

Development of a Diffuse Light Store for “Seed” Potato Storage

F.A. Babarinsa and J. O. Williams

Nigerian Stored Products Research Institute,

P.M.B. 1489, Ilorin, Nigeria.

E-mail: fababarinsa@yahoo.com

Abstract

A low-cost 2-tonne capacity diffuse light store (DLS) was designed and constructed for storage of “seed” potatoes. The DLS was built of clay bricks and provided with ventilation vents at the bottom and the top of the storage room. Natural diffuse light was admitted through wall openings covered with polyethylene sheets. The store was tested for storage of ‘seed’ potatoes and compared with the traditional storeroom (TSR) conventionally used by potato farmers of the highland (mountainous) area of Plateau State of Nigeria. During the 16 weeks’ storage, the average temperature in the DLS dropped 5°-10°C below the ambient and relative humidity was reduced by 25%. “Seed” potatoes of the Nicholas and B7716-2 varieties successfully stored for 16 weeks in DLS. The DLS performed better than traditional storeroom (TSR) by reducing losses due to weight loss and rotting by 54.2% and 44.7% respectively, due presumably to the applied convective ventilation. The higher losses in seed in the TSR were considered attributable to high temperature and respiration in the store which was corrected, in DLS, through convective ventilation. The reduced losses more than offset the extra cost of creating vents and diffuse light openings for the diffuse light store.

Keywords: Diffuse light store, Storage, ‘Seed’ potato, Rotting, Weight loss, Convective ventilation.

Introduction

Irish potato (*Solanum tuberosum* L.) has become an important crop in Nigeria and its production has been on the increase in the past two decades. The crop is particularly widely grown in the middle-belt zone especially in the mountainous area of the Plateau State where it adapts best to the cold climate. However, the non-availability of “seed” potatoes for planting poses the major constraints facing farmers in their drive towards intensive production. These problems are closely associated with lack of storage facilities for the seed potatoes in-between growing seasons (Okonkwo et al., 1986). Traditionally the seed potatoes (which are small tubers of previous crop) are stored in baskets kept in household rooms or in any available place in farm buildings. These stores are kept nearly totally dark and are inadequately ventilated. Under this condition, the small tubers deteriorate fast and lose viability shortly after harvest. The major problems are related to weight loss due to desiccation, rotting and excessive sprouting. Okonkwo et al. (1986) reported that farmers lose as high as 40% of their stored seeds within three months of storage as a result of poor storage.

In this respect, notable success of seed potato storage has been made in developing countries on the development of techniques and designs for using natural diffuse light in the storage of seed tubers (Anonymous, 1980, Potts et al., 1983 and Nwokocha and Ifenkwe, 1991). Potts et al. (1983) noted that the development of diffuse light seed storage technology by the International

Potato Centre (CIP) has made it practicable to store seed potatoes even at tropical temperature, largely because light suppresses excessive sprout growth. Diffuse light storage technology is effective in reducing storage losses and results in better quality seed value due to weight losses and growth of short robust sprouts instead of long, thin and weak ones. The admitted diffuse light suppresses premature and excessive sprouting (Potts et al., 1983 and Wiersema and Booth, 1985). Temperature ceases to be very critical because tubers can be successfully stored and maintained in acceptable physiological conditions (Anonymous, 1980). Additional advantages of diffused light over dark storage are increase in sprout number and increased resistance to several pests and diseases due to tuber greening and a reduction in apical dominance, which limits the number of stems that can develop from a planted seed. Natural diffused light has been recommended by Booth and Shaw (1981) as an alternative to low temperatures to control excessive sprout growth for storage of seed potatoes), particularly in simple low cost structures which are appropriate to for small farmers. These workers showed a range of sizes and construction in use of diffused light seed stores. Various potato varieties have also been stored under diffuse light store in Bangladesh (Hossain, et al., 1995).

This paper assesses the effect of using a diffuse light store developed with consideration of simplicity of construction and employment of locally available materials and skill. In this trial, a comparison was made between the DLS store and the traditional storeroom.

Materials and Methods

Store design and construction

A rectangular diffuse light structure (DLS) was constructed (at Kuru in the Plateau state of Nigeria) with local materials, mainly clay bricks, with a storage room 4.5 x 4.0 x 2.0m. One end side of the store has an access door made of sawn wood (Figure 1). Figure 2 shows the rear side. To admit diffused light (indirect sunlight) into the storage room, each side wall carries two sets of wall perforations 18cm x 18cm covered with transparent polyethylene sheets. The two side walls facing wind direction carry, in addition, two rows of rectangular vents 40cm x 22cm to induce convective ventilation in the store space. One row of four inlet vents is located at the floor level while the other row of four outlet vents are at the eave (wall top) level (Figure 3). The inlet vents are inwardly covered with control flaps consisting of polypropylene sheets cut to size and hung to the top edge; they open intermittently according to the prevailing wind direction. Flapped vents arrangement is flexible and also enables the airflow to be reduced for a high wind condition to prevent excessive potato shrinkage. To maximize wind influencing the ventilation, the long sides of the store are oriented to face prevailing wind direction. Whenever the flaps on one side open those on opposite walls close. Because only the set of inlet vents on one side opens at a time, intake air current is prevented from being short circuited by a cross flow across the floor level.

With the above vent arrangement, convective ventilation is induced in the storage space by upward air displacement as ventilating wind is admitted through the floor level vents. At nights, cold night air enters below the storage space and warm air exits above. This is complemented by the convection current resulting from the bottom-to-top temperature gradient naturally caused by evolution of heat from respiring tubers. The convective airflow is activated by temperature difference between the potatoes and the outside air. This system lowers the storage temperature by flushing the store with in-flowing night cool air to intermittently replace daytime hot air. The exit of warm moisture-laden air generated by the tubers also reduces the chances of rotting in the tubers. All wall openings, vents and perforations, are protected with wire netting to exclude

rodents, reptiles and birds. The store roof is constructed of thatch materials, consisting of “zana” grass and wooden trusses. The floor is rammed with a top layer formed of sand-cement mixture 5cm thick.

Slatted wooden shelves were provided in the store for loading potatoes for storage. These comprise a set of three racks, 80cm wide, fixed to the side of each wall with the racks vertically spaced 60cm. The ventilated shelves are rugged and seed tubers can be stored on them to a maximum depth of 2 to 3 tubers to permit light access to all tubers. Each rack is compartmentalized such that stored potatoes are carried as identifiable lots. Constructing slatted shelves aligned to the walls allows optimal ventilation as well as providing a central space or alleyway for handling activities. Okonkwo et al. (2003) recommend storage in crates, racks and on floor of well-ventilated stores for short-term (4 months) storage, since these methods provide good ventilation of stored seed and tuber rots are low.

Seed potato storage

Two varieties of potato, Nicholas and B7716-2, were used in experimental storage trial for assessing the DLS performance. The seed tubers, between 40mm and 50mm long, were freshly harvested and divided into three lots. A lot of each variety consisted of 450kg of tubers, subdivided into three units and laid on the three racks. A comparative storage trial was conducted under the simulated field loading condition of the farmer using a traditional storeroom. The paired units of varieties were randomly placed in different locations within the room. Daily temperature and relative humidity in the stores and ambient were recorded using thermohydrographs and glass thermometers. Fortnightly records were taken of weight loss, incidence of rot and incidence of sprout for a storage period of 16 weeks.

Results and Discussion

Storage temperature and relative humidity

During the experiment, ambient temperature ranged between 13.6° to 27.5°C (characteristic of Jos plateau) with a mean of 23.6° C. The daily average temperature in the diffuse light store (DLS) was within the range of 15.8° to 21.9°C and a mean 17.9°C while the traditional storeroom (TSR) had a range of 14.6 ° to 28.9°C with a mean 22.1°C. Thus, both the temperature and temperature fluctuation in the DLS were persistently lower than those obtained in the traditional storeroom.

Weight loss

Weight loss was observed in tubers stored in both stores. After two weeks, most of the tubers in the DLS had dry skin, showing adequate curing, when the weight loss was 0.8% and 1.7% in Nicholas and B-7716-12 varieties respectively (Table 1). After 8 weeks, weight loss in DLS rose to 5.5% and 11.9% in Nicholas and B-7716-12 varieties respectively, while TSR recorded 18.5% and 19.2%. After 16 weeks in DLS weight loss increased further to 8.9% and 29.8% in Nicholas and B-7716-12 varieties respectively while TSR recorded 35.8% and 41.4%. Average mean loss in weight was 17.8% and 38.9% in DLS and TSR respectively. There was persistently higher weight loss in the TSR than in the DLS and the higher moisture losses in the TSR were revealed by the more shriveled tubers. The higher losses in seed weight in the TSR were presumably due to poor ventilation and thus high temperature and respiration in the store. Weight loss occurred most prominently in top layer tubers, indicating an influence of surface ventilation.

Rotting

Rotting also increased with storage time. Before four weeks of storage, there was no remarkable difference in the percentage rotten potatoes in the two storage methods. After 8 weeks, however, rotting became greater in the traditional storeroom (TSR), reaching 10.4% and 11.7% in Nicholas and B-7716-12 varieties respectively (Table 1). This was reduced to 4.8% and 5.5% in the diffuse light store (DLS). After 16 weeks, rotting was greater in the TSR, reaching 19.6 % and 24.1% in Nicholas and B-7716-12 varieties respectively as compared to 9.4% and 14.2% in DLS. The overall mean losses in seed number, mainly by rotting, were 21.9 % in TSR and but were reduced to 12.1% in DLS. Most of the deterioration in the TSR was primarily due to rotting occurring at the lower layers of tubers where localized heating might have occurred due to lack of adequate ventilation. Lack of adequate ventilation is a known factor favouring the development of rotting in potatoes (Potts et al., 1983). Nicola seeds were more turgid and unwrinkled at the end of storage, and so appears to be a better suited variety for DLS storage than B-7716-12.

Sprouting

Before four weeks of storage, there was no noticeable sprout growth in all the healthy seed potatoes in the two stores. After 12 weeks in DLS the percentages of sprouted tubers in TRS were 15.8% and 18.0% in Nicholas and B-7716-12 varieties respectively while DLS recorded 8.6% and 6.5%. The average number of sprouts per tuber was reduced from 1.86 in the TRS to 1.3 in DLS. The average length of apical sprouts was also reduced from 16mm to 10mm. Furthermore the DLS sprouts were shorter, green and sturdy (robust) as opposed to the long, thinner, white and easily damaged sprouts on the tubers from traditional store. In seed potatoes storage, diffuse light is a factor which causes a remarkable toughening of the sturdy sprout and markedly reduced excessive sprout growth in the seed tuber (Potts et al., 1983). Storage of seed potato in DLS is a way of reducing apical dominance and increasing number of sturdy sprout (Booth and Shaw, 1981. and Meijers 1978). Meijers (1981) particularly noted that lowering of temperature, as well as lowering of range of temperature within seed potato stores is a desirable feature that helps to prolong dormancy period of tubers. The development of high quality sprouts in the DLS, which reduced losses were due in part to the effect of diffuse light. Commencement of sprout growth increases water loss because permeability to water vapour is higher on the surface of the sprouts than from the periderm of the tuber (Anonymous, 1960). Excessive sprouting therefore contributes to both weight loss and desiccation. It has been established that ensuing vigour of plants from shorter and sturdy seed tubers is better in the field (Anonymous, 1960).

Store performance

Regardless of storage method, spoilage was more rapid during the last two weeks. Deterioration of storeroom tubers was presumably due mainly to heat built up resulting from respiration within the pile ((Burton, 1969). The reduced spoilage in the DLS can thus be attributed to improved conditioning due to better ventilation and prevention of temperature rise in the DLS. The use of convective ventilation has long been identified as the cheapest form of cool storage and, consequently, reduction of loss in seed potatoes (Burton, 1969). With the system of ventilation applied, the DLS has demonstrated suitability for the potato production areas of Plateau State in Nigeria because ambient temperatures are usually low enough, particularly at night. The temperature in the ventilated DLS can thus be low enough to inhibit excessive sprouting for about 3 months before the planting season. Ventilation has also an emergency function in cooling or drying out patches of rot until they can be removed (Annonymous, 1972; Burton, W.

G., 1978). Nwokocha and Ifenkwe (1991) have noted that the 3 to 4 months of storage is considered sufficient for the farmer to escape the potato glut that is experienced each year.

The material and labour for the traditional store cost about ₦24,000 (US\$160). The extra cost of creating vents and openings on the DLS walls was about ₦2,000 (US\$13.3) while extra maintenance cost was minimal. The 200kg of seed potatoes saved in each loading amount to a gain of ₦8000 (US\$53.3) a growing season; so the reduced losses more than offset the extra cost of the DLS in four growing seasons. Economic viability of the storage method is thus apparent.

Conclusion

This work has expanded the technological base to check storage losses in fresh seed potatoes, which limit potato production in Nigeria. In the developed diffuse light store, favourable conditions for extended storage life of seed potatoes employs a passive system whereby the tubers are exposed to natural diffused light and ventilated on shelves by exposure to ambient condition and to convective ventilation under the cool highland condition. It effectively checked the losses caused by sprouting, rotting and weight loss. The system is economically viable for small and medium scale producers under tropical conditions.

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Table 1: Weight loss, rotting and sprouting of “seed” potatoes stored in diffused light store (DLS) and traditional storeroom.

Storage time (weeks)	Weight loss (%)		Rotting (%)		Sprouting (%)	
	DLS	TSR	DLS	TSR	DLS	TSR
Nicholas						
2	0.8	3.4	0.5	1.8	0.3	0.4
4	2.4	7.2	1.9	4.3	2.5	3.5
6	4.6	13.8	3.2	8.4	3.8	7.3
8	5.5	18.4	4.8	10.4	4.4	11.5
10	6.9	22.3	6.5	13.2	5.2	14.2
12	7.8	26.9	7.7	15.6	6.5	18.0
14	8.6	31.3	8.1	17.8	8.8	22.3
16	8.9	35.8	9.4	19.6	10.4	24.7
B7716-2						
2	1.7	7.8	0.8	3.1	0.5	0.3
4	4.4	11.9	2.0	6.2	2.8	2.7
6	8.3	14.6	3.9	8.8	3.8	6.2
8	11.9	19.2	5.5	11.7	4.5	10.4
10	16.2	27.4	6.6	15.5	6.1	12.9
12	21.6	32.4	8.4	18.8	8.6	15.8
14	27.9	35.6	12.4	20.5	11.2	19.5
16	29.8	41.4	14.2	24.1	16.8	26.4

DLS = Diffuse light store,

TSR = Traditional storeroom

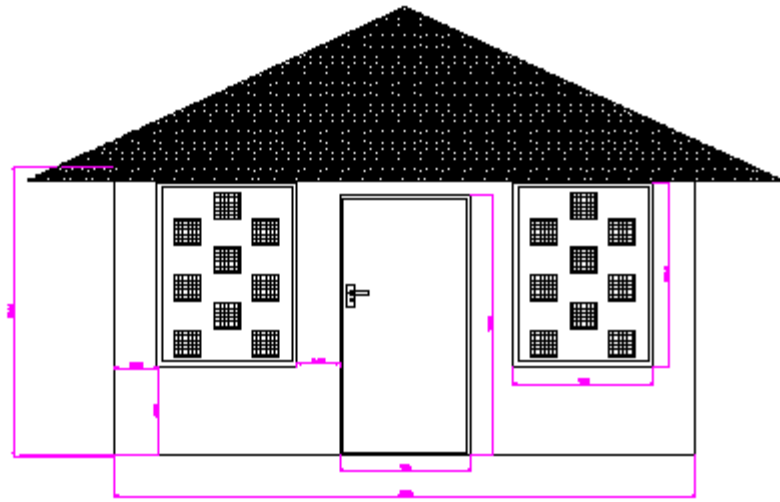


Figure 1: Front View of the Diffuse Light Store

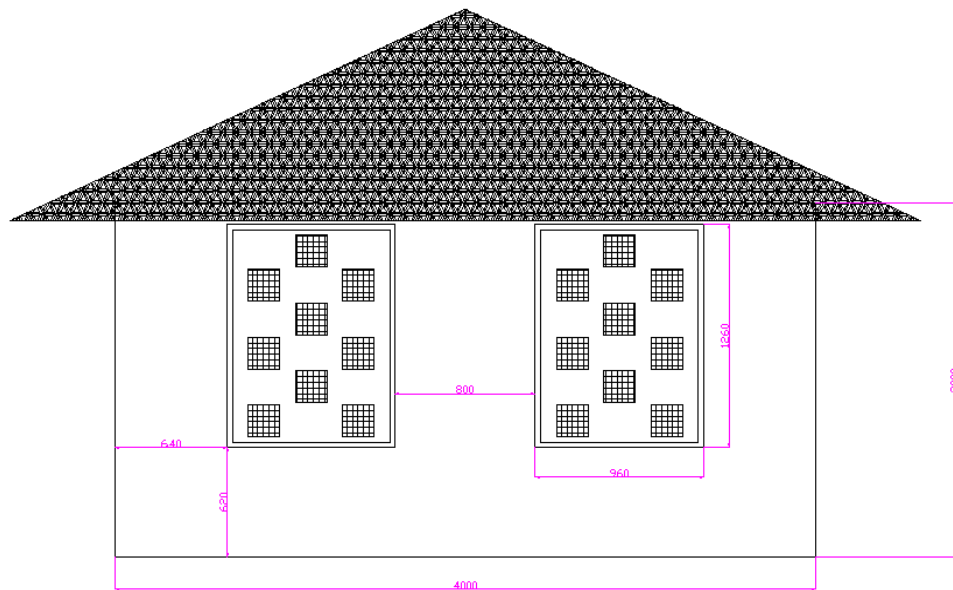


Figure 2: Rear View of the Diffuse Light Store

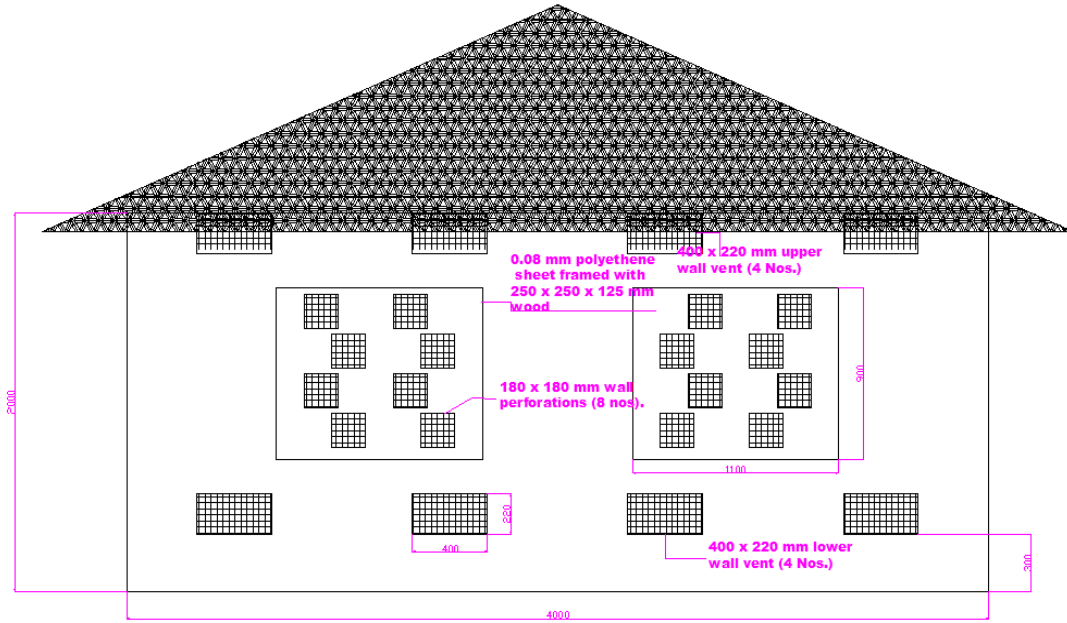


Figure 3: Ventilated Side of the Diffuse Light Store