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Effects of Different Seed Treatment Methods on the Percent Germination, Seedling Vigor and Biomass Production of Groundnuts in Ghana

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Abstract: Low plant stand due to poor seed germination accounts for over 70% of the low production and productivity of crops in Ghana. This led to the conduction of an experiment to ascertain the effects of hot water, diathane M45 (D) and maceration (M) treatments on the viability, vigor and biomass production of three groundnut varieties, Chinese, Manipintar and F-mix. Maceration and D produced significantly higher rate of germination in Chinese and Manipintar than their controls. The three main treatments had no significant effect on the speed of germination of F-mix seeds. Hot water at 50°C level (H50°C), M_1 and D_1 treatments gave significantly higher germination percentage values for Chinese and Manipintar but not for F-mix. M_1 and D_1 treatments gave mean vigor indices significantly higher than their controls for Chinese, Manipintar and F-mix. However, it was only in Chinese where 50°C hot water treatment produced significantly higher vigor index than the 60°C level. H50°C, M_1 and D_1 yielded significantly higher biomass than the other treatment levels in Chinese. However, D_1 and M_1 produced biomass significantly higher than their controls in Manipintar and F-mix, respectively. Chinese seeds treated with various levels of hot water and D_1 gave biomass yields significantly higher than seeds treated with hot water without diathane. Speed of germination, seedling vigor, germination percent and biomass production were about two or more times better and significantly higher in Chinese and Manipintar than F-mix, irrespective of the treatment levels. Maceration emerged as the best single treatment and could be adopted by farmers to increase germination percentage and plant stand at farm level since it is readily available to farmers and cheap.

Key words: Groundnuts, seed treatment, percent germination, seedling vigor, biomass production

INTRODUCTION

Groundnut, *Arachis hypogaea,* is the most important food legume in Ghana in terms of consumption and area under cultivation. It serves not only as an important and cheap source of protein in the diets of many Ghanaians but it is also a critical component in our cropping systems. This is because of the substantial quantities of nitrogen the crop fixes for succeeding cereal crops[1]. Long-term studies in northern Ghana have shown groundnuts to be the best proceeding crop for cereals in the cereal-legumes rotation systems.

Protein makes up 12.0–36.4% of the groundnut kernel[2] and 50% oil[17]. Seventy to eighty percent of Ghana's groundnut is produced in the northern part of Ghana[17] partly due to the congenial conditions for the harvesting and drying of the crop in addition to the shift by farmers towards planting of legumes which require minimal external inputs such as fertilizers compared with the cereals.

Despite its importance as evident by the tremendous expansion of area under cultivation of late, unavailability or inaccessibility to improved varieties of the crop is often cited among others, by farmers as a major constraint towards attaining the maximum potential yields of the crop in Ghana. Most farmers acquire planting materials from their own grain stock, purchase from other farmers or from the open market.

Seeds as they come from the production field may be carrying various types of microorganisms; most especially fungi, which affect stored seeds since they are able to grow under relatively, dry conditions. Storage fungi can invade and destroy seeds of peanuts. Their invasion can result in embryo destruction and loss of viability, an increase in free fatty acids, a decrease in non-reducing sugars, development of musty odors and discoloration. The seed coat of some groundnuts may prevent germination by preventing water uptake or gas exchange, mechanically restraining the growth of the embryo, chemically inhibiting germination or acting as a barrier to

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photoreception[3]. In some cases, even when the restrictions caused by the covering structures are removed, germination may fail due to embryo dormancy attributable to deficiencies or blocks within the embryo or cotyledons[4]. Seed dormancy, a natural phenomenon affecting several aspects of practical peanut culture can be beneficial when it prevents mature seeds from sprouting before harvest[5], however, it becomes detrimental when dormancy reduces stand or raises required seeding rates and, therefore production costs.

Unless seeds are properly treated to counteract the evading fungi or other microorganisms and barriers caused by dormancy associated with groundnut seeds, the chances of seedling establishment from poor quality seed will be significantly reduced.

This study was carried out to determine the effects of some seed treatments on the viability and vigor of three varieties of groundnuts.

MATERIALS AND METHODS

The experiment was carried out in the year 2002 using 3 genotypes (F-mix, Manipintar and Chinese) collected from the Savanna Agricultural Research Institute (SARI). Soil belonging to the Savanna Ochrosols of Tolon Series (FAO) classification was steam sterilized at 121°C and 15 bars for 1 h intermittently for 3 h (to ensure complete sterilization) and used for the studies. Fifty seeds of each variety with uniform moisture content of 0.35% were treated to different treatment combinations; Dithane M-45 (2 g a.i kg^{-1} seeds), maceration (1 kg Chinese pods soaked in 2 L of water overnight, the product solution used to imbibe experimental seeds for 1 h, air dry before sowing), heat (50 and 60°C) and a control each for Diathane M-45 and maceration. These were sown in plastic containers of 26 cm (top diameter) X 12 cm (height) X 18 cm (base diameter) dimension filled up to the 10 cm mark of the height.

A randomized block design with the treatments in split arrangements was used. There were eight replications (every week planting serves as a replicate thus time was used as a blocking factor) with varieties as main plots, diathane, maceration and heat as subplots and different levels of those as sub-sub plots.

Weeds were controlled by hand picking when necessary. The number of seedlings that emerged 10 days after sowing was recorded to determine germination percentage. Vigor index test[6], dry weight of seedlings and speed of germination[16] were determined.

Data collected were subjected to analysis of variance (ANOVA) and means separated using Fischer protected LSD ($P \leq 0.05$) when significant differences were observed.

RESULTS

Manipintar treated with hot water at 50 and 60°C recorded the highest speed of germination, followed by Chinese variety although the difference was not significant (Table 1). F-mix recorded significantly ($p=0.05$) lower speed of germination for both levels of heat treatments. Seeds treated at 50°C did marginally better than those treated at 60°C.

Chinese and Manipintar seeds treated with dithane (D_1) and maceration (M_1) gave significantly higher speed of germination than controls (D_O and M_O) applied where as no significant difference was observed for the same treatments to F-mix. Chinese variety had significantly ($p=0.05$) higher speed (Table 1) when treated with macerated hull solution (M_1) than without and dithane (D_1) with F-mix recorded lower speed of germination. Macerated seeds (M_1) gave the best yield across varieties followed closely by dithane (D_1) treated seeds (Table 1).

Pre-experiment germination test of the seeds on sterilized soil gave 80, 75 and 56% germination percentage for Chinese, Manipintar and F-mix, respectively. This trend was not surprising since they behave similarly in the field.

Table 1: Effects of seed treatment on the speed of germination of groundnut seeds

	Variety*				
Treatment	Chinese	Manipintar	F-mix	Mean	LSD
Heat at 50°C (H_1)	12.8	12.9	5.4	10.4	
Heat at 60°C (H_2)	12.2	12.9	5.1	10.1	
Mean	12.5	12.9	5.3		0.8
Maceration (M_1)	15.1	13.6	6.1	11.6	
No Maceration (M_O)	12.4	12.4	5.5	10.1	
Mean	13.8	13.0	5.8		0.8
Dithane (D_1) 14.9	13.5	5.6	11.3		
No Dithane (D_O)	12.5	12.2	5.3	10.0	
Mean	13.7	12.9	5.5		0.8
LSD (0.05)	1.3	1.3	1.3		
CV (%)	23.9	24.6	57.8		

*The higher the value, the higher the speed of germination

Table 2: Effects of seed treatment on the germination percentage of groundnut seeds

	Variety				
Treatment	Chinese	Manipintar	F-mix	Mean	LSD
Heat at 50°C (H_1)	93.2	79.8	53.8	75.6	3.0
Heat at 60°C (H_2)	74.2	77.6	56.6	69.5	
Mean	83.7	78.7	55.2		3.0
Maceration (M_1)	91.2	84.2	60.1	78.5	
No Maceration (M_O)	76.7	75.8	56.7	69.7	3.0
Mean	83.9	80.0	58.4		
Dithane (D_1)	90.3	81.1	55.9	75.8	
No Dithane (D_O)	77.6	78.9	54.6	70.4	
Mean	83.9	80.0	55.3		
LSD (0.05)	5.3	5.3	5.3		
CV (%)	23.1	25.1	47.3		

Chinese seeds gave the highest percentage of germination when treated with hot water at 50°C while F-mix seeds gave the lowest value (Table 2).

Seeds of Manipintar treated with hot water at 60°C gave the highest germination percentage of 77.6% with F-mix seeds recording the lowest percentage of 56.6%. Chinese seeds treated at 50°C gave germination percentage significantly higher than 60°C where as no significant differences were observed for the same level of heat treatment to Manipinter and F-mix. Seeds of all the three varieties treated with macerated solution (M_1) gave the higher percentage germination than control (M_O). Chinese seeds gave the highest percentage of (91.2%), with F-mix giving the lowest percentage of (60.1%). Chinese seeds gave the highest percentage for dithane treated seeds whilst F-mix seeds presented the lowest percentage. Control (D_O) recorded the lowest percentages of germination as compared with the diathane treated seeds. The germination percentage obtained from Chinese seeds, which were treated with dithane and macerated solution, were significantly higher than the control. However, the difference was not statistically significant for F-mix for the same treatments. Manipintar seeds treated with macerated solution were significantly higher than control whereas no significant difference was observed between dithane treated Manipintar seeds and control. Seeds treated with macerated solution gave the highest germination percentage across varieties followed by diathane treated seeds.

Chinese seeds treated at 50°C gave significantly higher vigor index than at 60°C whereas no significant differences were observed for the same level of heat treatment to Manipintar and F-mix (Table 3). Seeds treated with hot water at 50°C gave a better vigor index values across the varieties than at 60°C.

Seeds of the varieties treated with M_1 recorded higher vigor index than the control M_O with Chinese recording the highest vigor index and F-mix, the lowest. Dithane treated seeds of the varieties recorded higher vigor index (Chinese gave the highest mean vigor and F-mix, the lowest) than the control, D_O. Significant differences occurred between D_1 and M_1 treatments levels for Chinese and Manipintar but not for F-mix. Chinese variety had the highest vigor indices for all the treatments whereas F-mix had the lowest for all the treatments.

Dithane-treated seeds gave the best vigor index across varieties followed closely by seeds treated with macerated hull solution.

Results on dry weight of biomass are shown in Table 4. Manipintar seeds treated with hot water at 50 and 60°C gave higher dry weight of biomass (12.3 and 12.9 g, respectively) with F-mix seeds recording the lowest values in both cases.

Table 3: Effects of seed treatment on vigour index

	Variety				
Treatment	Chinese	Manipintar	F-mix	Mean	LSD
Heat at 50°C (H_1)	14.8	11.5	5.0	10.4	0.7
Heat at 60°C (H_2)	11.6	12.1	5.9	9.9	
Mean	13.2	11.8	5.5		0.7
Maceration (M_1)	14.0	12.6	5.9	10.8	
No Maceration (M_O)	12.1	10.9	5.0	9.3	0.7
Mean	13.1	11.8	5.5		
Dithane (D_1)	14.5	12.8	5.5	10.9	
No Dithane (D_O)	11.9	10.8	5.4	9.4	
Mean	13.2	11.8	5.5		
LSD (0.05)	1.2	1.2	1.2		
CV (%)	22.1	24.6	54.1		

Table 4: Effect of seed treatment on dry weight of biomass (g)

	VARIETY				
Treatment	Chinese	Manipintar	F-mix	Mean	LSD
Heat at 50°C (H_1)	11.3	12.3	3.9	9.2	0.6
Heat at 60°C (H_2)	8.9	12.9	3.3	8.4	
Mean	10.1	12.6	3.6		0.6
Maceration (M_1)	10.7	13.1	4.7	9.5	
No Maceration (M_0)	7.1	12.3	2.7	7.4	0.6
Mean	8.9	12.7	3.7		
Dithane (D_1)	11.5	13.5	3.9	9.6	
No Dithane (D_0)	8.8	11.9	3.3	8.0	
Mean	10.2	12.7	3.6		
LSD (0.05)	1.0	1.0	1.0		
CV (%)	24.7	19.0	66.6		
D_1 & H_1 interaction	12.31	-	-	-	1.6
D_1 & H_2 interaction	10.55	-	-	-	1.6
D_0 & H_1 interaction	10.2	-	-	-	1.6
D_0 & H_2 interaction	7.44	-	-	-	1.6

Table 5: Interaction effects of heat treatment and Chinese variety on the various parameters (i.e. Vigor index, dry weight of biomass, speed and percentage of germination)

Variety	Heat	Vigor index	Biomass dry weight	Speed of germination	Percentage of germination
Chinese	50°C	14.8	11.3	15.3	63.3
	60°C	11.6	8.9	12.2	47.5
LSD = 0.05		2.5	1.8	2.7	10.7

M_1 and D_1 treated seeds of Manipintar gave the highest dry weight of biomass (13.1 and 13.5 g, respectively) and F-mix gave the lowest values (4.7 and 3.9 g, respectively). Seeds of the three varieties treated with Dithane and Maceration gave the highest values of dry weight across varieties than control treatments. Manipintar seeds gave the highest dry weight of biomass at each level of treatment. Significant difference (p= 0.05) existed among various treatment levels for Chinese variety but not for Manipintar and F-mix except between M_1 and M_O for F-mix and between D_1 and D_O for Manipintar.

DISCUSSION

The research was carried out to ascertain the effect of dithane, maceration and hot water treatment on the viability and vigor of three groundnut varieties; Chinese, Manipintar and F-mix. Considering the mean speed of germination in Table 1, there was no significant difference between heat treatments levels. The lowest mean speed of germination obtained when Chinese and F-mix seeds were treated with hot water at 60°C as compared to 50°C might have been due to damage to seed embryo by the higher temperature.

The number of macerated seeds emerged from the three varieties gave the highest speed of germination than untreated seeds (M_0). This corroborated the findings that soaking seeds followed by re-dehydration, when not too extreme (as may be the case in this study), has shown improved speed of germination[7]. Also, according to Marfo[8] wetting groundnut seeds with a solution made from maceration of Chinese groundnut, which is no-dormant, can accelerate germination. It could also be theorized that macerated solution contained ethylene, which contributed to inducing more seeds to germinate, as was observed by Toole *et al*.[4]. The macerated solution may contain hormones such as gibberellic acid, which promotes germination of peanut seeds by competing with an inhibitor of germination as was reported by Sanders *et al*.[5]. This role is very useful since according to Ketring[9] mature seed of dormant peanut genotypes had relatively high absciscic acid-like inhibitor content, high phenolic content which were predominantly inhibitory in nature, high coumarin content, low cytokinin content, low gibberellin content and low ethylene-producing capacity. The results also showed that the number of dithane-treated seeds emerged had higher speed of germination compared with control. This might probably due to the ability of diathane to suppress/eliminate the growth of fungi and other pathogens on the seed coat.

In Table 2, Chinese and Manipintar seeds treated at 50°C gave significantly higher percent germination than at 60°C. This might have been due to damage to seed embryo by the higher temperature. F-mix seeds treated at 60°C rather gave higher percentage of germination (26.6%) than at 50°C (23.8%) but the difference was not significant. The reason for these results might also be that, the seed dormancy factor of F-mix required much heat to enhance germination. According to Phipps[10] germination percentage of *Centrosema pubescens* was increased by immersion in boiling water for one second. In fact, treatment at 50°C, (hot water) exhibits superior starting material and improved seedling establishment. These results are in agreement with those of Daniels[11] who observed that reducing seed infection by hot water treatment significantly reduced the levels of subsequent seedling infection and improved seedling establishment.

Macerated seeds recorded higher germination percentage than untreated control. This was presumably due to the soaking of the seeds upto 1 h before seeding and germination process might have started before sowing thus overcoming the high soil temperatures during the initial seed germination, which could have resulted into seeds rotting. IITA[12] reported that, in tropical regions, soil temperatures at planting during the first rainy season have been known to reach between 35 and 45°C but Mayeux[13] reported that the optimum temperatures for growing groundnuts range from 25 to 35°C.

Dithane treated seeds had higher percent germination than untreated control. This might be that, the chemical dithane as a fungicide reduced seeds infestation, which resulted in inducing seed germination. Copeland and McDonald[14] confirmed that, applying chemical substance to seeds in order to reduce, control or repel seed borne, soil borne or airborne organisms to enhance viability and vigor does seed treatment. However, it can be concluded from the present experiment that the various treatment levels have significant effect on seedling germination for all the varieties except between the heat levels, which did not have any significant effect on seedling germination for F-mix since the difference was statistically not significant.

Generally vigor index for all treatments performed better than untreated control except heat treatment levels. Seeds of Manipintar and F-mix treated at 60°C had a slightly higher vigor index than at 50°C. Maceration and the chemical dithane-treated seeds had higher means of vigor index than untreated controls for the three varieties. This might also be due to the fact that, higher means of speed and percent germination obtained from seeds treated with M_1 and D_1 (Table 1) influenced early establishment of shoots and roots and subsequent fast growth. This is an indication that the promptness of radicle emergence in the germination test had good predictive value for field performance of seed as observed by Mixon[15]. There was no significant difference between the levels of each of the treatments applied to F-mix seeds. This shows that, the various treatment applied did not have any effect on the viability and vigour of F-mix variety.

Manipintar seeds treated with dithane and macerated solution produced higher dry weight of biomass than Chinese and F-mix at the same level of treatments. This might be due to the fact that, Manipintar have high branching potential and grow much taller than the Chinese and F-mix varieties. Therefore more dry matter accumulation in Manipintar seedlings. Seeds of Chinese and F-mix treated with hot water at 50°C gave higher dry weight of biomass than at 60°C but not for Manipintar. The significant difference in dry weight of biomass observed in Chinese variety among the various treatment levels was probably as a result of the higher values recorded for speed and percentage of germination at 50°C heat treatment, D_1 and M_1. This might have led to early establishment and faster growth of emerged seedlings (i.e. shoot and root growth).

Results in Table 4 indicated that the interaction of heat treatment and dithane on biomass dry weight of Chinese seedlings were significantly different with the interaction of the two levels of heat treatment (50 and 60°C) and dithane (D_1) recording higher means of biomass dry weight than the interaction of heat levels of treatment and untreated control (i.e. no dithane). This might have been that, the combine effect of heat and dithane enhanced permeability of seed coat to water and gases and reduced seed and soil borne infections, which stimulated early germination and subsequent dry matter accumulation.

Results in Table 5, also indicated that, the interaction of heat treatment and Chinese variety was statistically significant for vigor index, biomass dry weight, speed and percentage of germination. This might be due to the fact that, Chinese, a non-dormant variety recorded higher speed and percentage of germination than Manipintar and F-mix with 50°C being its enzymatically favorable temperature.

Seeds treated with macerated hull, diathane and heat at 50°C were better except F-mix seeds, which performed better under 60°C. Investigations must be carried out to find cheaper fungicide from the botanicals as a substitute to diathane since it may not be readily available to farmers or may be expensive if available or the risks involved in its application, especially when farmers are not familiar with the handling of such chemicals.

Maceration emerged as the best single treatment and could be adopted by farmers to increase germination percentage and plant stand at farm level since it is readily available to farmers and cheap.

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