Journal of Stored Products and Postharvest Research Vol. 2(2) pp. 29 - 36, February 2011
Available online http://www.academicjournals.org/jsppr
ISSN 2141 – 6567 ©2010 Academic Journals

Full Length Research Paper

Effects of storage conditions and pre-storage treatment on sprouting and weight loss of stored yam tubers

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Accepted 13 December, 2010

The effect of intermittent forced air flow using a fan and pre-storage treatment prepared by soaking neem bark in water for 12 h and blending neem leaves with water on weight loss and sprouting of stored yam tuber were investigated. A total of 36 tubers of white yam, (*Dioscorea rotundata*) were stored for six months in barn with fan and barn without fan. The results showed that the temperature in the barn with fan was slightly lower than that of the barn without fan. The neem bark extract treated tubers had lower sprout weights (25 g/kg) compared to 45 g/kg for the control. This difference is statistically significant at ($P \leq 0.05$). The neem leaf slurry treated tubers also had less sprout weights (33 g/kg) tuber. The tubers treated with neem leaf slurry had the least weight loss (21%) compared to 26% for the tuber treated with neem bark extract. Tubers stored in the barn with fan had the least sprout weight and least weight loss. From the result, it can be concluded that intermittent air flow on stored yam tubers reduces sprouting and weight loss and neem bark extract treatment have an effect in suppressing sprouting in stored yam tubers.

Key words: Yam, storage, neem bark, neem leaf slurry, air flow, weight loss, sprouting.

INTRODUCTION

Yams (*Dioscorea* spp.) are the most important food crops in West Africa, next to cereals, (Onwueme, 1978; Opara, 1999). In 2005, 48.7 million tones of yams were produced worldwide. West and Central Africa account for about 94% of world production, Nigeria being the major producer (IITA, 2007). The white yam (*Dioscorea rotundata*) which originated in West Africa is the most important species of yam cultivated for human nutrition in the region (Gerardin et al., 1998). In Nigeria yam is not only an important staple food, but also has ritual and socio-cultural significance and it is considered a man's crop. Before the introduction of cereals and grains, also important staple foods in West Africa, yams were the major source of carbohydrate (Osunde and Yisa, 2003).

The storage life of the yam tuber is ended at the termination of dormancy, when new sprouts develop. Sprouting in stored yam causes weight and quality loss (Osunde and Orhevba, 2009; Sahore et al., 2007). Good storage should therefore maintain tubers in their most edible and marketable condition by preventing large moisture losses, spoilage by pathogens, attack by insects and animals, and sprout growth (Osunde, 2008). In order to obtain good quality tubers after storage (that is fresh, edible and marketable yams), the freshly harvested yams to be stored must be clean and undamaged. Also, excessive temperature must be avoided and good aeration provided. Causes of storage losses of yam tubers include: sprouting, transpiration, respiration, rot due to mould and bacteriosis, insects, mammals, nematodes (Osagie, 1992; Ravi et al., 1996a; Opara, 1999). Methods of yam storage vary from delayed harvesting or storage in simple piles or clamps to storage in buildings specially designed for the purpose and application of sophisticated modern techniques (Ravi et al., 1996a). Also, Osagie (1991), Nwakiti and Makurdi (1989) adequately described yam storage practices.

Neem tree derivatives have been used as pest control in rural areas of developing countries (Ganguli, 2002). All parts of the neem tree have medicinal properties and are used for many different medical preparations. Ganguli

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(2002) reported that neem is used for the treatment of scabies mite and also, it is effective in treating infestation of lice in humans. Ibrahim et al. (1987) reported that neem tree extract treatment have favorable effect on sprouting in stored yam, as it was able to suppress sprouting for 5 months in stored yam tubers (*D. rotundata*). The effect of air flow in stored yam has been studied by Mozie (1983). In this study, a significant difference was observed in the percentage sprouting rate and the rate of weight loss of yam tubers stored in the conventional barn when supplied with airflow intermittently, continuously or without airflow. He observed that intermittent airflow allowed significant less weight loss and less sprouting than continuous airflow and no airflow. Other treatments such as oil coating and chemical treatments have been used to reduce sprouting and weight loss in stored yam. Ohu et al. (2007) reported that yam tubers coated in palm oil experienced significantly less loss of weight, moisture and dry matter. It was also reported that the Chloro-Isoprophyl Phenyl Carbamate (CIPC) chemicals which is successfully used to suppress sprouting in stored potato has no effect in stored yam (Orhevba and Osunde, 2006). Malic hydrazide (1000 ppm) has been reported to prolong dormancy of yam tubers of *Dioscorea alata* and *D. rotundata* (Ramanujam and Nair, 1982). The present study is aimed at investigating and evaluating the effect of intermittent forced airflow and neem tree bark and neem leaf slurry treatments on sprouting and weight loss of stored yam tubers.

MATERIALS AND METHODS

The experiment was conducted in Minna, Niger State of Nigeria which is located on the Guinea Savannah Ecological zone. Two traditional yam barns were used for this experiment; they were erected in the open air, where sufficient shade and ventilation was available. The frame of the barn consisted of vertically erected wooden poles of 2 m height, set at a distance of 1 m to each other. These wooden poles were stabilized by attaching horizontal poles to them. The dimensions for each barn were 2.5, 3.5 and 2 m, width, length and height, respectively. Locally knitted thatch (made of dried plant stalks) were wound round the frame and the top, this served as the roof and the wall. There was a slight opening between the roof and wall to allow for optimum ventilation and reduction in ambient temperature inside the barn.

Two of such structures were built and a standing fan to aid airflow was placed in one of them. The fan, with a blade diameter of 40 cm and airflow rate of 0.86 m^3/ second was placed at a corner and allowed to supply air at 2 hourly intervals throughout the experiment period (8 to 10 am, 12 to 2 pm, 4 to 6 pm, 8 to 10 pm) while the second barn was without a fan and airflow was natural. The “medium” fan speed with 27.24 m/s speed and which rotated at 1800 (to enable even ventilation for all the tubers) was used for providing the forced intermittent airflow. A total of 36 tubers of white yam *D. rotundata* tubers “giwa” variety were stored in each barn, this were further sub-divided into three sub-groups of 12 tubers each. The initial weight of the tubers were measured and recorded based on treatments used. The neem bark extract was prepared by soaking 5 kg of neem bark in water for 12 h and twenty four tubers of yam (twelve for each barn) with a total weight of 28.5 kg were treated using the prepared neem bark extract. The neem leaf slurry was prepared by blending 1 kg of neem leaves with 2 L of water and was used for twenty four tubers of yam with a total weight of 26.8 kg.

In addition to this, a control sample of 12 tubers in each barn with no treatment was stored. The tubers were arranged on a raised wooden platform, which were placed on the floor of the barns to reduce bruising and to facilitate airflow, weighing and making observations. Temperature and relative humidity inside the barns were measured three times a week and four times a day (8:00 am, 12 noon, 4:00 and 8:00 pm). Temperature and humidity readings were taken using a Mebus 4.0 digital thermo-hygrometer. The tubers were weighed before storage and at monthly intervals throughout storage period. To determine the sprout vigor the sprouts were removed manually twice a month and weighed. Percentage weight loss was determined based on the initial tuber weight while sprouting vigor was determined by weighing the sprouts of the yam tubers. The experimental design employed for this work was 3 x 2 factorial designs with 3 replicates. The results were analyzed using ANOVA and the means analyzed using F-LSD at $P \leq 0.05$.

RESULTS

Temperature in the barns

The summary of the average monthly minimum and maximum temperature in the two barns is presented in Table 1. The temperature in the barn with fan fluctuated between 20.5 and 36°C with an average of 29°C while that in the barn without fan fluctuated between 23 and 38°C, with an average of 33°C over the storage period. The average temperature in the barn with fan was 4°C less than in the barn without fan. The maximum temperature was obtained at 4:00 pm while the minimum temperature was recorded at 8:00 am. Figure 1 shows the average daily temperature variation for the two barns. From the figure, the barn without fan had the highest temperature (36.5°C) at 4:00 pm while the barn with fan had a temperature of (33.5°C) at the same period. The barn with fan had the lowest temperature (27.08°C) at 8:00 am while that of barn without fan was 30.92°C during the same period.

Relative humidity in the barns

The summary of the average monthly minimum and maximum relative humidity in the two barns is as presented in Table 2. The relative humidity in the barn with fan ranged between 26.5 and 60.4% with an average of 38% while that in the barn without fan ranged between 23 and 55% with an average of 44% over the storage period. The average relative humidity in the barn with fan was about 6% higher than in the barn without fan. Figure 2 shows the average daily humidity variation for the two barns. From the figure, the barn without fan had the lowest relative humidity (33.67%) at 4:00 pm while the barn with fan had 38.83% during the same period.

Table 1. Average monthly minimum and maximum temperature inside the two barns.

Months	Barn with fan		Barn without fan	
	Minimum	Maximum	Minimum	Maximum
January	20.5	29.5	23	32
February	26.5	34.5	29.5	36.5
March	28	36	31	38
April	28.5	35.5	32	37
May	30	33.5	32.5	35.5
June	29	32	31.5	34

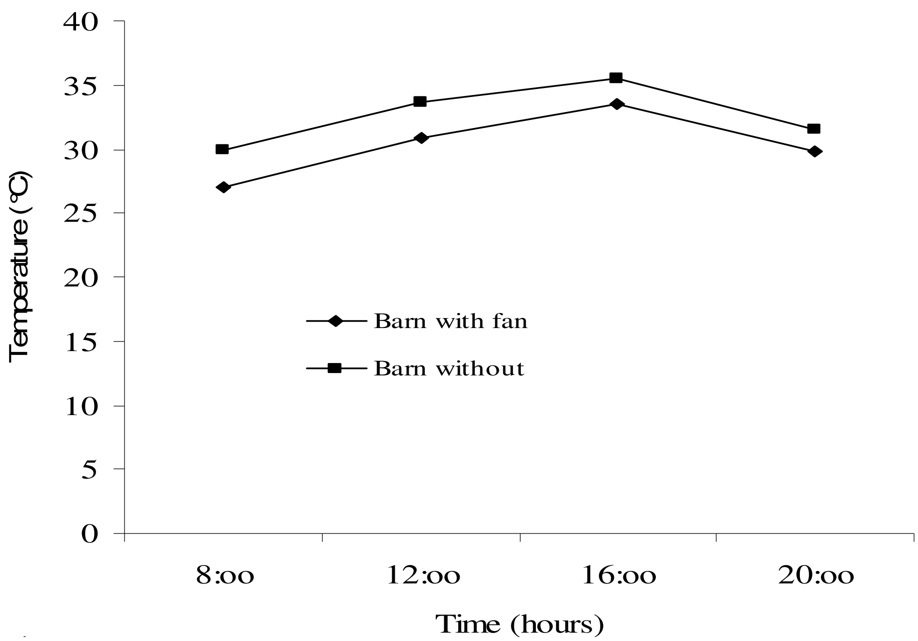

Figure 1. Average temperature in the two barns.

Table 2. Average monthly minimum and maximum relative humidity inside the two barns.

Months	Barn with fan		Barn without fan	
	Minimum	Maximum	Minimum	Maximum
January	26.5	32.4	23	29.5
February	28	32	25	30
March	32.4	51.5	26	49
April	35	57	32	55
May	45.8	57	42.5	55
June	53.4	60.4	48.5	55

Effect of neem bark extract and neem leaf slurry treatments on weight loss of stored yam tubers

Figure 3 shows the percentage weight loss of tubers treated with neem tree bark extract and neem leaf slurry stored in barn with fan while Figure 4 shows that of the barn without fan. From Figure 3 tubers treated with neem leaf slurry had the lowest weight loss throughout thestorage period. A similar observation was made in the barn without fan (Figure 4). The neem bark extract treated tubers and the control had higher weight loss compared to the neem leaf slurry treated tubers throughout the storage period. Summary of average weights loss of yam tubers treated with neem extract at the end of the storage period for the two storage methods is presented in Table 3. From the table, it is seen that tubers stored in the barn with fan has the lowest weight loss for all the treatment. It is also observed that in all

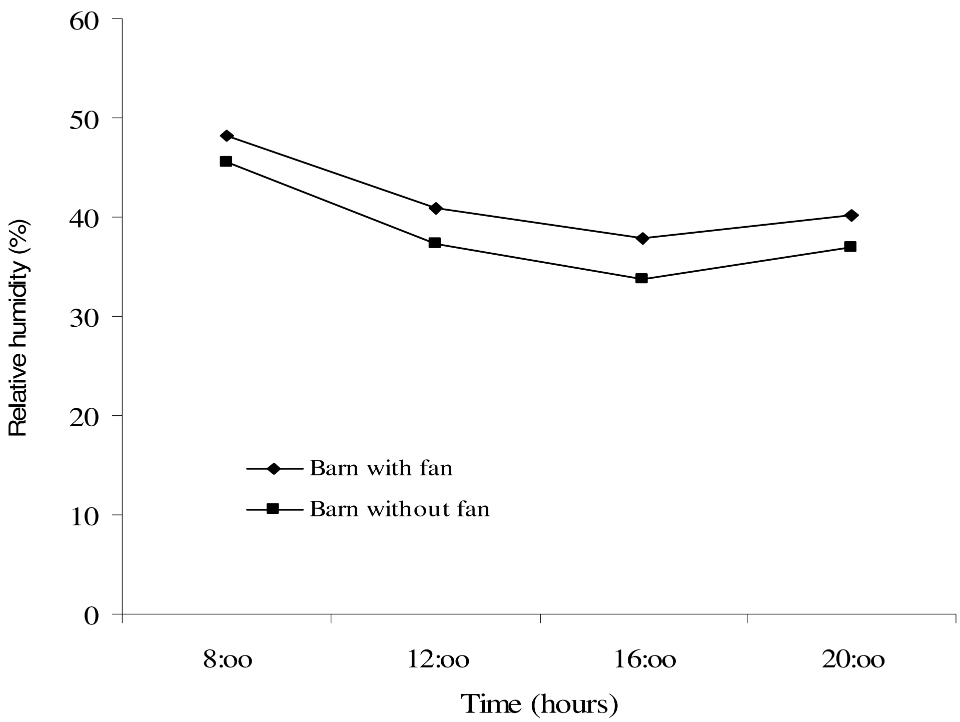

Figure 2. Average relative humidity in the two barns.

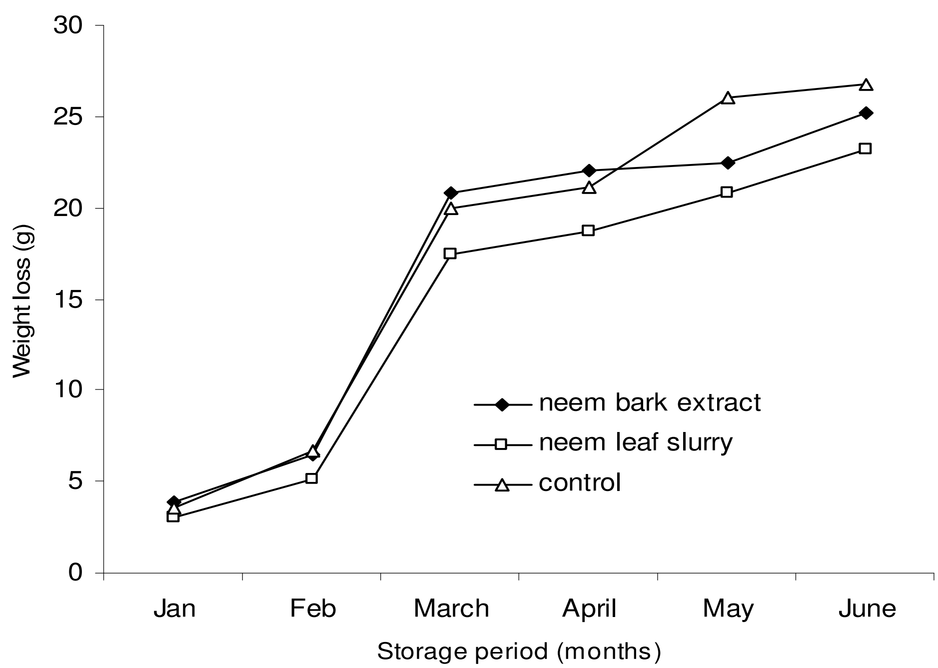

Figure 3. Monthly average percentage weight loss of yam tubers stored in barn with fan.

cases (structure and treatment) the tuber lost more than 20% of its initial weight at the end of six month storage period. After six months of storage the tubers stored in the ventilated barn showed 6.2% less weight loss compared to the tubers in barn without fan. The Analysis of Variance (ANOVA) for weight loss presented in Table 4 shows that, both the treatment and the barn type had significant effect on the weight loss and there was no interaction effect. The means for the treatment were separated by LSD to determine the factor with significant

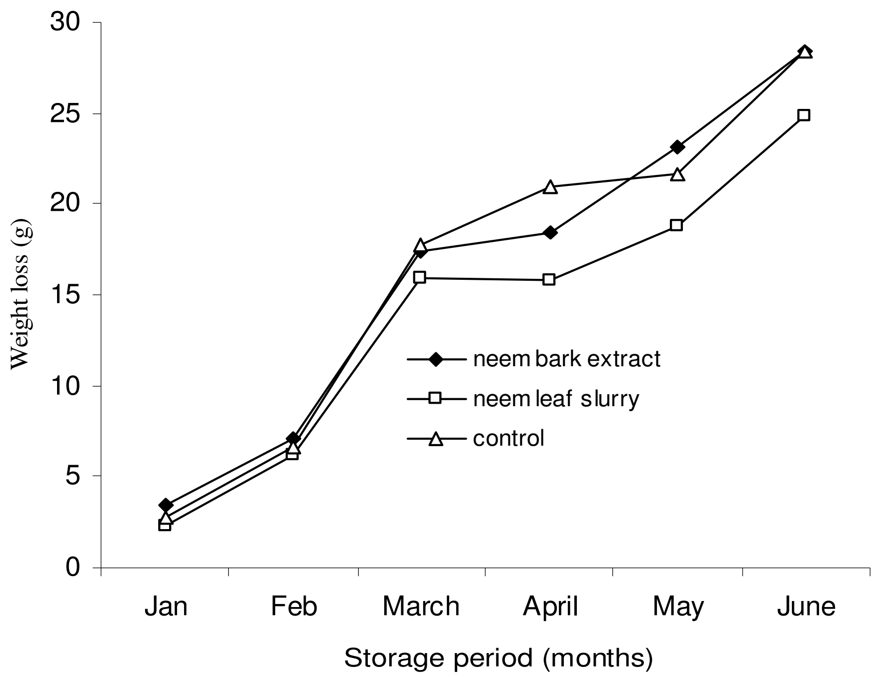

Figure 4. Monthly percentage weight loss of yam tubers stored in barn without fan.

Table 3. Average percentage weight loss of yam tubers at the end of the storage period.

	Weight loss (%)		
	Neem bark extract	**Neem leaf slurry**	**Control**
Barn with fan	26.2	21	26.8
Barn without fan	28.42	24.6	28.36

Table 4. ANOVA table for weight loss.

Sources of variation	df	ss	ms	Fcal	Ftab	Remarks
Treatment combinations	7	199.86	28.55	0.006	2.66	ns
Factor A (Neem extract)	3	27691.77	19230.59	3.738	3.21	*
Factor B (barn type)	1	43592.92	43592.92	8.473	4.49	*
Interaction AB	3	11236.75	3745.58	0.728	3.21	ns
Error	16	82321.58	5145.10			
Total	23					

ns = not significant; * = Significant.

effect on weight loss. Table 5 shows the result of the F-LSD for weight loss.

Effect of neem bark extract and neem leaf slurry treatment on sprouting of stored yam tubers

Figure 5 shows the sprouting vigor of neem bark extract and neem leaf slurry treated yam tubers and stored in barn with fan. Sprout vigor was high in the control sample compared with the neem tree extract treated tubers. The neem bark extract treated tubers generally had the lowest sprout weights followed by the neem leaf slurry treated tubers. Figure 6 shows the sprouting vigor of neem bark extract and neem leaf slurry treated yam tubers and stored in barn without fan. Similarly, as in the barn with fan, the control had the highest sprout weights; however, there was no remarkable difference between the tubers

Table 5. Result of F – LSD for weight loss.

Sources of variation	Sum of squares	Degree of freedom	Mean differences	LSD values at 0.05% variances	Remarks
Between bark extract and leaf slurry	8607.81	2	15.18	14.24	*
Between bark extract and control	9525.71	2	8.72	11.53	ns
Between leaf slurry and control	7033.42	2	7.46	6.46	*

ns = not significant.; * = significant.

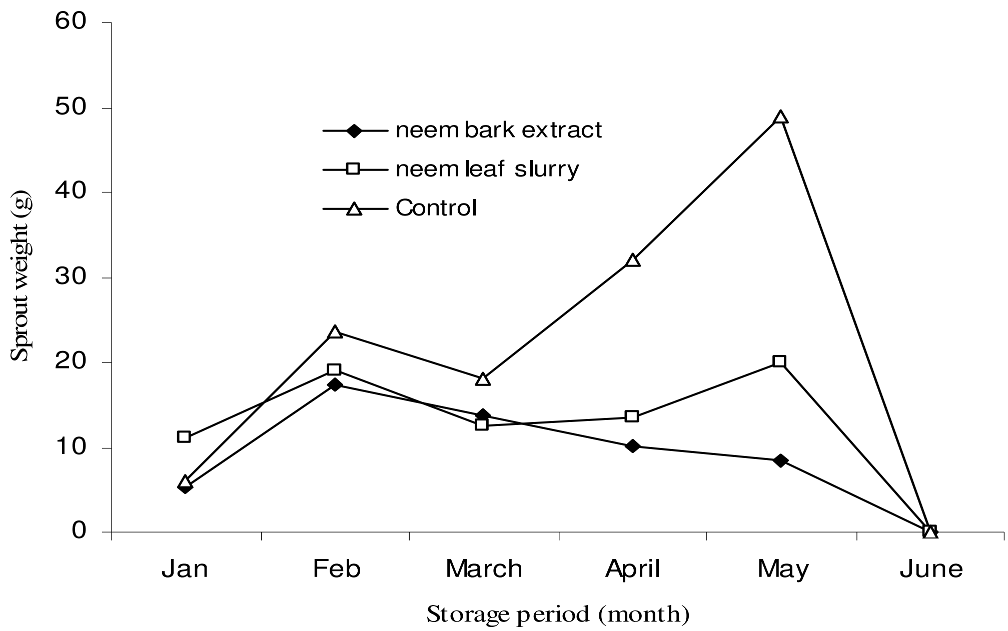

Figure 5. Average sprout weight of tubers stored in barn with fan.

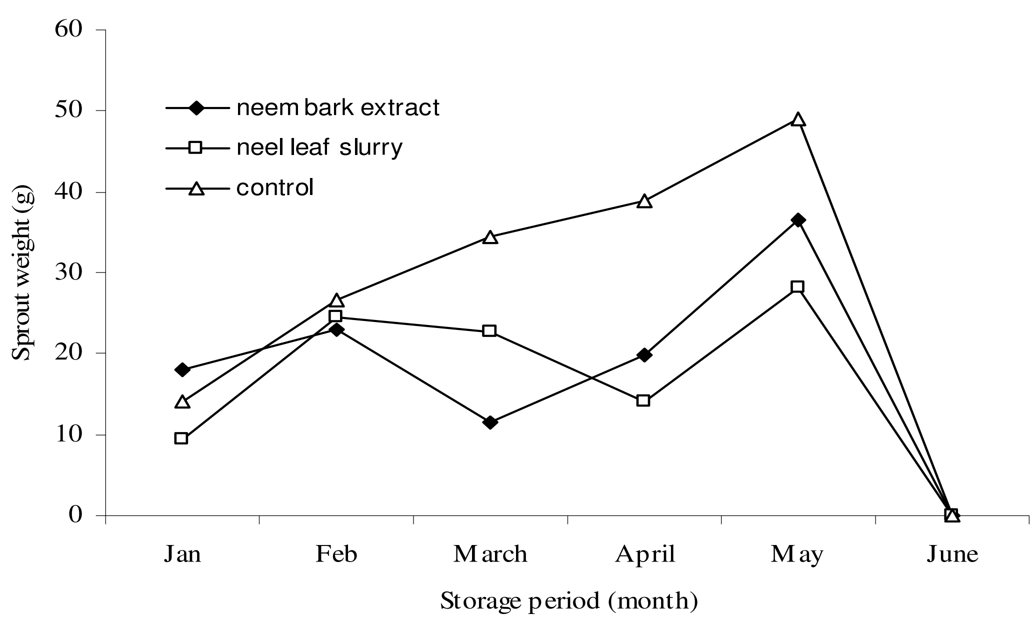

Figure 6. Average sprout weight of tubers stored in barn without fan.

Table 6. ANOVA table for sprouting.

Sources of variation	df	Ss	ms	Fcal	Ftab	Remarks
Treatment combinations	7	1100.54	157.22	0.0379	2.66	ns
Factor A (neem extract)	3	24043.53	18014.51	4.346	3.21	*
Factor B (barn type)	1	37503.64	27503.64	9.047	4.49	*
Interaction AB	3	58881.78	1960.59	0.473	3.21	ns
Error	16	66,328.41	4145.52			
Total	23					

ns = not significant; * = significant.

Table 7. Result of F – LSD for sprouting.

Sources of variation	Sum of squares	Degree of freedom	Mean differences	LSD values at 0.05% variances	Remarks
Between bark extract and leaf slurry	6090.3	2	13.76	20.44	ns
Between bark extract and control	9468.8	2	9.45	19.78	ns
Between leaf slurry and control	7403.6	2	23.20	22.92	*

ns = not significant ; * = significant.

treated with the neem leaf slurry and neem bark extract, as both treatments showed low sprout weights.

For all the treatments, the tubers stored in the barn with fan had less sprout weight compared to the barn without fan. There was an average of 7% less sprout weight in the barn with fan. The analysis of variance for the effect of neem extract on sprouting of stored yam tubers is given on Table 6. From the table both the treatment and storage conditions had an effect on sprout weight. The means for the neem extract treatment were separated by LSD, to determine the factor with significant effect on sprouting. Table 7 shows the result of the F-LSD for sprouting. From the result, it can be concluded that the leaf slurry treatment has a significant effect on sprouting of stored yam tubers.

DISCUSSION

The difference observed in temperature and relative humidity between the two barns could be attributed to the presence of fan which helped to improve airflow and dispersed accumulated heat and moisture on and around the surface of the yam tuber. This is in agreement with the findings of Mozie (1983). The sprout weight in the tubers stored in the barn with fan was lower than that of the tubers stored in the barn without fan. Also, the weight loss at the end of the storage period was less in the yam tubers stored in the barn with fan than that of tubers stored in barn without fan. This could be due to the reduction in temperature and increase in relative humidity in the barn with fan. Similar results were obtained by Mozie (1983). Gerardin et al. (1998) also reported reduction in sprout weight and in weight loss with reduction in temperature and increase in relative humidity of the storage environment.

From the result, it can be concluded that the leaf slurry treatment has a significant effect on weight loss of stored yam tubers. This agrees with the finding of Ibrahim et al. (1987) and Schmutterer et al. (1980). Weight loss in stored yam tubers is as a result of sprouting, respiration and transpiration (Ravi et al., 1996b). Neem bark extract treated tubers had low sprouting but high weight loss; even though sprouting is one of the factors responsible for weight loss. The reason for the high weight loss when sprouting was low could be due to high rate of respiration and transpiration, as individual tubers have different respiration and transpiration pattern. Respiration and transpiration also depends on the size of the tuber. Even though sprouting may be low, other factors such as explained above may be responsible for the high weight loss of the neem bark extract treated tubers. Sprouting started at the end of January and was highest at the end of March for the neem tree extract treated tubers; the control recorded the highest sprout weight throughout the storage period. At the end of the storage period sprouting reduced and eventually stopped completely at the sixth month of storage (June), this could be due to temperature change (that is, decrease in temperature as a result of the rains) and the regular removal of sprouts. Ibrahim et al. (1987) reported that neem tree extract treatment have effect on sprouting as they were able to suppress sprouting for five months in stored yam tubers (*D. rotundata*). However, in this work none of the neem bark treatments used was able to suppress sprouting, it only reduced the sprout weight compared to non treated tubers.

Conclusions

The effect of intermittent forced air flow using a fan and pre-storage treatment using neem leaf slurry and neem bark extract on weight loss and sprouting of stored yam tuber were studied. The result showed that the temperature of the storage environment was low in barn with fan while the humidity was high compared to the barn without fan. It was also observed that the intermittent air flow in stored yam tuber reduces sprout vigor and weight loss after six months of storage. The neem tree extract treatment had significant effect on weight loss and sprouting on the stored yam tubers; with the neem leaf slurry having a greater influence than the neem bark extract. Weight loss of the yam tubers was more influenced by the treatment than sprouting.

RECOMMENDATIONS

Based on the work done, the following recommendations for further work were made:

1. Different concentration rates and application rates of neem tree extract should be further investigated to identify the optimum rate of application.
2. Farmers should be encouraged and sensitized on the effectiveness of neem extracts on sprout suppressing and weight loss reduction.
3. Effect of neem tree ash on sprouting and weight loss should be investigated, as it might be easier to use ash than slurry or paste. .

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