FOOD RESEARCH INSTITUTE

SHELFLIFE STUDIES OF TWO YAM VARIETIES AT 20°C

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ABSTRACT

Yam is a tropical tuber crop produced mainly in West Africa, the Caribbean, South-East Asia, India and part of Brazil. Behaviour of yams in storage is dependent on the environmental conditions, genetic constitution, and agronomical practices during cultivation and physical condition at harvest. The traditional system of yam storage has been found to be inadequate and should be improved to permit long-term storage of yam either on farm or outside farm gate.

Dobare and *Puna* yam varieties of two different sizes from the Brong-Ahafo region of Ghana were stored at 20°C and 100% relative humidity. The initial weights of the yams were noted with the yams being weighed weekly. Buds from the sprouted yams were manually removed. The rotten yams were discarded.

The small-sized *Puna* and *Dobare* yams kept for 7months whilst the big-sized *Puna* and *Dobare* varieties kept for 61/2 months. Regression analysis carried out on the rates of weight losses showed that the *Dobare* variety had a less storage potential than the Puna since it lost moisture readily as a result of its higher metabolic activities. However, the surface area volume ratio had a negative effect on the bigger sized yams. Controlled environs of small-sized yams, with proper storage management could extend the shelf life.

ACKNOWLEDGEMENT

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1.0 LITERATURE REVIEW

1.1 Introduction

Yams (*Dioscorea spp*) are a tropical tuber crop produced mainly in West Africa, Caribbean, Southeast Asia, India and parts of Brazil. Botanically and gustatorically yams are distinct from the moist- type sweet potato tubers in the US that are often called yams. (*Hardenburg et al ,1986)*

Yams is a natural storage organ whose function in the wild state is to tie the plant over through the dry season until the wet season when conditions become favourable for growth. Yams in storage are alive, and they continue with the essential life processes of respiration and transpiration. The behaviour in storage depends to a large extent on the environmental conditions, genetic constitution, agronomic practices during cultivation, pest and disease attacks as well as the physical condition of the tuber. Through understanding of this living tissue and the influencing factors are necessary if storage losses are to be kept at a minimum (Wilson, 1985). The vegetative cycle of yam only allows one harvest per year, and the early cultivars can be eaten 4months before the later cultivars. Therefore to ensure year-round availability, a storage period of 8 months is needed. The yam, like other root and tuber crops such as cassava and taro, suffers postharvest losses ranging from 25 to 60% (Coursey & Booth 1997; Lancaster & Coursey 1984; Asiedu 1986).

1.2 Storage Losses

Physiological damage of tubers will occur due to exposure to extremes of temperatures. In addition, the yam tubers should not be exposed to direct sunlight after harvest. Storage losses in yams are largely due to respiration as shown by (*Coursey et al 1966*). However, yams being of tropical origin will be affected by chilling injury when exposed to temperatures below 13 degree Celsius (*Kader et al , 1985)*

1.3 Harvesting Practices

Yams, like most other food crops, are not all consumed immediately after harvesting, and a considerable proportion of the crop has therefore to be stored, often for substantial periods. In modern times, the season during which new yams are available has to some extent been increased by improved communications between areas in which the harvest takes place at somewhat different times of the year. Nevertheless, storage is still of the greatest importance. Yams are normally harvested in any particular district only during a limited period of the year. It follows therefore that they must be stored at least for several months, that are from the end of one harvest to the beginning of the next, if they are to be available as food at all times. *(Coursey, 1967).*

1.4 Moisture Losses

As shown in appendix 1, wide variations occur in the moisture content of yams, both between one species and another, and also within a species. There are considerable differences between one part of an individual tuber and another. The moisture content of the tuber changes, both during its development and during the period of dormancy *(Coursey, 1967)*. During storage of the dormant tubers, only a slight reduction in moisture content takes place *(Coursey, 1961)*

1.5 Causes of loss in yam storage

In West Africa, the most favoured species is the white yam (*Dioscorea rotundata*) whereas worldwide, the most common species is the water yam (*D. alata*). Losses are due to a variety of disease and pests and to sprouting, but these losses can be reduced if proper care is taken. In West Africa the main crop of yams is harvested between September and November. Some of the harvest is eaten or taken to the market immediately. But most of the yams are stored to be eaten and marketed during the 6 months following harvest. (*Wilson,* 1985).

Yam is one of the non-traditional exportable and an important local staple in Ghana. Its storage life ranges 2-7 months for sound yams and this depends on the variety, the stage of maturity at harvest, mode of handling and storage. However the industry is beset with losses mainly due to rottenness through fungal infestation, carbohydrate loss through sprouting and moisture loss due to high respiratory rates due to the high ambient temperature. In the yam

tuber, sprout initial are formed beneath the periderm just prior to breakage of dormancy (Onwueme, 1973). The sprouting process, which accelerates the losses and limits storage life, starts with the appearance of the sprouting loci (Passam 1982; Wickham et al. 1984; Wickham 1988).

A summary of some experiments that was conducted to date to show very serious losses in weight during normal storage is in the appendix 2.

1.6 The importance of dormancy in yam storage

Dormancy is of major importance in yam storage because it determines the length of storage life. Once sprouting occurs protracted storage is no longer practicable. Secondly the suppression of endogenous metabolism during dormancy reduces the rate of loss of storage carbohydrate (Passam, 1977). Dormancy for most young varieties occurs between 1 to 2 months after harvest.

1.7 Percentage weight loss

In general terms it may be said on the basis of these observation that losses in weight of 10-15 per cent occur during the first three months of storage and that after six months which is not abnormally long storage period in many districts, the loss may be more than 30, or even approach 50 per cent. When the substantial proportion of yam crop that is stored for periods of several months is taken into consideration, it will be realised that the total quantity of yam lost during storage must be very large. (Coursey, 1965). In West Africa alone, quantity of edible yams approaching a million tons is lost annually. These

losses are not simply losses of water by desiccation as occur in some kinds of produce in storage but are, at least in part, real losses of dry matter that is of food.

The traditional system of yam storage has been found to be inadequate and should be improved to permit long-term storage of yam either on farm or outside farm gate.

Two popular varieties of yams were evaluated for the length of dormancy and shelf life storage at 20°C and 100% humidity.

1.8 OBJECTIVES

1. To find alternative method to suppress sprouting.
2. To evaluate the environ on storage duration.

2.0 MATERIALS AND METHODS

2.1 Materials

Two varieties of yams; *Dobare* and *Puna* of two different sizes from Techiman in the Brong Ahafo region of Ghana. The yams were stored at 20 degree Celsius and 100% relative humidity.

2.2 Method

The initial weights of the yam tubers were noted and grouped into two sizes of 25 tubers each for the big and small *Dobare* and 25 tubers for the big *Puna* and 24 for the small *Puna*. They ranged as

Puna 1-1.5kg (small); 1.7-2.5kg (large)

Dobare 1.5-2.0kg (small); 2.2-3.2kg (large)

There were 25 tubers each of the big and small *Dobare* 25 tubers of the big *Puna and* 24tubers of the small *Puna*. The tubers were observed weekly and their weights taken. The deteriorated tubers were discarded. Any sign of sprouting were noted down and the buds removed manually as done traditionally. The experiment which was initiated on the 11th of November 1996 ended on 5th May 1997 for the big size *Puna* and *Dobare* tubers whilst for the small size tubers ended on the 19th of May 1997.

3.2 Losses in weight

There was a very serious loss in weight for each of the varieties during the storage period. Inspite of the generally held opinion that yams suffer little deterioration during storage.

The comparatively few experiments that were conducted to date have shown that very serious losses in weight occur during normal storage. The changes in fresh weight of the yam are highly dependent on species and cultivar.

Brown (1931) has suggested that the heavy weight losses that occur in stored yams are simply the result of a process called desiccation. Desiccation caused by evaporation of water is physical of importance in yam storage. Yams are stored mainly through the dry season, and considerable loss of water might reasonably be expected, especially in view of the high moisture content - usually well over 50 per cent of the tubers.

3.2.1 Changes in stored yams

Sprouting in yam lead to change in taste, loss in weight, shrivelling of skin and utilisation of stored carbohydrate with subsequent monetary losses. The sprouting of yams were suppressed in this case by resorting to manual removal by cutting the growing buds. Although this method is tedious and temporal, it still causes losses in taste, appearance and weight however it helped the yams keep for a longer time. The length of dormancy, the growth of sprouts and the decrease in weight during sprouting are factors which most affect the final losses (Girardin 1996). Successful yam storage depends on adequate ventilation, so that the natural respiratory metabolism of the tubers is not

impaired. Selection of sound, undamaged material for storage is important to extend shelf- life. Damaged or partially rotten tubers are best reserved for immediate consumption and processing. Physical protection from rodents and termites may be necessary in some districts.

3.3 Percentage weight loss during storage

From Fig. 1 the small sized *Dobare* variety showed a higher percentage weight loss compared to the small sized *Puna* variety. The value for the highest percentage weight loss for the *Dobare* variety is 21.88% whilst that for the *Puna* variety is 16.16%. For the *Dobare*, 2.69% is the lowest percentage weight loss and 1.76% for the *Puna* variety. For the small sized *Dobare* variety, there was a progressive increase in percentage weight loss for the first 18 weeks thereafter, the percentage weights loss decreased. In the *Puna* variety, the increase in percentage weight loss was up to the 17^{th} week of storage and this then reduced for the subsequent weeks. The percentage of weight loss is shown in Figures 1-4. The small sized *Dobare* variety showed a higher percentage loss compared to the small *Puna* variety.

In the case of both the large- sized *Puna* and *Dobare* variety (Fig. 2) the percentage weight loss increased till the 14^{th} week, whilst that of the *Dobare* variety started after the 19^{th} week.

In general, the study showed that the rate of percentage weight loss was faster in the small sized yams than in the large sized yams . The percentage weight loss of the large-sized *Puna* increased rapidly till the 14^{th} week of storage and

Fig 1 Percentage Weight Losses of Small sized Puna and Dobare Yam varieties during Storage at 20°C

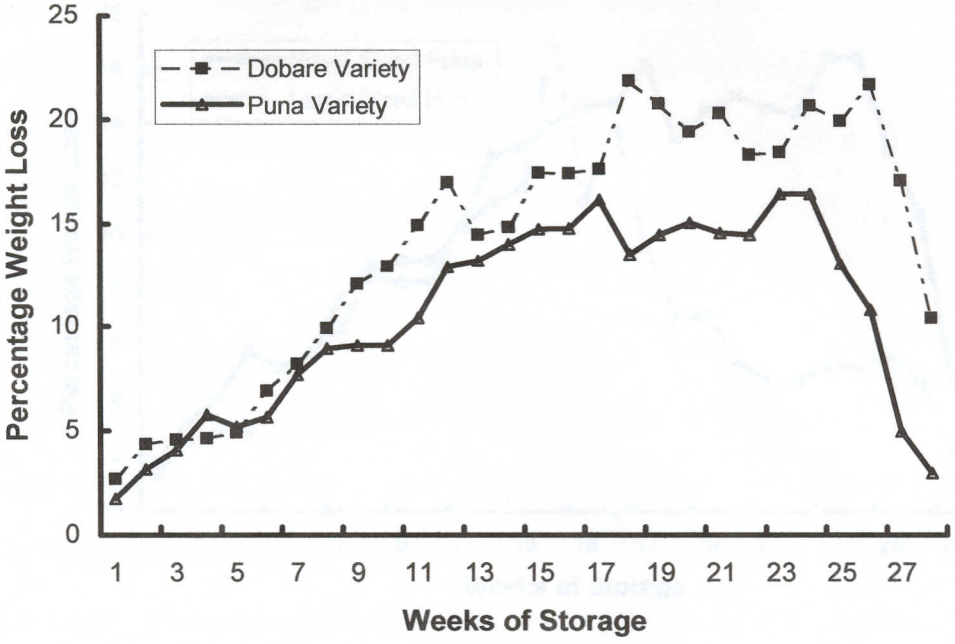


Fig. 2 Percentage Weight Losses of large sized Puna and Dobare yam varieties During Storage at 20°C

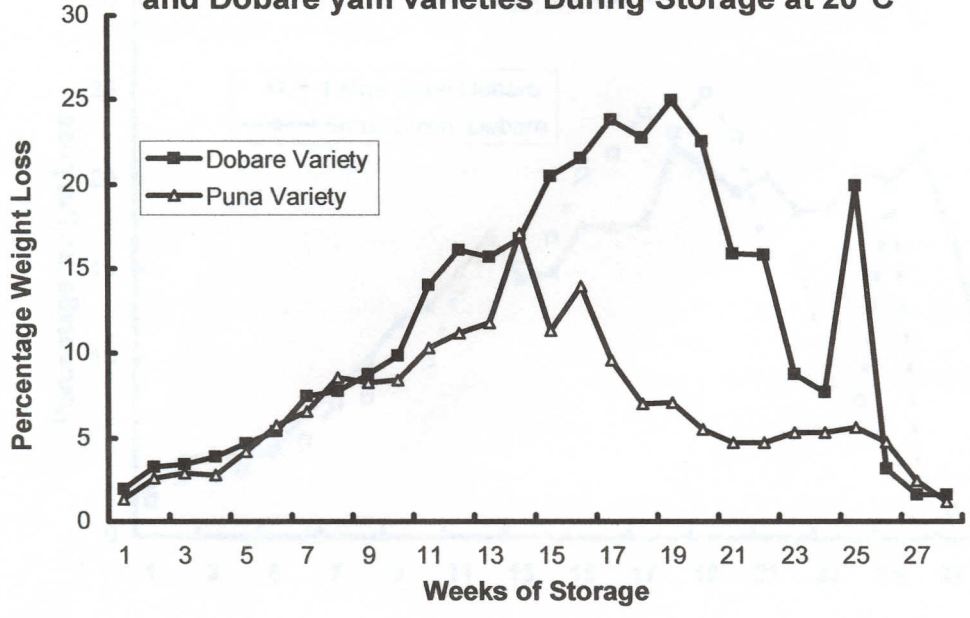


Fig.3 Comparative Percentage Weight Losses of Small and Large sized Puna Yam varieties during Storage at 20°C

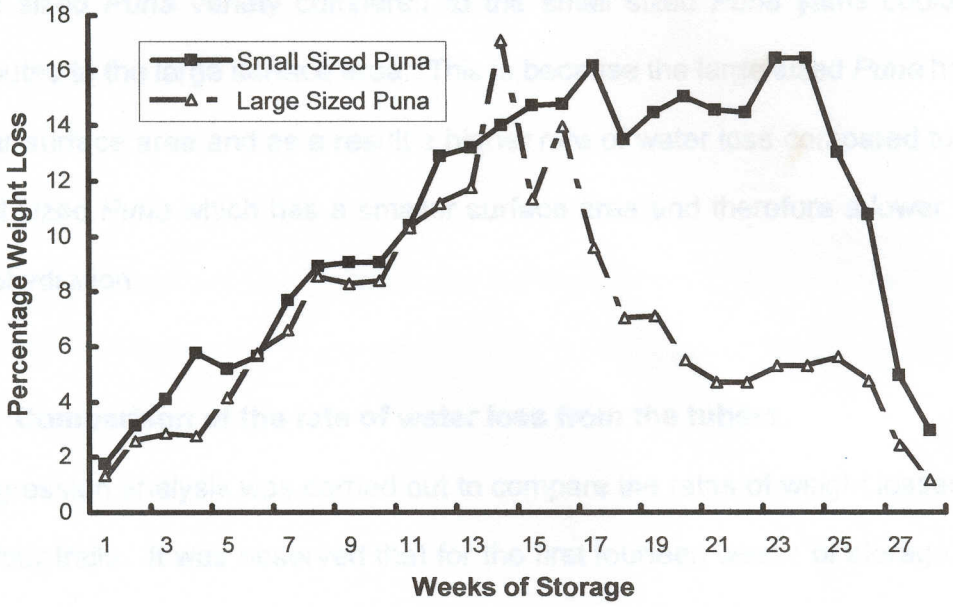
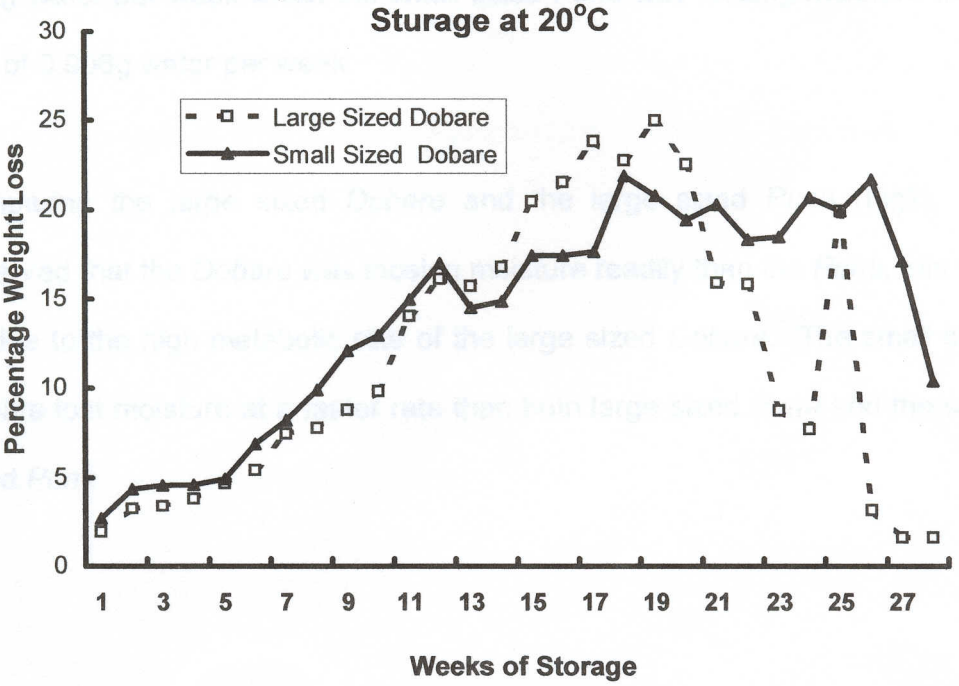


Fig.4 Comparative Percentage Weight Losses of Small and Large sized Dobare Yam varieties during Sturage at 20°C



then declined gradually till the 28th week of storage. The value for the highest percentage weight loss in the large- sized *Puna* yam is 17.07% whilst that of the small sized *Puna* is 16.16% (Fig.3). The high rate of weight loss in the large sized *Puna* variety compared to the small sized *Puna* yams could be attributed to the large surface area. This is because the large sized *Puna* has a larger surface area and as a result a higher rate of water loss compared to the small sized *Puna* which has a smaller surface area and therefore a lower rate of dehydration.

3.4 Comparison of the rate of water loss from the tubers.

A regression analysis was carried out to compare the rates of weight losses for the four trails. It was observed that for the first fourteen weeks of storage, the large sized *Dobare* was loosing moisture at the rate of 1.12g water per week. On the other hand, the large sized *Puna* was loosing moisture at the rate of 1.02g water per week whilst the small sized *Puna* was loosing moisture at the rate of 0.906g water per week.

Comparing the large sized *Dobare* and the large sized *Puna* (Fig2), it is observed that the *Dobare* was loosing moisture readily than the *Puna*, this may be due to the high metabolic rate of the large sized *Dobare*. The small sized *Dobare* lost moisture at a faster rate than both large sized *Puna* and the small sized *Puna*.

It can therefore be inferred from the regression that the *Dobare* variety has the tendency to lose moisture readily due to its high metabolic activities. From the data collected, it can be deduced that the *Dobare* variety got rotten along the weeks of storage, this could be due to its high metabolic activity, whilst the *Puna* variety stayed longer probably due to its low metabolic rate. The total loss is mainly determined by growth of sprouts and the reduction in weight after onset of sprouting which are highly dependent on species and cultivar.

It is rather the avoidance of excessively high temperatures and the provision of adequate ventilation that appear to be of the greatest importance in successful yam storage (Coursey, 1967).

4.0 CONCLUSION

The *Dobare* yam losses more moisture readily than the *Puna* yam. This may be due to a higher metabolic rate in the *Dobare* and the high tendency of sprouting than in *Puna*.

This study indicates the *Dobare* variety has a less storage potential than *Puna* variety. The surface area- volume ratio also had a negative effect on the bigger sized yams.

Further work

A modified storage structure has been constructed and this will be evaluated for its cost, and storage effectiveness.

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APPENDIX 1

Summary of proximate analyses of yam tubers (Proximate Composition of Yam tubers)

Species	*Moisture Content %*	*Carbohydrate %*	*Crude Protein %*	*Crude Fibre %*	*Fat %*	*Ash %*
Alata	*65-73*	*22-29*	*1.12-2.78*	*0.65-1.40*	*0.03-0.27*	*0.67-2.06*
Cayenesis	*83*	*15*	*1.02*	*0.40*	*0.05*	*0.53*
Rotundata	*58-73*	*23*	*1.09-1.99*	*0.35-0.79*	*0.12*	*0.68-2.56*
Opposita	*70-80*	*16-29*	*1.11-3.10*	*0.33-1.00*	*0.06-1.10*	*0.69-1.10*
Esculenta	*67-81*	*17-25*	*1.29-1.87*	*0.18-1.51*	*0.04- 0.29*	*0.50-1.24*
Bulbifera	*63-67*	*27-33*	*1.12-1.50*	*0.70-0.73*	*0.04*	*1.08-1.51*
Dumetorum	*79*	*17*	*2.78*	*0.30*	*0.28*	*0.72*
Hispida	*78*	*18*	*1.81*	*o.93*	*0.16*	*0.69*
Trifida	-	*38*	*2.54*	-	*0.44*	-

APPENDIX 2

Percentage weight loss during storage.

Country of origin	Species	1 months	2 months	3months	4 months	5 months	6 months	8 months	Reference
Puerto Rico	Guinea yam	1	3	8	sound tubers				Anon, 1938
Trinidad	D. alata	-	-	-	-	-	-	30- 40	Campbell *et al* 1962b
Nigeria	D.rotundata	-	-	-	-	-	50	-	Anon, 1959
Trinidad	D. alata	-	-	-	7-23	-	-	-	Gooding, 1960
Nigeria	D. rotundata	5	7	12	20	29	-	-	Coursey, 1961
Nigeria	D. cayenesis	6	17	29	39	48	-	-	Coursey, 1961
Ghana	D. rotundata	1	5-7	15-17	26-27	34-40	-	-	Rawnsley, unpublished work

Treated with Methyl Alpha Naphthyl Acetate to inihibit Germination

Variety : PUNA
Source : Techiman
Size : Small
Starting Date: 1ST November, 1996

APPENDIX III

ID. No	Weight of variety	11-08-96	15/11/96	22/11/96	29/11/96	12-09-96	16/12/96	23/12/96	30/12/96
1	1.55	1.55	1.5	1.5	1.5	1.45	1.45	1.4 (sprouted)	1.45
2	1.9	1.9	1.9	1.85	1.85	1.85	1.85	1.8	1.8
3	1.35	1.3	1.3	1.3	1.3	1.3	1.3	1.25	1.25
4	1.7	1.65	1.65	1.65	1.65	1.6	1.6	1.6	1.55
5	1.25	1.25	1.2	1.2	1.2	1.2	1.2	1.15	1.15
6	1.35	1.35	1.35	1.35	1.35	1.3	1.3	1.3	1.25
7	1.15	1.1	1.1	1.1	1.1	1.1	1.1	1.05	1.05
8	1.05	1	1	1	1	0.95	0.95	0.95	0.95
9	1.45	1.45	1.4	1.4	1.4	1.4	1.35	1.35	1.35
10	1.35	1.35	1.3	1.25	1.25	1.2	1.2	1.2	1.15
11	1.4	1.4	1.35	1.35	1.35	1.35	1.35	1.3	1.3
12	1.45	1.45	1.4	1.4	1.4	1.4	1.4	1.35	1.35
13	1.75	1.75	1.7	1.7	1.7	1.7	1.7	1.65	1.65
14	1.7	1.7	1.65	1.65	1.65	1.65	1.6	1.6	1.6
15	1.45	1.4	1.4	1.35	1.35	1.35 (sprouted)	1.3	1.3	1.3
16	1.35	1.35	1.3	1.3	1.3	1.3	1.25	1.25	1.2
17	1.75	1.7	1.65	1.65	1.65	1.6	1.6	1.6	1.55
18	1.7	1.7	1.7	1.65	1.65	1.65	1.65	1.6	1.6
19	1.15	1.1	1.1	1.1	1.1	1.1	1.1	1	1
20	1	1	1	0.95	0.95	0.95	0.95	0.9	0.9
21	1.5	1.45	1.45	1.45	1.45	1.45	1.4	1.4	1.35
22	1.3	1.25	1.25	1.25	1.25	1.2	rotten	rotten	rotten
23	1.15	1.15	1.15	1.1	1.1	1.1	1.05	1.05	1.05
24	0.9	0.85	0.85	0.85	0.85	0.85	0.8	0.8	0.8

01-06-97	13/1/97	20/1/97	27/1/97	02-03-97	02-10-97	17/2/97	24/2/97	03-03-97	03-10-97	17/3/97	24/3/97
1.4	1.4	1.4	1.35	1.35	1.35	1.35	1.3	1.3	1.25	1.25	rotten
1.8	1.8	1.75	1.75	1.7	1.7	1.7	1.65	1.55	rotten	rotten	rotten
1.25	1.25	1.2	1.2	1.2	1.15	1.15	1.15	1.1	1.1	1.1	1.1
1.55	1.55	1.5	1.5	1.45	1.45	1.45	1.45	1.4	1.4	1.35	1.35
1.15	1.15	1.1	1.1	1.05	1.05	1.05	1.05	1.05	1.05	0.95	0.95
1.25	1.25	1.2	1.2	1.2	1.15	1.15	1.15	1.1	1.1	1.05	1.05
1.05	1.05	1	1	1	0.95	0.95	0.95	0.9	0.9	0.85	0.85
0.9	0.9	0.9	0.85	0.85	0.8	0.8	0.8	0.8	rotten	rotten	rotten
1.3	1.3	1.3	1.25	1.25	1.25	1.25	1.25	1.25	1.2	1.2	1.2
1.15	1.15	1.1	1.1	1.1	1.1	1.05	1.05	0.95	rotten	rotten	rotten
1.3	1.3	1.2	1.2	1.2	1.15	1.15	1.15	1.15	1.15	1.15	1.15
1.35	1.35	1.25	1.25	1.25	1.2	1.2	1.2	1.2	rotten	rotten	rotten
1.65	1.65	1.6	1.6	1.6	1.55	1.55	1.55	1.4	1.4	1.35	1.3
1.55	1.55	1.55	1.5	1.5	1.5	rotten	rotten	rotten	rotten	rotten	rotten
1.3	1.2	1.2	1.2	1.15	1.15	1.15	1.1	1.05	1.05	1	1
1.2	1.2 (sprouted)	1.15	1.15	1.15	1.1	1.1	1.1	1.1	1.05	1.05	1.05
1.55	1.55	1.55	1.5	1.5	1.45	1.45	1.45	1.4	1.4	1.35	1.35
1.55	1.55	1.55	1.45	1.45	1.4	1.4	1.35	1.3	1.3	1.25	1.2
1	1	0.95	0.95	0.95	0.9	0.9	0.95	0.95	0.9	0.9	0.9
0.85	0.85 (sprouted)	0.85	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
1.35	1.35 (sprouted)	1.35	1.3	1.3	1.25	1.25	1.25	1.25	1.2	1.2	1.2
rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten
1	1	1	0.95	0.95	0.95	0.95	0.8	0.8	0.8	0.8	0.8
0.8	0.8	0.75	0.75	0.75	0.7	0.7	0.7	0.7	0.7	0.7	0.7

30/3/97	04-07-97	14/4/97	21/4/97	28/4/97	5/597	05-12-97	19/5/97
rotten	rotten	rotten	rotten	rotten	rotten		
rotten	rotten	rotten	rotten	rotten	rotten		
1.05	1	1	1	1	rotten		
1.35	1.3	1.25	1.25	1.25	rotten		
0.95	0.95	rotten	rotten	rotten	rotten		
1.05	1	1	0.9	rotten	rotten		
0.85	rotten	rotten	rotten	rotten	rotten		
rotten	rotten	rotten	rotten	rotten	rotten		
1.2	1.15	1.1	1.1	1.1	1.1	0.95	0.95
rotten	rotten	rotten	rotten	rotten	rotten		
1.15	1.1	1.1	1.05	rotten	rotten		
rotten	rotten	rotten	rotten	rotten	rotten		
1.3	1.3	1.2	1.2	1.2	1.2	1.1	1.1
rotten	rotten	rotten	rotten	rotten	rotten		
1	0.95	rotten	0.95	0.95	rotten		
1.05	1.05	1	1.2	1.2	rotten		
1.35	1.3	1.25	rotten	rotten	rotten		
1.2	1.15	rotten	rotten	rotten	rotten		
0.9	0.9	rotten	rotten	rotten	rotten		
0.8	0.8	0.75	0.75	0.7	rotten		
1	1	1	1	rotten	rotten		
rotten	r	rotten	rotten	rotten	rotten		
0.8	0.8	0.8	rotten	rotten	rotten		
0.7	0.7	rotten	rotten	rotten	rotten		

Variety : PUNA
Source: Techiman
Size: Big
Starting Date: 1st November,1996

APPENDIX IV

ID.No	Intial weight of variety	11-08-96	15/11/96	22/11/96	29/11/96	12-09-96	16/12/96	23/12/96	30/12/96
1	2.15	2.1	2.1	2	rotten	rotten	rotten		
2	1.75	1.7	1.7	1.7	1.7	1.7	1.65	1.65	1.65
3	1.7	1.65	1.65	1.65	1.65	1.65	1.6	1.6	1.6
4	2	2	1.95	1.95	1.95	1.95	1.9	1.9	1.9
5	1.55	1.55	1.55	1.55	1.55	1.5	1.5	1.5	1.45
6	1.6	1.6	1.6	1.6	1.6	1.6	1.55	1.55 (sprouted)	1.55
7	2.4	2.35	2.35	2.35	2.35	2.35	2.3	2.3	2.25
8	1.8	1.75	1.75	1.75	1.75	1.7	1.7	1.65	1.65
9	1.6	1.6	1.55	1.55	1.55	1.5	1.5	1.45	1.45
10	1.25	1.25	1.2	1.2	1.2	1.2	1.1	1.1	1.1
11	1.65	1.6	1.6	1.6	1.6	1.6	1.5(sprouted)	1.55	1.5
12	1.65	1.6	1.6	1.55	1.55	1.5	1.5	1.45	1.45
13	2.1	2.1	2.05	2.05	2.05	2.05	2	2	2
14	2.45	2.45	2.4	2.4	2.35	2.3 (sprouted)	2.25 (sprouted)	2.2	2.2
15	1.9	1.9	1.85	1.85	1.85	1.85	1.85	1.8	1.8
16	2.4	2.35	2.35	2.35	2.35	2.3	2.3	2.25	2.25
17	2.4	2.4	2.35	2.35	2.35	2.35	2.35	2.35	2.3
18	2	1.95	1.9	1.9	1.9	1.9	1.85	1.8	1.8
19	2.6	2.55	2.55	2.55	2.55	2.5	2.5	2.45	2.45
20	1.65	1.65	1.6	1.6	1.6	1.55	1.55	1.5	1.5
21	1.75	1.75	1.7	1.7	1.7	1.7	1.65	1.6 (sprouted)	1.6
22	1.25	1.25	1.2	1.2	1.2	1.1	1.1	1.1	1.05
23	1.9	1.85	1.85	1.85	1.85	1.75	1.7	1.7	1.7
24	1.75	1.7	1.7	1.7	1.7	1.7	1.65	1.65	1.65
25	1.95	1.9	1.9	1.9	1.9	1.9	1.9	1.8	1.8

03-10-97	17/3/97	24/3/97	30/3/97
rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten
1.4	1.4	1.35	1.35
1.6	1.6	1.6	1.6
rotten	rotten	rotten	rotten
1.2	1.2	1.2	1.2
rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten
1.2	rotten	rotten	rotten
rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten
1.25	rotten	rotten	rotten
1.8	1.8	1.75	1.75
rotten	rotten	rotten	rotten
1.6	1.55	1.5	1.5
rotten	rotten	rotten	rotten
1.95	1.9	1.85	1.85
rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten

04-07-97	14/4/97	21/4/97	28/4/97	05-05-97
rotten	rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten	rotten
1.25	1.25	1.2	1.2	rotten
1.55	1.45	1.45	1.4	rotten
rotten	rotten	rotten	rotten	rotten
1.2	1.1	1.1	1.1	rotten
rotten	rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten	rotten
1.7	1.6	1.6	1.6	rotten
rotten	rotten	rotten	rotten	rotten
1.45	1.45	1.35	1.35	rotten
rotten	rotten	rotten	rotten	rotten
1.8	1.7	1.65	1.65	rotten
rotten	rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten	rotten
rotten	rotten	rotten	rotten	rotten

Variety : Dobare
Source : Techiman
size: Small
Starting Date: 1st November,1996

APPENDIX V

ID. No	Initial weight	11-08-96	15/11/96	22/11/96	29/11/96	12-09-96	16/12/96	23/12/96	30/12/96	01-06-97	13/1/97	20/1/97	27/1/97
1	2	1.95	1.9	1.9	1.9	1.9	1.9(sprouted)	1.85	1.85	1.75	1.6	1.6	1.55
2	2	1.95	1.95	1.95	1.95	1.95	1.95 (sprouted)	1.85	1.85	1.85	1.85	1.7	1.7
3	1.7	1.65	1.6	1.6	1.6	1.6	1.55	1.55	1.55	1.5	1.5	1.4	1.4
4	1.85	1.8	1.75	1.75	1.75	1.7	1.7	1.65	1.65	1.65	1.55	1.5	1.5
5	1.9	1.85	1.8	1.8	1.8	1.8	1.8(sprouted)	1.7	1.7	1.7	1.65	1.6	1.6
6	1.85	1.75	1.7	1.65	1.6	1.6	1.6	1.55	1.55	1.45	1.45	1.4	1.4
7	1	0.95	0.95	0.95	0.95	0.95 (sprouted)	0.9(sprouted)	0.85	0.85	0.85	0.8	0.8	0.7
8	1.6	1.6	1.55	1.55	1.55	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.3
9	1.65	1.6	1.6	1.6	1.6	1.6	1.55	1.55	1.55	1.5	1.5	1.45	1.45
10	1.75	1.7	1.65	1.65	1.65	1.65	1.65	1.5	1.5	1.5	1.5	1.45	1.45
11	1.65	1.6	1.6	1.6	1.6	1.6	1.55	1.55	1.55	1.5	1.5	1.45	1.45
12	1.7	1.65	1.65	1.65	1.65	1.65(sprouted)	1.6(sprouted)	1.55	1.55	1.55	1.5	1.5	1.4
13	1.65	1.65	1.6	1.6	1.6	1.6	1.6	1.55	1.55	1.5 sprouted	1.5	1.5	1.45
14	1.6	1.6	1.55	1.55	1.55	1.55	1.5	1.5	1.5	1.5	1.45	1.45	1.45
15	1.7	1.65	1.55	1.55	1.55	1.55	1.5	1.5	1.5	1.5	1.45	1.4	1.4
16	1.8	1.8	1.75	1.75	1.75	1.7	1.65	1.65	1.65	1.6(sprouted)	1.6	1.6	1.55
17	2.2	2.2	2.15	2.1	2.1	2.1	2.1	2.1	2.1	2.1 (sprouted)	2	2	2
18	2.35	2.2	2.2	2.2	2.15	2.15	2.1	2.05	2.05	2.05 (sprouted)	2	1.9	1.9
19	1.4	1.35	1.3	1.3	1.3	1.3	1.3	1.25	1.25	1.25 (sprouted)	1.2	1.2	1.2
20	2.05	1.95	1.95	1.95	1.95	1.9	1.9	1.85	1.85	1.8	1.8	1.75	1.75
21	2.2	2.15	2.1	2.1	2.1	2.1	2.1	2.1	2.05	2.05	2	1.9	1.9
22	1.95	1.9	1.9	1.9	1.9	1.85	1.85	1.8	1.8	1.8	1.7	1.7	1.65
23	1.9	1.85	1.85	1.85	1.85	1.8	1.8	1.75	1.75	1.75	1.6	1.6	1.6
24	1.65	1.6	1.55	1.55	1.55	1.55	1.55	1.45	1.45	1.4	1.4	1.4	1.35
25	1.5	1.45	1.45	1.45	1.45	1.4	1.4	1.4	1.4	1.4(sprouted)	1.35	1.35	1.3

02-03-97	02-10-97	17/2/97	24/2/97	3/397	03-10-97	17/3/97	24/3/97	30/3/97	04-07-97	14/4/97	21/4/97	28/4/97	05-05-97	05-12-97	19/5/97
1.55	1.55	1.5	1.5	1.45	1.45	1.3	1.3	1.25	1.25	1.2	1.2	1.15	1.5	1	1
1.65	1.65	1.6	1.6	1.55	1.55	1.45	1.45	1.2	rotten	rotten	rotten	rotten	rotten	rotten	rotten
1.4	1.35	1.2	1.2	1.15	1.15	1.1	1.1	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8
1.5	1.5	1.4	1.4	1.4	1.3	1.3	1.3	1.25	1.2	1.2	1.15	1.15	1.15	1.1	1.1
1.6	1.55	1.55	1.5	1.5	1.4	1.35	1.35	1.35	1.35	1.3	1.3	1.25	1.25	1.15	1.15
1.4	1.4	1.25	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten
0.7	0.7	0.7	0.65	0.65	0.6	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten
1.3	1.3	1.3	1.25	1.25	1.15	1.15	1.1	1.1	1.1	1.1	1.1	1	1	1	0.95
1.4	1.4	1.35	1.35	1.3	1.3	1.2	1.2	1.1	1.1	1.1	1.1	1.05	1.05	rotten	rotten
1.45	1.45	1.4	1.35	1.35	1.2	1.2	1.15	1.2	1.2	1.2	1.15	1.15	1.15	1.1	1.1
1.45	1.3	1.3	1.3	1.3	1.25	1.25	1.25	1.15	1.15	1.1	1.1	1.1	1.1	rotten	rotten
1.4	1.4	1.4	1.4	1.3	1.3	1.25	1.25	1.2	1.2	1.2	1.15	1.15	1.15	rotten	rotten
1.45	1.45	1.45	1.4	1.4	1.3	1.3	1.3	1.2	1.2	1.2	1.15	1.15	1.15	1	1
1.4	1.4	1.3	1.25	1.25	1.15	1.1	1.1	1.1	1.1	1.1	1.1	1	1	0.85	0.85
1.35	1.35	1.25	1.2	1.2	1.1	1.1	1.1	1	rotten	rotten	rotten	rotten	rotten	rotten	rotten
1.5	1.5	1.5	1.5	1.4	1.35	1.35	1.3	1.3	1.3	1.3	1.3	1.25	1.25	rotten	rotten
1.95	1.95	1.9	1.75	1.75	1.7	1.7	1.7	1.6	1.6	1.55	1.5	1.5	1.5	rotten	rotten
1.9	1.85	1.7	1.65	1.65	1.5	1.5	1.5	1.35	1.3	1.2 rotten	rotten	rotten	rotten	rotten	rotten
1.2	1.15	1.1	1.1	1.05	1	1	1	1	1	0.95	0.95	0.95	0.9	0.9	0.85
1.7	1.7	1.65	1.6	1.6	1.6	1.4	1.4 rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten
1.9	1.85	1.75	1.65	1.65	1.65	1.5	1.5	1.4	1.4	1.35	1.3	1.3	1.25	1.1	1.1
1.65	1.65	1.6	1.55	1.55	1.4	1.4	1.4	1.35	1.35	1.3	1.3	1.25	1.15	1.15	1.15
1.55	1.55	1.45	1.4	1.4	1.4	1.25	1.2	1.2	1.2	1.2	1.15	1.15	1.15	0.95	0.95
1.35	1.35	1.3	1.3	1.3	1.25	1.25	1.2	1.15	1.15	1.15	1.1	1.1	1	0.95	0.95
1.3	1.3	1.25	1.2	1.2	1.15	1.05	1	1	1	1	0.95	0.95	0.95	0.8	0.8

27/1/97
1.4
1.95
2.3
2.6
2.15
2.75
2.5
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2.1
1.85
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1.65
2.25
2
2.05
3.55
1.8
1.4
1.7
2.15
1.5
2.75
2.75

02-03-97	02-10-97	17/2/97	24/2/97	03-03-97	03-10-97	17/3/97	24/3/97	30/3/97	04-07-97	14/4/97	21/4/97	28/4/97	05-03-97
1.35	1.35	1.25	1.25	1.2	1.2	1.15	1.15	1.05	1.05	0.95	0.9	0.9	rotten
1.9	1.9	1.75	1.75	1.65	1.65	1.6	1.6	rotten	rotten	rotten	rotten	rotten	rotten
2.3	2.25	2.15	2.15	2	2	1.8	1.8 rotten	rotten	rotten	rotten	rotten	rotten	rotten
2.6	2.55	2.45	1.45	2.2	2	1.85	1.85 rotten	rotten	rotten	rotten	rotten	rotten	rotten
2.15	2.15	2	1.95	1.85	1.85	1.75	1.75	1.6	1.6	1.55	rotten	rotten	rotten
2.7	2.7	2.55	2.5	2.5	2.3	2.3	2.3	2.2	2.2	2.2	2.1	rotten	rotten
2.4	2.35	2.2	2.15	2.1	2.1	1.95	1.9	rotten	rotten	rotten	rotten	rotten	rotten
2.05	2.05	1.8	1.8	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten
2.1	2.1	1.95	1.85	1.7	1.9	1.7	1.65	1.55	1.55	1.5	1.45	1.4	rotten
1.85	1.85	1.7	1.65	1.55	1.5	1.5	rotten	rotten	rotten	rotten	rotten	rotten	rotten
2.25	2.2	2.1	2.1	1.95	1.95	1.8	1.75 rotten	rotten	rotten	rotten	rotten	rotten	rotten
3.45	3.45	3.2	3.1	2.9	2.9	2.75	2.75	2.6	2.6	2.5	rotten	rotten	rotten
1.8	1.8	1.7	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten
1.65	1.65	1.6	1.6	1.55	1.55	1.4	1.4	1.35	1.35	1.3	1.25	1.25	rotten
2.25	2.2	2.15	2.1	2.05	2.05	1.95	1.95	1.8	1.8	1.75	1.7	1.7	1.65 rotten
2	2	1.8	1.75	1.75	1.75	1.7	1.7	1.55	1.5	rotten	rotten	rotten	rotten
2.05	2.05	2	1.95	1.85	1.85	1.75	1.75	1.4	1.4	rotten	rotten	rotten	rotten
3.55	3.55	3.3	3.3	3.15	3.05	2.95	2.95	rotten	rotten	rotten	rotten	rotten	rotten
1.75	1.75	1.65	1.6	1.5	1.5	1.45	1.45	1.3	1.3	rotten	rotten	rotten	rotten
1.4	1.4	1.25	1.25	1.2	1.1	1.1	1.05	rotten	rotten	rotten	rotten	rotten	rotten
1.7	1.65	1.65	1.6	1.55	1.5	1.45	1.45	1.3	1.25	rotten	rotten	rotten	rotten
2.15	2.1	2	1.9	1.75	1.75	1.65	rotten	rotten	rotten	rotten	rotten	rotten	rotten
1.5	1.45	1.4	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten	rotten
2.65	7.65	2.55	2.5	2.45	2.4	2.25	2.2	1.9	1.9	1.9	1.9	1.85	rotten
2.75	2.75	2.5	2.3	2.1	2.05	1.9	1.9 rotten	rotten	rotten	rotten	rotten	rotten	rotten