of Helsinki, Helsinki, Finland
[3]Crops Research Institute, Council for Scientific and Industrial Research, Fumesua, Kumasi, Ghana

Abstract

The principal aim of this study was to find out if the temperature at which dormancy was broken would affect the subsequent performance of rice on the field in terms of plant stand (emergence), plant height and number of leaves produced. The varieties TOG6565 (VI), CG17 (V2), WAB 450-24-2-5-P4-HB (V3) and CG14 (V4) were exposed to temperatures of 50°C for 4 days and 80°C for 1, 2, 3 and 4 days, and temperature effects on their field performance studied in a randomized complete block design of three replicates (i.e. a two factor experiment). The result indicated that differences in plant height and number of leaves produced three weeks after seeding as well as plant stand were insignificant with respect to temperature. Thus the performance of the rice varieties with respect to the stated parameters when exposed to a temperature of 50°C for 4 days was not different from exposure to a temperature of 80°C for 4 days. However, significant differences existed at 5% level of probability among the varieties with respect to plant height and the number of leaves produced but not with respect to plant stand. This observation could be attributed to the unique characteristics of individual varieties, e.g., *O. glaberrima* are known to be more vigorous than their inter-specific progenies. Work by a colleague showed that dormancy in *O. glaberrima* varieties is best broken at 60°C for 2 days. Based on the results reported here, it is recommended that this temperature (60°C for 2 days) can be safely used to break dormancy as exposure to higher temperatures (up to 80°C for 4 days) do not result in reduced plant performance. The ability of rice seed to tolerate high temperatures and still remain viable has also been proven.

Keywords

Heat Treatment, Number of Leaves, Plant Height, Plant Stand, Rice (*Oryza* spp.), Seed Dormancy, Temperature

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1. Introduction

Rice (*Oryza sativa* L.), one of the most important food crops in the world is the major food for about 40% of the world's population. It is produced in about 110 countries, including to a varying degree, every West African country. The cultivated rice plant belongs to the tribe Oryzeae (sub-family Pooideae), in the grass family Gramineae (Poaceae) (Chang and Bardenas, 1965: 5; Dutta, 2000). The rice plant is a free-tillering annual grass with round, hallow, jointed culms, rather flat leaves, sessile leaf blade and a terminal panicle. Under favorable conditions, (Ikehashi, 1973; Dutta, 2000) the plant may grow for more than one year. Plants vary in size, depending on the growing conditions, from dwarf mutants only 0.3-0.4 m tall to floating varieties more than 7 m tall (Chang et al., 1972). However, the great majority of

* Corresponding author
E-mail address: mgloverk@yahoo.com (M. K. Glover)

commercial varieties range from 1-2 m in height (ibid.). Rice, as other taxa in the tribe Oryzeae, is adapted to growing in aquatic environments (Chang and Bardenas, 1965: 5). The main sub-divisions of *O. sativa* are japonica, indica and javanica. When classified based on cultivation system, rice could be described as being upland, lowland and deep water rice (Matsuo, 1955). The chromosome number of rice is n=12 (2n=24). Rice has many uses, which include: boiling the grains as a main dish, preparing rice flour, feeding livestock with husks, preparing drinks etc. (ibid.).

Rice is propagated by seed. One of the interesting and important problems encountered in seed physiology is the failure of a viable seed to germinate when supplied with water, and oxygen at temperatures recognized as favorable for germination (Doneen and MacGillivray, 1943; Harrignton and Minges 1954; Hegarty 1975; Mayer and Poljakoff-Mayber, 1975; USDA, 2008). This phenomenon is known as dormancy (Pollock and Toole, 1961). In plant physiology, the term dormancy broadly refers to lack of growth (Pollock and Olney, 1959) in any plant part, which results from internally or externally induced factors. On the other hand, seed technologists define dormancy in a narrower sense as the result of conditions within the seed (other than non-viability) that prevent germination. In this sense, a dormant seed is one that fails to germinate even though it has absorbed water and it is exposed to favourable temperature and oxygen levels (Hartman and Kester 1983, Hartman et al., 2001, USDA, 2008). Shepherd (1986) describes a seed to be dormant when it would not germinate when placed under conditions that are favourable for germination. He continues that such seeds can be induced to germinate freely if first subjected to one or other of a number of pre-sowing treatments. According to Kozlowski (1972) and Shepherd (1986), seed dormancy may be due to the following mechanisms:

a). A state of dormancy in the embryo itself – internal dormancy.

b). Low permeability of the seed coat to gases

c). Mechanical resistance to expansion of the embryo and seed contents by enclosing structure – seed coat dormancy.

d). Complete imbibition or water absorption.

e). Immaturity of embryo – morphological dormancy.

f). A combination of some of the above.

Rice exhibits seed dormancy, which must be broken, before the seed could germinate. Different types of seed dominancy are recognized according to their manner of origin (Misra and Misro, 1970). The interaction of morphology and physiology is the basis for the various types of seed dormancy. The two major types of dormancy are: primary and secondary dormancy. Primary dormancy (exogenous) includes conditions that exist within the seed to prevent germination when seed mature on the mother plant and immediately afterwards. Secondary dormancy refers to the dormancy that develops within the seed after it is removed from the mother plant and subjected to diverse conditions (endogenous) (Mayer and Poljakoff-Mayber, 1975; Miyashi and Sato, 1997; Hartman et al., 2001).

Over the years, various methods have been employed in breaking the dominancy in rice. Some of these methods are: scarification, temperature treatment, light treatment and treatment with growth regulators and other chemicals (Lona, 1956; Nagao, Kanegawa and Sakai, 1980; Cohn, 1996; Khan and Smith, 1957; Cohn, 1997). Ageing could be used. When dormancy is due to endogenous factors, seed is subjected to stratification (temperature treatment) i.e. incubation of seed at low temperatures (0-5°C) over a moist substratum for 3–10 days (to break dormancy) before placing it at optimum temperatures for germination. Prolonged stratification (2-6 months at 5-10°C) is required for a number of Rosaceae spp. to break the dormancy (Agrawal, 1987).

Day in day out, rice researchers all over the world are discovering different and varying ways by which dormancy of rice seed can be easily and effectively broken without it affecting the subsequent performance of the plant (Miyashi and Sato, 1997). Many experiments have been carried out and positive result recorded. Suran (1945) found that paddy rice stored for 7 years at 3.6% to 4% moisture gave 80% germination at the end of the period. Saran (1945), Adair (1966) and Grist (1986) also noted that viability of paddy might be retained for ten years when its moisture content is kept at a low level in airtight container at a temperature not exceeding 10°C. According to Grist (1986), soaking seeds before water-planting allow partial removal of the inhibiting substance but a 0.05% sodium hypochlorite solution of chlorine water is an effective treatment. Roberts (1960) and Roberts (1961) discuss the influence of temperature, moisture and gaseous environment and suggested that dormancy be broken by sun drying the seed to 11% moisture content or less and then placing it in a hollow container in an incubator at approximately 49°C 7 days of this treatment without a danger of loss of viability during treatment.

Since temperature treatment is one of the cheapest methods for breaking seed dormancy in rice, many potential rice grower may be tempted to adopt this practice but the question which arises is: What temperature should the seed be subjected to and for what duration of time in order to break the dormancy without causing harm to the subsequent performance of the rice plant in the field? The purpose of this study, therefore, is to determine the best temperature for breaking the seed dormancy of four varieties of rice in order to get best germination rate as well as the best viability. It is hoped that this information would help rice growers to get maximum yield for their labour.

2. Materials and Methods

2.1. Location and Area

The germination test experiment was carried out in a room on the campus of University of Education, Winneba -Mampong (UCEW-M), Ghana, while the test for viability was carried out on the experimental field; also on the campus of the same institution. It lies between latitude 07°, 04° N and longitude 01°, 24° W with mean annual rainfall and temperature of about 1 0944.2 mm ((Nyameasem and Borketey-La, 2014) and 26°C, respectively. The potential evapotranspiration (PET) is estimated at 1450mm per annum. The average humidity during the wet season is typically high (86%) and falls to about 57% in the dry period (MSA, 2006). Geographically, Mampong is in the transitional zone and is about 60 km north of Kumasi; the Ashanti Regional Capital (Mampong Municipal Assembly, 2015). The potential evapotranspiration (PET) of the area is estimated at 1450 mm per annum. The average humidity during the wet season is typically high (86%) and falls to about 57% in the dry period (MSA, 2006).

2.2. Germination Test

Twelve varieties of rice were used in the germination test. These varieties are presented in tabular form (Table 1) as follows:

Table 1. Entry numbers of varieties of rice, their designation and category.

ENTRY NUMBER	DESIGNATION	CATEGORY*
1	TOG 6545	OG
2	CG 17	OG
3	WAB 450-24-2-5-P4-HB	OG × OS
4	CG 14	OG
5	WAB 450-IBP-133-HB	OG × OS
6	TOX 3108-56-4-2-2-2	OS – INDICA
7	SALUMPIKIT	OS – INDICA
8	WAB 56-50	OS - JAPONICA
9	KLEMINSIN	OS - JAPONICA
10	WAB 450-24-3-2-P18-HB	OG ×OS
11	WAB 450-IBP-26-1-1	OG× OS
12	WAB 450-IBP-26-HB	OG × OS

*OG = *Oryza glaberrina*; OS = *Oryza sativa;* OG × OS = Inter- specific hybrids.

Each of the twelve varieties of rice used in the test was taken through a heating process at temperatures of 40, 50, 60, 70, 80, 90 and 100°C in order to break dormancy in the seed. Samples of the seeds were removed from the oven after periods of 24, 48, 72 and 96 hours. Control seeds were not treated. The various seed samples were then germinated on wet paper tissues and the number of seeds that germinated was recorded from the 4th to the 7th day. The various temperatures at which seed dormancy was broken represent the various treatments in the experiment. Each treatment contained 50 seeds.

2.3. Experimental Design Treatments for Viability Test

The experiment for the viability test lasted a period of 3weeks. It was two factor (variety and temperature exposure) experiment in the Randomized Complete Block Design (RCBD). The temperatures considered and used in this experiment were: 80°C for 4 days, 80°C for 3 days, 80°C for 2 days, 80°C for a day and 50°C for 4 days. If plant performance at 80°C were poorer than at 50°C, exposure to 70°C would have been the next to be considered. The variety of rice used were varieties 1, 2, 4, and 10 (designations).

Table 2. Treatment and their descriptions.

TREATMENT	IDENTITY
1	V1 50 deg. 4 days
2	V2 50 deg. 4 days
3	V4 50 deg. 4 days
4	V10 50 deg. 4days
5	V1 80 deg 1day
6	V2 80 deg 1day
7	V4 80 deg 1day
8	V10 80 deg. 1day
9	V1 80 deg.2 days
10	V2 80 deg. 2 days
11	V4 80 deg. 2 days
12	V10 80 deg. 2days
13	V1 80 deg. 3days
14	V2 80 deg. 3days
15	V4 80 deg .3days
16	V10 80 deg. 3days
17	V1 80 deg. 4 days
18	V2 80 deg. 4 days
19	V4 80 deg. 4 days
20	V10 80 deg. 4days

The samples of the 4 varieties of rice were pre-germinated on moist tissue paper as was done in the germination test. The number of seeds in each sample that germinated on the 6th day was counted and recorded. A plot of land on the school's experimental field was cleared with hoes and cutlasses and 3 beds of equal dimension (2m × 1.8m) were prepared on the weeded plot (Fig. 1). The beds were heavily watered using watering cans, making them moist before planting out of the pre- germinated seedlings was done. Each seed sample contained 150 seeds, which was divided into three and replicated on the beds. The treatments were randomized on the beds to prevent biases with the help of an electronic calculator.

Each bed was divided into 2 equal parts and the 20 treatment (each containing 50 seeds) were drilled on the bed (ten drills on each half of the bed) as indicated in Fig. 1. The seeds were drilled at the same depth in the soil (a depth of about 2cm). The field was visited frequently and the beds were watered. The rate of emergence of the rice seed was noted and records kept for the various treatments as follows:

a) Days of 50% emergence of seedlings after drilling.

b) Days of 100% emergence of seedlings after drilling.

After 3 weeks of planting, the following parameters were taken:

a) The number of seedlings that emerged in each drill.

b) The average height of seedlings in each drill.

c) The average number of leaves in each drill.

In determining the number of seedlings that emerged, a – head-counted of seedlings was done. The height of a sample of seedlings in each drill was measured using a rule and the average was calculated. A sample of seedling in each drill was selected and their leaves counted. The average was calculated.

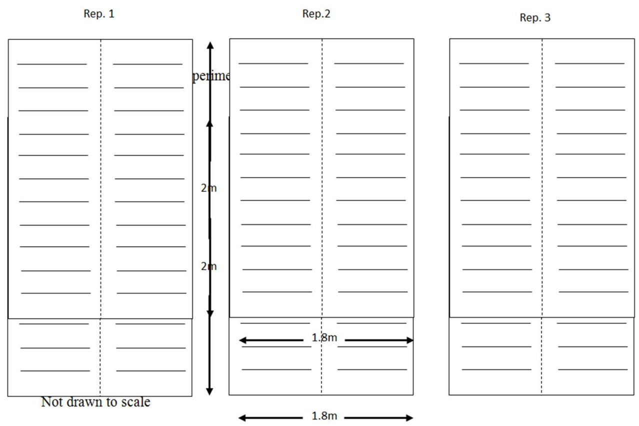

Fig. 1. Field layout of experimental plot.

2.4. Data Analysis

The data taken for all the measurements made were subjected to the Analysis of variance (ANOVA) when appropriate to determine whether there were any significant differences between treatments with respect to the parameters determined.

Determination of Parameters

The effect of temperature on the subsequent performance of rice in terms of:

a) Emergent percentage (plant stand) after 3 weeks.

b) Number of leaves of plants 3 weeks after planting.

c) Plant height 3 weeks after planting.

3. Results and Observations

3.1. Germination Test

Results obtained in the germination test showed that exposure of rice seeds to a temperature of 80oC for 4 days did not render them inviable any more than at 80°C for I day. The fact is established from the results that germination percentage at 50°C for 4 days is the same as 80°C for 4 days. Dormancy in the O. glaberrima varieties is best broken at 60°C for 2 days according to the results of the test. It also indicated that a temperature of 80°C for 4 days can be safely used to break dormancy in rice as exposure to a higher temperature (80°C for 4 days) do not result in reduced germination percentage and plant performance. The ability of rice seeds to tolerate high temperatures and still remain viable has been proven.

3.2. Emergence Percentage (Plant Stand)

The emergence percentage for the various treatment 3 weeks after planting indicated that there were variations among the treatments (Table 3). It was observed that treatments 2, 19 and 20 recorded the highest emergence of 17 seedlings while treatment 14 recorded the least at 11 seedlings. Statistical analysis, however, showed no significant different at 5% level of probability among the temperatures and variations at 1% (Table 4).

Treatment total is a sum of three readings recorded from the blocks of plots. It was observed that treatments 2, 19 and 20 recorded the highest emergence of 17 seedlings whiles treatment 14 recorded the least at 11 seedlings (Table 3). The data collected showed variations in the percentage of emergence of the seeds on the 3 different blocks of plots (Table 3).

Table 3. Emergence percentage of seedlings taken 3 weeks after planting.

Plant stand (cm)									
Treatment	**Designation**	**B1**	**B2**	**B3**	**Total**	**Av**		**Total**	**Av**
1	V1 50deg. 4days	12	14	13	39	13	V1	209	14
2	V2 50deg. 4days	19	15	16	50	17	V2	221	15
3	V4 50deg. 4days	18	15	11	44	15	V4	228	15
4	v10 50deg.4days	16	13	15	43	14	V10	220	15
5	V1 80deg.1day	17	15	15	47	16			
6	V2 80deg.1day	19	12	17	48	16	50deg.4 days	176	15
7	V4 80deg.1day	14	14	12	40	13	80deg. 1day	178	15

Plant stand (cm)									
Treatment	Designation	B1	B2	B3	Total	Av		Total	Av
8	V10 80deg.1day	13	16	14	43	14	80deg. 2days	173	14
9	V1 80deg.2days	17	16	9	42	14	80deg. 3days	161	13
10	V2 80deg.2days	13	9	21	43	14	80deg. 4days	190	16
11	V4 80deg.2days	17	16	15	47	16			
12	V10 80deg.2days	18	8	14	40	13			
13	V1 80deg.3days	16	12	14	41	14			
14	V2 80deg.3days	13	19	0	32	11			
15	V4 80deg.3days	16	15	14	45	15			
16	V10 80deg.3days	16	17	9	45	14			
17	V1 80deg.4days	17	12	11	40	13			
18	V2 80deg.4days	16	16	14	47	16			
19	V4 80deg.4days	18	17	17	52	17			
20	V10 80deg.4days	15	15	21	51	17			
	Total	318.85	285.02	273.97	877.83	292.61			
CF	12843.18935								

- B1 = Block 1, B2 = Block 2, B3 = Block 3, Av = Average, CF = Common factor analysis

Table 4. Analysis of variance for mean plant stand 3 weeks after planting.

SV	df	SS	MS	F cal	F tab	
TOTAL	59	665.22			5%	1%
VARIETY	3	12.44	4.15	0.32	2.84	4.31
TEMPERATURE	4	36.17	9.04	0.69	2.61	3.83
VAR. x TEMP.	12	93.27	7.77	0.59	2.00	2.66
TREATMENTS	19	141.88	7.47	0.57	1.84	2.37
ERROR	40	523.35	13.08			

Coefficient of Variation (CV) = 1.2%; No significant difference.

It was observed that treatment 19 (V4 80°C 4 days) recorded the highest number of leaves (average) at 8 leaves per plant whilst treatments 1, 5, 8, 16 and 20 recorded the least at 4 leaves per plant (Table 5).However statistical analysis shows that there were significant differences in the number of leaves and plant height among varieties at 5% level of probability (Table 6 and Table 8). The results show that varieties 2 and 4 had the highest mean value of leaves at 6 followed by variety 1 (Table 5).

Table 5. Mean number of leaves per plant 3 weeks after planting.

Number of leaves									
Treatment	designation	B1	B2	B3	Total	Av		Total	Av
1	V1 50deg. 4days	4	4	5	13	4	V1	73	5*
2	V2 50deg. 4days	7	7	5	18	6	V2	83	6*
3	V4 50deg. 4days	7	7	6	19	6	V4	97	6*
4	v10 50deg.4days	4	4	8	16	5	V10	64	4*
5	V1 80deg.1day	5	5	3	13	4			
6	V2 80deg.1day	5	5	7	17	6	50deg. 4days	66	6*
7	V4 80deg.1day	4	4	6	14	5	80deg. 1day	55	5*
8	V10 80deg.1day	4	4	4	11	4	80deg. 2days	66	5*
9	V1 80deg.2days	5	5	6	15	5	80deg. 3days	66	5*
10	V2 80deg.2days	5	5	6	16	5	80deg. 4days	64	5*
11	V4 80deg.2days	6	6	10	22	7			
12	V10 80deg.2days	4	4	6	14	5			
13	V1 80deg.3days	5	5	9	19	6			
14	V2 80deg.3days	5	5	7	16	5			
15	V4 80deg.3days	7	7	6	19	6			
16	V10 80deg.3days	4	4	5	12	4			
17	V1 80deg.4days	5	5	5	15	5			
18	V2 80deg.4days	5	5	6	16	5			
19	V4 80deg.4days	7	7	9	23	8*			
20	V10 80deg.4days	4	4	4	11	4*			
Total		99	99	119.4	146.4	105.8			
CF	1679.046								

Table 6 shows that, all varieties were significantly different from each other when the result of the number of leaves was further subjected to the least significant difference (LSD).

Table 6. Analysis of variance for mean number of leaves of plants 3 weeks after planting.

SV	df	SS	MS	F cal	F tab	
TOTAL	59	116.474			5%	1%
VARIETY	3	40.30	13.43	11.51**	2.84	4.31
TEMPERATURE	4	7.11	1.78	1.52	2.61	3.83
VAR. x TEMP.	12	22.11	1.87	1.60	2.00	2.66
TREATMENTS	19	69. 40	3.67	3.15	1.84	2.37
ERROR	40	46.67	1.17			

Coefficient of Variation (CV) = 1.0%; Least significant difference (LSD) (0.05) = O.65; LSD (O.O1) = O.94.

3.3. Plant Height

The heights of plants were recorded 3 weeks after planting. Table 7 shows the height of plants recorded on the three blocks for all the 20 treatments. It was observed that treatment 15 (V4 80oc for 4 days) recorded the highest plant height at 24cm while treatment 13 (V1 80°C for 3 days) recorded the least plant height at 6cm. The statistical analysis showed no significant difference in the height of plants among the temperatures at 1% level of probability. However, there was significant difference among varieties at both 5% and 1% levels of probability (Table 8). This shows that temperature of exposure did not significantly affect plant height 3 weeks after planting but varietal differences did. It was observed that treatment 15 (v4 80°C 3 days) recorded the highest mean value in terms of plant height (24 cm) whilst treatment 13 recorded lowest mean value of 6 cm (Table 7).

Table 7. Mean planting height 3 weeks after planting.

Plant Height									
Trt*	**Designation**	**B1**	**B2**	**B3**	**Total**	**Av**		**Total**	**Av**
1	V1 50°C 4 days	13	12	2	27	9	V1	148	10
2	V2 50°C 4 days	21	2	15	38	13	V2	180	12
3	V4 50°4 days	40	23	3	66	22	V4	305	20
4	V10 50°C 4 days	6	29	5	40	13	V10	126	8
5	V1 80°C 1 day	21	1	17	39	13			
6	V2 80°C 1 day	23	6	12	41	14	50°C 4 days	171	14
7	V4 80°C 1 day	21	15	17	53	18	80°C 1 day	157	13
8	V10 80°C 1day	10	6	8	24	8	80°C 2 days	142	12
9	V1 80°C 2 days	14	13	6	33	11	80°C 3 days	149	12
10	V2 80°C 2 days	10	9	9	28	9	80°C 4 days	140	12
11	V4 80°C 2 days	24	17	22	63	21			
12	V10 80°C 2 days	7	13	8	28	9			
13	V1 80°C 3 days	6	2	11	19	6			
14	V2 80°C 3 days	18	15	0	33	11			
15	V4 80°C 3 days	21	25	27	73	24			
16	V10 80°C 3 days	13	2	9	24	8			
17	V1 80°C 4 days	16	9	4	29	10			
18	V2 80°C 4 days	16	10	14	40	13			
19	V4 80°C 4 days	16	15	18	49	17			
20	V10 80deg.4days	8	7	5	20	7			
	Total	326	221	212	759	253			
CF	9601.35								

*Trt = Treatment; All values are in centimeters (cm).

Table 8. Analysis for variance for mean plant height 3 weeks after planting.

SV	df	SS	MS	F cal	F tab	
TOTAL	59	3827.65			5%	1%
VARIETY	3	1278.98	426.33	7.69	2.84	4.31
TEMPERATURE	4	53.23	13.31	0.24	2.61	3.83
VAR. x TEMP.	12	278.77	23.23	0.42	2.00	2.66
TREATMENTS	19	1610.98	84.79	1.51	1.84	2.37
ERROR	40	2216.67	55.42			

Coefficient of Variation (CV) = 2.9 Least significant difference (LSD) (0.05) = 4.6; LSD (O.O1) = 6.6.

4. Discussion

The study work was undertaken with a clearly stated objective in mind: To find out whether the use of temperature in the breakage of dormancy in rice would have an effect on the germination and subsequent performance of the rice in the field. Varietal differences in rice were also considered. This aspect of the project discusses the effect of temperature (Ikehashi, 1973; Hegarty, 1975) and varietal differences on the subsequent performance of rice in terms of: Number of leaves produced by the plant; Height of the plant and the stand (emergence). The effects of 2 factors (temperature and variety) were studied in the experiment. The statistical analysis involved partitioned the treatment effect into:

a) Main effects (temperature and variety).

b) Interaction effect.

Least significant differences (LSD's) were calculated and used to separate mean value. Main effects were considered only when interaction effects were insignificant. The level of significance was calculated at 0.05(95%). The three basic requirements for the germination and emergence of seeds which include: Viability, non-dormant seeds and the required climatic conditions necessary for germination (Doneen and MacGillivray, 1943; Roberts, 1972; Janick et al., 1981; Hartmann and Keste, r 1983) were met.

Results obtained after the experiment, as indicated in this study show that differences in plant height with respect to temperature were insignificant. This shows that exposure of seed for 4 days at 80°C did not render them unviable any more than at 80°C for 4 days, then break dormancy at 80°C for 1 day to save time and labour. The fact is established from the results that germination percentage at 50°C for 4 days is the same as at 80°C for 4 days. In order to save and conserve electricity or fuel, it is advisable; to break dormancy at 50°C since the same results would be obtained. Umali et al. (1960) noted that dormancy in rice is broken by smoking the seeds at 120 °F (38°C) for 84 hours. The results of this experiment have shown that even at higher temperature (80°C) dormancy could be broken without any significant effect on the subsequent performance of the rice on the field. Shephered (1986) and Wan et al. (1997) noted that a seed is dormant when it will not germinate under favourable conditions. Shephered (1986) continued that germination could be induced by pre-sowing treatment. This experiment has showed that pre-sowing treatment by temperature is very effective since all the varieties of rice germinated well after the heat treatment.

Roberts' (1961) finding that at a temperature of approximately 49°C for 7 days all seeds will have their dormancy broken without danger of loss of viability of seeds has been proved incorrect. Results obtained in the germination test show that the *Oryza glaberrima* (V1, V2 and V4) (Table 1) did not germinate well at 40 nor at 50°C. This shows that the *O. glaberrima's* high dormancy was effectively broken at 60°C and 70°C.

The results also show that West African Rice Development Association (WARDA)'s (1993) choice of 40°C for 3 days is inadequate to break dormancy of the *Oryza glaberrima* varieties. Maybe the variety used by WARDA had been stored for some time in which case natural breakage of dormancy might have begun. The results have shown that the different temperatures of exposure had no significant effect on the plant stand. However, significant differences were observed in the number of leaves and plant height among varieties at 5% level of probability in the statistical analysis (Table 6 and Table 8). The results indicate that varieties 2 and 4 had the highest mean value of leaves at 6 followed by variety 1. All these three varieties are glaberrimas. This confirms WARDA statement that the *Oryza glaberrima*s are vigorous growing. Variety 10 recorded the least value at 4. It is inter- specific hybrid.

When the result of the number of leaves was further subjected to the least significant difference (LSD) it was found that all varieties were significantly different from each other (Table 6). When the result on plant height was subjected to the least significant difference (LSD) it was noted that varieties 1 and 2 were not significantly different from each other. However, varieties 1 and 2 were significantly different from varieties 4 and 10. The differences among the varieties are as a result of the individual characteristics of the varieties. In the case of the plant stand, there was no significant difference among the varieties. They all performed well. Variety 4 recorded the highest whilst 10 recorded the least value.

5. Conclusions and Recommendation

The objective for the study was to find out if the use of temperature for breaking of dormancy in rice and varietal differences in rice would have effect on the germination and subsequent performance of the rice on the field in terms of plant stand (emergence), number of leaves produced by plants and plant height. The temperatures of exposure used in the test were: 50°C for 4 days, 80°C for 1, 2, 3 and 4 days. Four varieties of rice used were: VI (TOG 6545), V2 (CG17), V4 (CG 14) and V10 (WAB 450-24-3-3-p18-HB): Varieties 1, 2 and 4 are *Oryza glaberrima*s whiles variety 10 is an inter–specific hybrid. The measurement of all the parameters (plant height, number of leaves and plant stand) were done after 3 weeks of planting.

The results obtained indicated that there were no significant differences in plant height, plant stand and number of leaves produced by plants among temperatures. The significant differences recorded in plant height and number of leaves among varieties came as a result of unique characteristics of individual varieties. Results obtained in the germination test show that the *Oryza glabberima*s are highly dormant and the best temperature treatment for breaking their dormancy is 60°C (for better germination results).

It is recommended that rice farmers wishing to use heat treatment as a pre–sowing treatment for breaking dormancy in rice break the dormancy at 50°C to save electricity and other heat energy sources. However, if it is *Oryza glaberrrima*, then the best temperature is 60°C. It is also recommended that any work done on the germination and subsequent performance of rice be done during the rainy season to save the tedious job of watering plants. More work (experiments) should be done on the performance of rice in the field so that more comparisons could be done among different treatments. It is finally recommended that heat treatment be used to break dormancy in rice since it is effective and cheaper than the other means apart from the aging treatment. The *Oryza gleberrima* varieties are fast growing and could be recommended for farmers.

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