EFFECTS ON SEED QUALITY OF CHANGES IN CULTURAL SEED SAVING TECHNIQUES UNDER GHANAIAN CONDITIONS

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SUMMARY AND CONCLUSIONS

The three trials presented in this report are preliminary in scope but show clearly that there is the potential to develop a series of best practices from amongst the techniques already used by small farmers for seed storage.

Specifically the trials have shown that:

- Maize germination is maximised when it is harvested after physiological maturity, when moisture content has fallen below 16%.

- Maize seeds may maintain better viability when they are stored in conditions where temperature variations are kept to a minimum.

- Maize seeds that have been shelled and treated with insecticide show highest germination levels (although this was not compared with cobs treated with insecticide). Insect attack had the greatest effect on germination of all the factors considered.

- Cowpeas that are left unthreshed show better germination than threshed cowpeas. This observation may need to be clarified after studying the relative merits of both insecticidal and traditional admixtures.

These trials were relatively cheap to set up and easy to manage. They have provided some basic, though incomplete, information that could usefully be included in extension messages aimed at small scale farmers. Further trials of the type used here should be set up to examine the full range of farmer techniques and combinations of techniques so as to be able to develop the most appropriate seed saving technologies for on-farm use.

INTRODUCTION

1. This report forms part of an on-going research programme, funded through the Overseas Development Administration, examining aspects of the traditional seed sector and factors influencing germination decline during seed storage.

2. The majority of seeds used by Ghanaian farmers are derived from their own stocks saved from previous seasons. Although the germination percentage of these seeds is generally good there is a considerable range in the quality of home saved seeds(Wright *et al*, 1995).

3. A wide range of cultural practices are currently followed by farmers and some preliminary trials were begun to compare the efficacy of these practices in maintaining seed germination potential so that those showing the most promise could be included in future, more detailed, trials prior to them being included in an extension package of best practices.

4. Trials were therefore undertaken with collaborators in Ghana to examine the effect of various factors on subsequent seed viability. Trials were run by staff of the Ghana Seed Inspection Unit (GSIU) in Accra and by the Grains and Legume Development Board (GLDB) in Kumasi.

5. Three distinct trials were initiated:

Expt. 1 - to determine the optimal period for seed grain harvesting to minimise germination decline during storage (maize).

Expt. 2 - to determine the quantitative difference between farmer storage systems and ideal conditions in terms of germination decline (maize).

Expt. 3 - to determine the relative advantages of simple changes to the seed storage system (maize and cowpea).

GSIU had responsibility for Experiment 2 (Germination changes during storage) and Experiment 3 (Changes in storage trial, maize).

GLDB were responsible for Experiment 1 (Harvest time trial) and Experiment 3 (Changes in storage trial, cowpea).

6. In all experiments, germination percentage was determined using standard ISTA (1993) procedures.

7. The statistical analyses were all carried out on the mean of four germination replicates (each of 100 seeds). All data was transformed using the angular transformation and subjected to analysis of variance using the GENSTAT statistical package. Unless otherwise stated in the text statistical significance implies a significance probability of at least 5%.

<u>EXPERIMENT 1</u> - Effect of harvesting time on germination decline in maize.

Objective: To determine the optimal period for seed grain harvesting to minimise germination decline during storage.

Method

8. Two improved maize varieties, Dorke and Obatanpa were used for the trial. They were available from the fields of the GLDB's Foundation Seed Farms at New Bomfa and Akomadan respectively. The maize had been planted between the 18-28 July 1994. Cobs from each of the varieties were collected at four different stages of maturity:

2 weeks before physiological maturity

harvest at physiological maturity

2 weeks after physiological maturity

4 weeks after physiological maturity

9. Physiological maturity was assumed to correspond to the nominal maturity period (95 and 105 days for Dorke and Obatanpa respectively). At each of the four sample stages, 150 cobs were harvested at random, the central third of each cob shelled, and the grains mixed well. 400 seeds were taken at random for the working sample (4 replicates of 100 seeds). The remaining seeds were stored in cotton mini-bags and kept protected in an inside store i.e. under ambient conditions for subsequent monthly sampling.

10. At each monthly sampling, the remaining seeds were mixed well in their bags and 400 seeds randomly removed as the working sample. The moisture content and germination percentage were determined using ISTA procedures. The seeds

were grown out on a paper substrate, kept at a temperature of 25-30°C and seedlings assessed after 8 days.

Results

11. The full data set is given in Annex 1. A summary of results is given in Tables 1-2 and shown in Figures 1-2 for Obatanpa and Dorke respectively. In the analysis, the 3-way interaction (i.e. variety x harvest time x stage) is used as the residual term against which all effects are compared.

- Both varieties show the same trends, although Obatanpa has better germination than Dorke (mean germinations of 86.8% and 84.6% respectively; $p<0.001$).

- No significant germination decline was noted over the time frame used in this trial.

- Germination potential is maximised if seeds are harvested after physiological maturity ($p<0.001$). Both varieties show a significantly higher germination, at harvest time, for seeds selected at 2 weeks (mean germination - 94.3%) and 4 weeks (mean germination - 96.2%) after maturity as compared to those selected at physiological maturity or before.

- Seeds selected at 4 weeks after maturity are significantly better than those chosen at 2 weeks after maturity. However, the performance of seeds selected at these two times becomes indistinguishable after 12 weeks of storage.

- The superior germination associated with later selection remains a constant feature for at least 24 weeks storage ($p<0.001$).

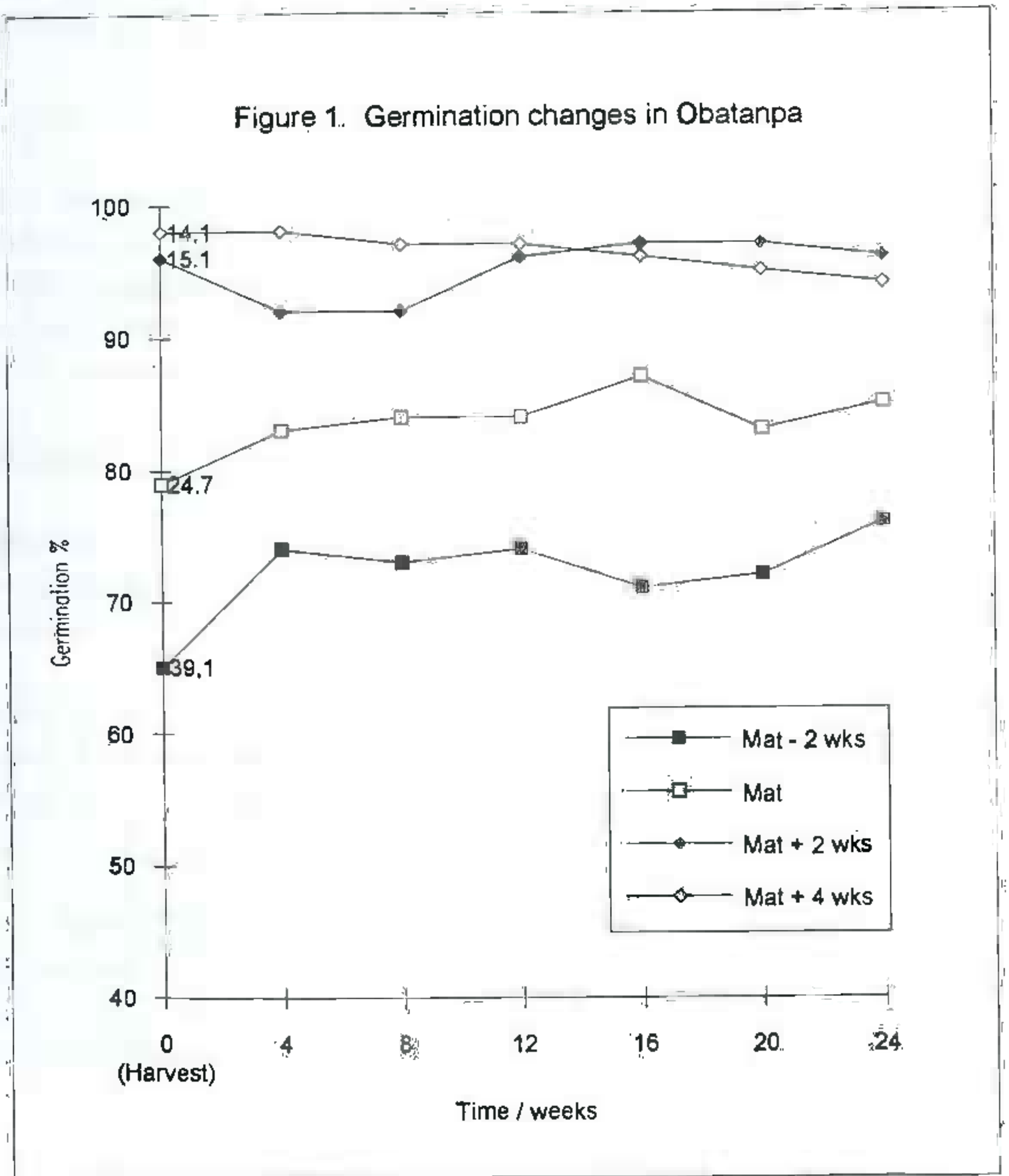
12. In practical terms, farmers should be encouraged only to harvest seed maize once physiological maturity has passed. It is likely that the optimal period of harvest,

resulting in superior germination could be assessed by a farmer in terms of the moisture content of the seeds at time of selection. In this case, higher germination is associated with seeds having a moisture content of 16% or below, at harvest, which farmers can judge by grain hardness.

Table 1. Germination of maize variety Obatanpa, harvested at different times

Stage / weeks	Mean germination %			
	Mat - 2 wks	Mat	Mat + 2 wks	Mat + 4 wks
0 (Harvest)	65	79	96	98
4	74	83	92	98
8	73	84	92	97
12	74	84	96	97
16	71	87	97	96
20	72	83	97	95
24	76	85	96	94

Mat = Physiological maturity



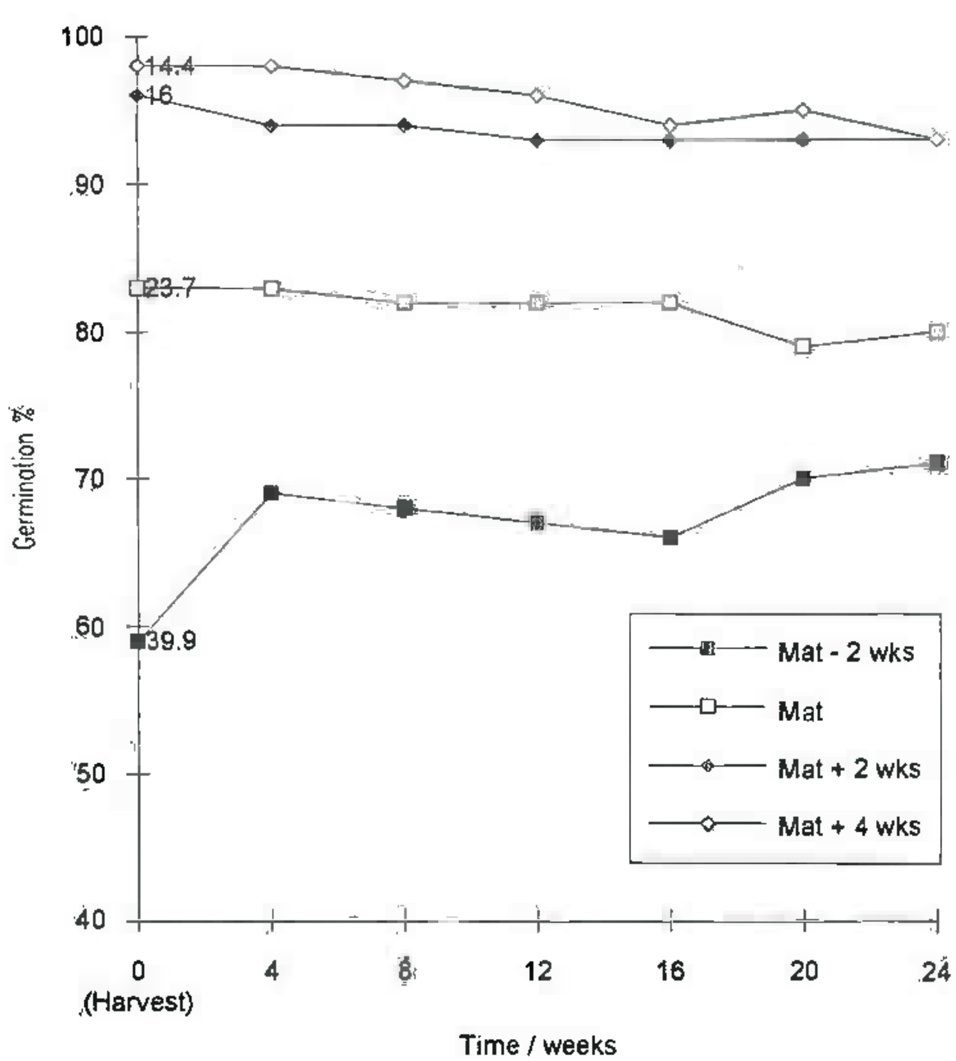
NB. Figures on first data points show moisture contents of seeds at time of harvest

Table 2. Germination of maize variety Dorke, harvested at different times

Stage / weeks	Mean germination %			
	Mat - 2 wks	Mat	Mat + 2 wks	Mat + 4 wks
0 (Harvest)	59	83	96	98
4	69	83	94	98
8	68	82	94	97
12	67	82	93	96
16	66	82	93	94
20	70	79	93	95
24	71	80	93	93

Mat = Physiological maturity

Figure 2. Germination changes in Dorke



NB. Figures on first data points show moisture contents of seeds at time of harvest

EXPERIMENT 2 - To compare ideal and farmer seed storage conditions through their effect on germination changes of maize during storage.

Objective: To determine the quantitative difference between farmer storage systems and ideal conditions in terms of germination decline. This should give an indication of the potential for improvement in the traditional system. Ideal conditions were defined in this study as the reasonably constant conditions found in a cool room designed for seed storage by the Ghana Seed Inspection Unit.

Method

13. Three improved maize varieties (Abeleehi, Obatanpa, Okomasa) and three traditional (farmer) varieties (all local white types) were used for the trial. 600 cobs of each variety were taken from farmers' fields during the period of 19-25 October 1994. Details are given below:

Variety	Location	Harvest date	m.c.
Abeleehi	Dunkorkrom	23/11/94	18.1%
Obatanpa	Tafi Atome	22/11/94	16.6%
Okomasa	Bredi	24/11/94	20.3%
Local 1	Atakora	25/11/94	27.1%
Local 2	Akwamu	23/11/94	23.9%
Local 3	K. Oppongkrom	19/11/94	22.2%

14. Moisture content (m.c.) and germination percentage were determined at harvest and after 3 weeks of sun-drying, to below 13%. Moisture content was measured using a Dole 500 moisture tester.

15. After sun-drying the cobs were hand shelled and cleaned with hand sieves. The seeds were split into 500g lots and packaged into polythene or calico bags as described below.

16. For *ideal conditions* - 36 thick polythene bags (i.e. 6 varieties x 6 sampling dates) each containing 500g of seeds were sealed and labelled clearly with varietal name. These were stored under constant conditions in a cold room at Winneba. Conditions were monitored on a daily basis using a Seedburo hygrometer. Temperatures were constant at 24-26°C and relative humidity (r.h.) ranged from 45-91%.

17. For *fluctuating conditions* - 36 breathable calico bags (i.e. 6 varieties x 6 sampling dates) each containing 500g of seeds were sealed and labelled clearly with varietal name. These were stored under ambient conditions in an outdoors narrow crib at Weija. Temperature and r.h. fluctuations were recorded using a 7-day thermohydrograph. During the course of the trial the following extremes of conditions were recorded:

Temperature:	Minimum	18°C
	Maximum	33°C
Relative humidity:	Minimum	22%
	Maximum	92%

18. At each of the monthly assessments, one of the remaining bags for each variety was selected, at random, and the seeds tested for germination percentage and moisture content using ISTA procedures. Four replicates of 100 seeds were used, planted out on moistened sterilised sand. Seedlings were evaluated after 7 days.

Results

19. The full data set is given in Annex 2. A summary of the results is given in Tables 3-4 and shown in Figures 3-4

for fluctuating and constant conditions respectively. In the analysis, the 3-way interaction (i.e. storage conditions x variety x stage) is used as the residual term against which all effects are compared. Certain points are apparent from the results.

- Germination declines significantly over the time frame used in this trial ($p<0.001$).

- There are significant differences between varieties ($p<0.001$) with Local 1 (mean germination - 83.8%) performing worse than the other five varieties.

- In the results collected after 12 weeks, it is not possible to disaggregate the effects of fluctuating conditions and *Sitophilus* spp. attack, although it is clear that the result of insect infestation is a drastic decline in germination.

- Germination of seeds kept under constant temperature conditions (though not necessarily, as in this case, cool conditions) perform better than those where temperature is allowed to fluctuate (mean germinations of 90.2% for constant and 83.0% for fluctuating; $p<0.001$). However, it is not clear how much of this difference is due to insect attack.

- This effect becomes apparent in this trial after 12 weeks (mean germinations of 89.2% for constant and 83.4% for fluctuating conditions) which coincides with the onset of insect infestation. The difference between treatments becomes more pronounced with increased storage periods.

20. The important point, as far as the small scale farmer is concerned, is that in order to maximise the germination potential of their maize seed, it must be kept free of insect attack and in a container or surroundings that minimises seed temperature changes.

Table 3. Germination of maize under ambient (fluctuating) conditions

Stage / weeks	Mean germination % (Traditional vars)			Mean germination % (Improved vars)			
	Local 1	Local 2	Local 3	Abeleehi	Obatanpa	Okomasa	
0 (Harvest)	90.5	92.8	97.5	96.5	93.8	98.0	
4	85.8	90.8	90.3	88.8	88.5	91.8	
8	82.3	90.0	87.5	88.3	84.8	88.0	
12	81.8	89.3	82.0	84.0	83.8	79.5	#
16	75.8	75.0	81.3	82.0	79.5	80.3	##
20	71.3	47.5	65.5	59.8	72.3	71.3	##

\# Sitophilus infestation ## Heavy Sitophilus infestation

Figure 3. Germination of maize varieties under ambient conditions

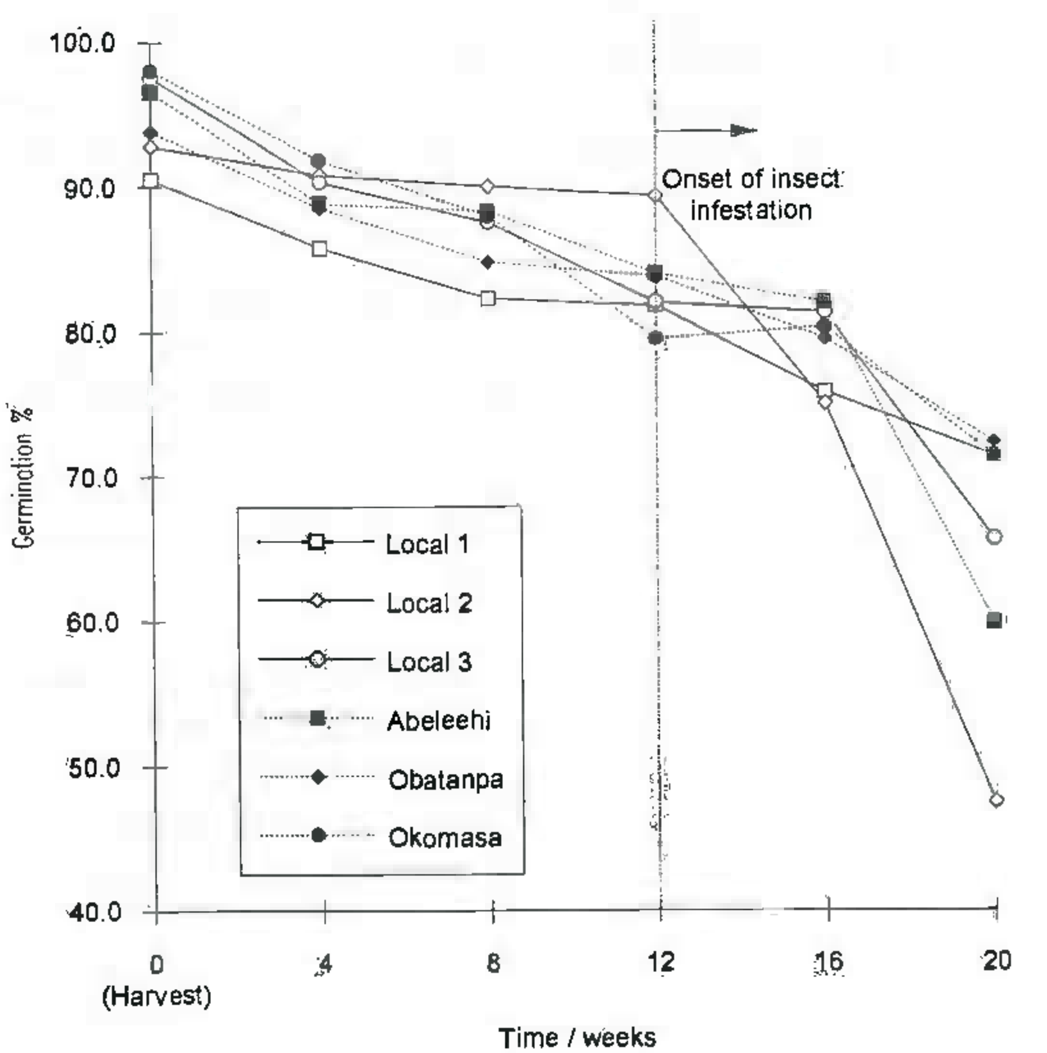
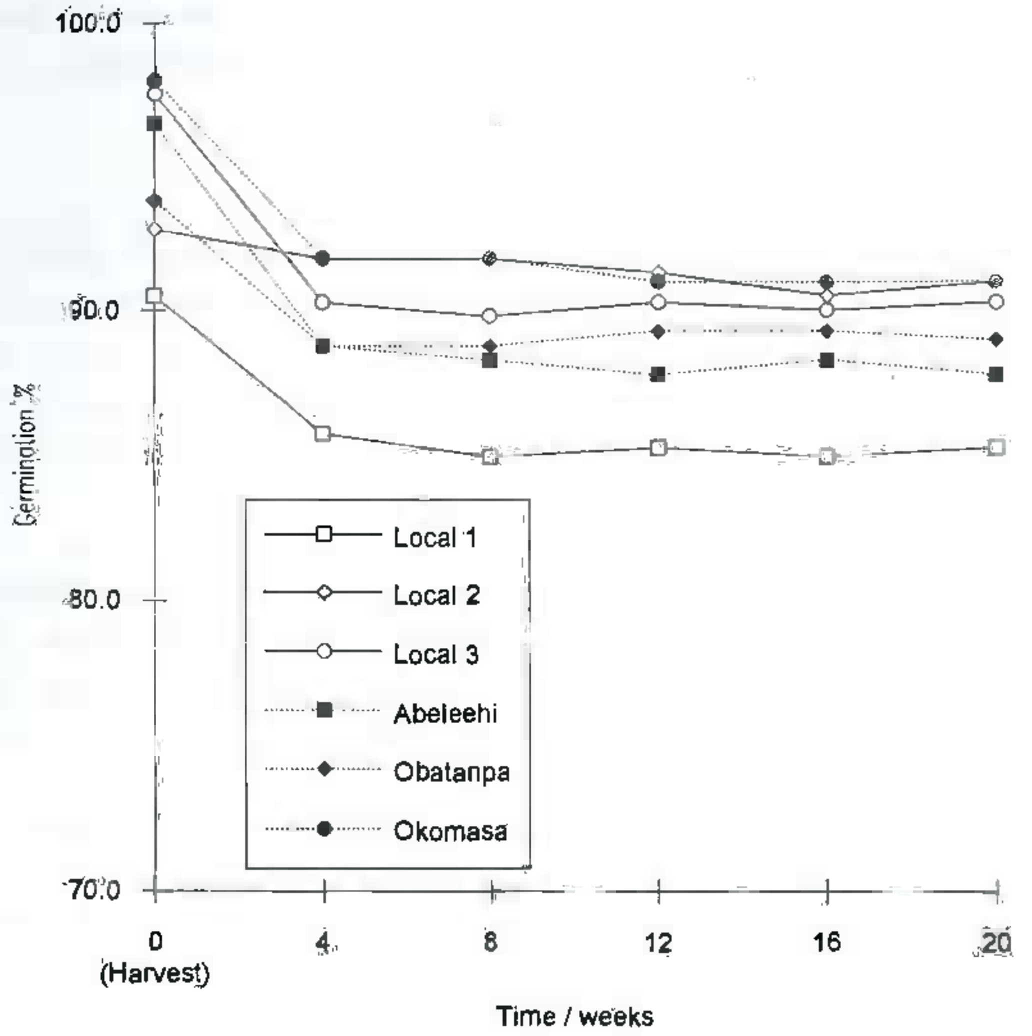


Table 4. Germination of maize under cool room (steady) conditions

Stage / weeks	Mean germination % (Traditional vars)			Mean germination % (Improved vars)		
	Local 1	Local 2	Local 3	Abeleehi	Obatanpa	Okomasa
0 (Harvest)	90.5	92.8	97.5	96.5	93.8	98.0
4	85.8	91.8	90.3	88.8	88.8	91.8
8	85.0	91.8	89.8	88.3	88.8	91.8
12	85.3	91.3	90.3	87.8	89.3	91.0
16	85.0	90.5	90.0	88.3	89.3	91.0
20	85.3	91.0	90.3	87.8	89.0	91.0

Figure 4. Germination of maize varieties under cool room conditions



EXPERIMENT 3 - Effect of simple changes to seed storage practices on viability of maize and cowpea seeds.

Objective: To determine the relative advantages of simple changes to the seed storage system, namely shelling (threshing), insecticide use and packaging type.

(i) MAIZE - Effect of shelling and insecticide use

Method

21. Actellic Super (permethrin 0.3% + pirimiphos methyl 1.6%) was selected as a suitable insecticide because it is widely available and used in Ghana for the protection of stored grain. Two improved varieties of maize (Abeleehi and Obatanpa) were used. In all, there were six treatments:

a) Variety A - shelled and untreated

b) Variety A - shelled and treated with Actellic Super at the rate of 50g pesticide to 100 kg shelled maize

c) Variety A - cobbed and untreated

d) Variety B - shelled and untreated

e) Variety B - shelled and treated with Actellic Super at the rate of 50g pesticide to 100 kg shelled maize

f) Variety B - cobbed and untreated

22. The maize was harvested from seed farms on 8 December 1994; the Abeleehi from Ho-Ziavi and the Obatanpa from Somanya. For each variety, 600 cobs were collected and sun-dried for about two weeks until moisture content had fallen below 13%. Moisture content was established using a Dole 500 moisture tester. Care was taken to keep the varieties separate at all times. The cobs were then hand shelled and

cleaned with hand sieves. The grains were well mixed and divided to form the treatments as above.

23. There were four replicates of each variant (a-f), kept in a narrow crib at Weija in clearly labelled polypropylene sacks, under ambient conditions, with space around each sack. Each sack contained 3 kg of seed (or 92 cobs which is equivalent to 3 kg of seeds). Temperature and relative humidity were monitored with a 7-day thermohydrograph. During the course of the trial the following extremes of conditions were recorded:

Temperature:	Minimum	18°C
	Maximum	33°C
Relative humidity:	Minimum	22%
	Maximum	92%

24. At each sampling period and for each variety, 500g of seed (or seed equivalent) was taken from each of the four sacks and moisture content established. From this sample, 100 seeds were taken for each of the four replicates and, following ISTA guidelines, germination percentage established.

25. For cobbed maize, 10 cobs were taken from each replicate. The grain was shelled from the central third of the cob and winnowed to remove chaff. From each replicate, 100 seeds were taken at random and germination percentage established.

26. Germination tests were carried on moistened sterilised sand and seedlings were evaluated after 7 days.

Results

27. The full data set is given in Annex 3. The data from the trial is summarised in Table 5 and shown in Figure 5.

In the analysis, the 3-way interaction (i.e. variety x variant x stage) is used as the residual term against which all effects are compared. Some useful information can be derived from the results.

- Abeleehi and Obatanpa showed statistically identical responses to the different treatments.

- Germination declines significantly over the time frame used in this trial (p=0.01 over the first 16 weeks).

- For the first 12 weeks of storage no significant differences can be detected between the six treatments.

- At 16 weeks differences become apparent (mean germinations for cobs/untreated - 81.9%, shelled/untreated - 85.1%, shelled/treated - 90.9%). However, this time corresponds to the period in which insect attack has occurred. It is not possible to say whether the decline in germination is due to the treatment effect or insect activity, although it seems likely that the sharp germination decline is largely due to insect damage.

- Assuming the insects had a free choice, treated maize suffers significantly less insect attack than untreated cobbed maize, which in turn is significantly less attacked than untreated shelled maize.

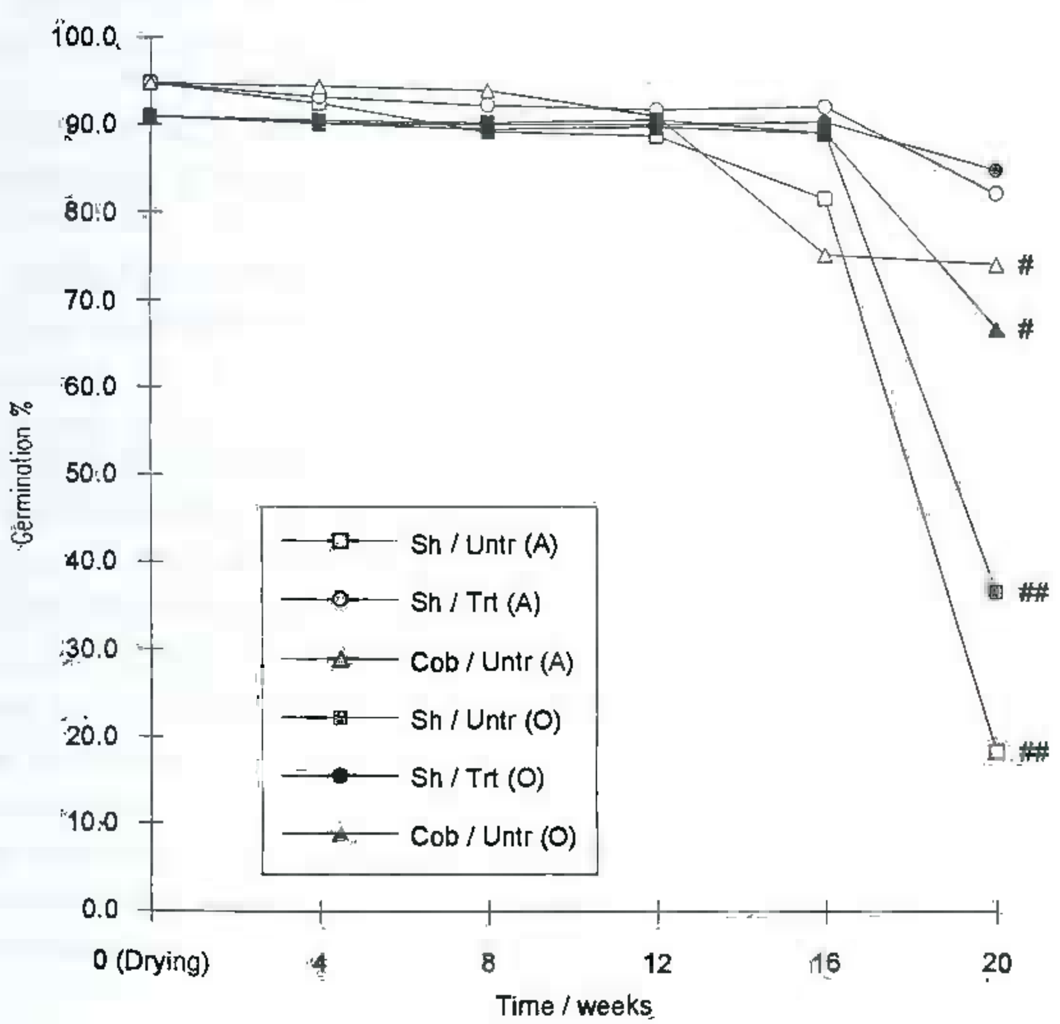
28. In conclusion, farmers wanting to maximise the germination potential of their maize seeds should shell and treat them with insecticide. If for some reason this is not possible and there is a high risk of *Sitophilus* attack, it is better to store the seed on the cob (although this may make it more susceptible to the Larger Grain Borer, *Prostephanus truncatus* in areas where it is present).

Table 5. Effect of shelling and treating on maize seed storage

Time / weeks	Abeleehi - Mean Germination %			Obatanpa - Mean germination %		
	Sh / Untr (A)	Sh / Trt (A)	Cob / Untr (A)	Sh / Untr (O)	Sh / Trt (O)	Cob / Untr (O)
0 (Drying)	94.8	94.8	94.8	91.0	91.0	91.0
4	92.3	93.0	94.3	90.3	90.0	90.0
8	89.0	92.0	93.8	90.0	89.8	89.3
12	88.5	91.5	90.8	90.3	89.8	89.5
16	81.3	91.8	75.0	88.8	90.0	88.8
20	18.3	81.8	73.8	36.5	84.5	66.5

Sh - Shelled, Untr - Untreated Trt - Treated

Figure 5. Effect of shelling and treatment on maize seed germination



NB. (A) = Abeleehi; (O) = Obatanpa
= Slight insect infestation ## = Heavy insect infestation

(ii) <u>COWPEA - Effect of threshing and container</u>

Method

29. One improved cowpea variety (Asontem) was used with four experimental variants:

a) threshed in jute bag

b) unthreshed in jute bag

c) threshed in sealed polythene bag

d) unthreshed in sealed polythene bag

30. The cowpeas, from a farmers field in Ejura, were harvested on 24 October 1994 and sun-dried for 6 days. Half the cowpeas were threshed by placing the pods in a jute sack and beating them with a stick, as the farmers do, and then the opened pods removed by winnowing. The unthreshed pods had their seeds removed by hand at their respective assessment dates and were then winnowed.

31. There were four replicates of each variant (a-d) kept indoors in clearly labelled bags, under ambient conditions, with space around each bag. Each bag contained 3 kg of seed. Temperature and relative humidity were monitored with a 7-day thermohydrograph. During the course of the trial the following extremes of conditions were recorded:

Temperature:	Minimum	20°C
	Maximum	32°C
Relative humidity:	Minimum	34%
	Maximum	93%

32. At each sampling time 100 seeds were taken from each of the four containers (replicates) and, following ISTA

guidelines, germination percentage determined. Seeds were planted out on moistened sterilised sand and the seedlings evaluated after 8 days.

Results

33. The full data set is supplied in Annex 4. Results from the trial are summarised in Table 6 and shown in Figure 6. In the analysis, the 3-way interaction (i.e. bag x threshed x stage) is used as the residual term against which all effects are compared. Several important points can be derived from the data.

- Germination declines significantly over the time frame of this trial (p=0.007).

- Each of the four treatments followed similar rates of decline in germination over the 18 weeks.

- Threshing of the cowpeas caused a significant reduction on the germination of the cowpea seeds (mean germinations, threshed 84.7%, unthreshed 88.7%; p=0.01). This is at variance with the findings from a seed box survey carried out in Ghana (Wright *et al*, 1995) during which threshed seeds, which is the common practice, tended to perform better. Threshing does not take place to obtain the pods themselves because the pods do not have any perceived value and are normally thrown away (although some farmers feed them to livestock, use them as mulch or as household fuel). The difference may reflect the difference in threshing techniques used in the trial or may reflect the fact that the cowpeas, when threshed by farmers, are frequently treated with an insecticide or local admixture and consequently suffer less insect infestation.

- There is no difference from using either jute sacks or polythene bags (p=0.11).

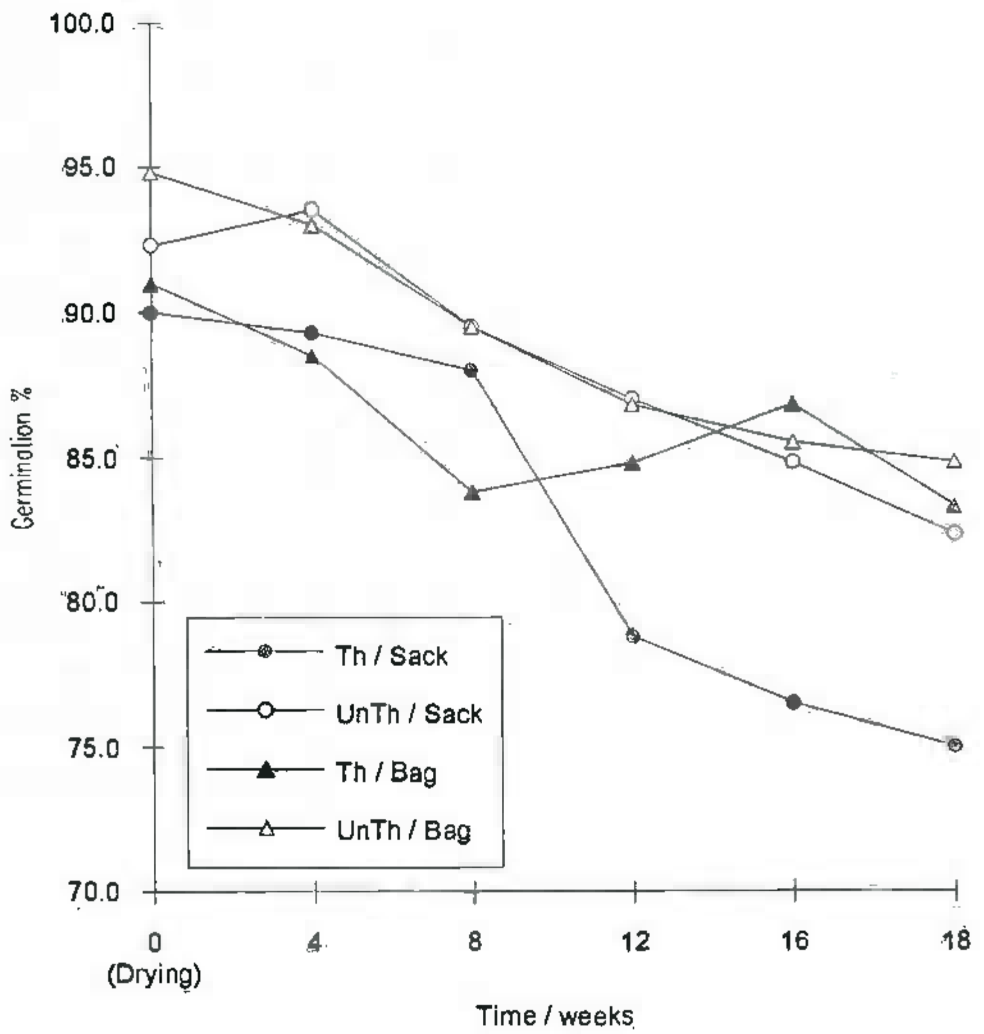
34. The evidence indicates that cowpeas undergo a steady decline in germination with time. That decline occurs irrespective of whether the seeds are kept in sack or polythene bags. The evidence for the relative merits of threshing or storage in pods, from this and other studies, is conflicting and merits further investigation.

Table 6. Effect of threshing and container on cowpea seed storage

Time / weeks	Mean germination %			
	Th / Sack	UnTh / Sack	Th / Bag	UnTh / Bag
0 (Drying)	90.0	92.3	91.0	94.8
4	89.3	93.5	88.5	93.0
8	88.0	89.5	83.8	89.5
12	78.8	87.0	84.8	86.8
16	76.5	84.8	86.8	85.5
18	75.0	82.3	83.3	84.8

Th - Threshed; UnTh - Unthreshed.

Figure 6. Effect of threshing and container on cowpea seed germination



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Annex 1 - Harvest time

Maize variety - Dorke

Harvest	Stage / weeks	Germination %					Moisture content / %
		1	2	3	4	Average	
Mat - 2 wks	0	60	59	61	57	59.3	39.9
Mat - 2 wks	4	69	70	70	68	69.3	13.5
Mat - 2 wks	8	65	68	68	70	67.8	13.3
Mat - 2 wks	12	66	67	65	69	66.8	13.1
Mat - 2 wks	16	65	65	66	67	65.8	12.9
Mat - 2 wks	20	69	71	72	68	70.0	12.7
Mat - 2 wks	24	74	72	69	70	71.3	11.0
Maturity	0	83	78	84	85	82.5	23.7
Maturity	4	86	81	83	83	83.3	13.0
Maturity	8	79	82	85	81	81.8	13.0
Maturity	12	82	83	84	80	82.3	12.8
Maturity	16	84	78	85	82	82.3	12.8
Maturity	20	78	79	80	80	79.3	12.4
Maturity	24	78	81	82	79	80.0	11.4
Mat + 2 wks	0	95	96	96	97	96.0	16.0
Mat + 2 wks	4	93	94	93	95	93.8	13.0
Mat + 2 wks	8	95	95	93	92	93.8	12.8
Mat + 2 wks	12	96	91	94	91	93.0	12.9
Mat + 2 wks	16	90	95	95	90	92.5	12.7
Mat + 2 wks	20	88	93	96	94	92.8	11.1
Mat + 2 wks	24	91	94	93	92	92.5	11.0
Mat + 4 wks	0	99	99	97	96	97.8	14.4
Mat + 4 wks	4	97	98	99	99	98.3	13.0
Mat + 4 wks	8	98	97	98	96	97.3	12.7
Mat + 4 wks	12	96	95	97	96	96.0	12.5
Mat + 4 wks	16	94	93	95	94	94.0	12.3
Mat + 4 wks	20	95	95	96	95	95.3	11.4
Mat + 4 wks	24	92	94	94	93	93.3	11.3

Mat = Physiological maturity

Annex 1 - Harvest time

Maize variety - Obatanpa

Harvest	Stage / weeks	Germination %					Moisture content / %
		1	2	3	4	Average	
Mat - 2 wks	0	62	68	64	66	65.0	39.1
Mat - 2 wks	4	72	77	75	73	74.3	13.3
Mat - 2 wks	8	75	70	74	71	72.5	13.3
Mat - 2 wks	12	73	73	73	75	73.5	12.9
Mat - 2 wks	16	69	75	71	68	70.8	12.6
Mat - 2 wks	20	70	73	72	74	72.3	12.8
Mat - 2 wks	24	76	78	76	75	76.3	11.3
Maturity	0	81	79	78	76	78.5	24.7
Maturity	4	83	81	83	84	82.8	13.1
Maturity	8	79	85	85	86	83.8	12.9
Maturity	12	85	83	84	82	83.5	12.8
Maturity	16	87	87	82	90	86.5	12.9
Maturity	20	84	86	80	81	82.8	12.6
Maturity	24	87	88	82	84	85.3	11.6
Mat + 2 wks	0	93	96	97	98	96.0	15.1
Mat + 2 wks	4	90	93	94	92	92.3	13
Mat + 2 wks	8	89	94	93	93	92.3	12.7
Mat + 2 wks	12	95	96	97	95	95.8	12.8
Mat + 2 wks	16	97	98	96	98	97.3	12.8
Mat + 2 wks	20	96	98	96	98	97.0	11.4
Mat + 2 wks	24	95	97	94	96	95.5	11.3
Mat + 4 wks	0	99	98	97	99	98.3	14.1
Mat + 4 wks	4	97	100	96	97	97.5	12.8
Mat + 4 wks	8	99	97	98	95	97.3	12.6
Mat + 4 wks	12	96	96	98	97	96.8	12.5
Mat + 4 wks	16	96	95	96	96	95.8	12.2
Mat + 4 wks	20	97	94	95	95	95.3	11.6
Mat + 4 wks	24	95	96	93	93	94.3	11.3

Mat = Physiological maturity

Annex 2 - Storage conditions

Ambient (fluctuating) conditions

Stage / weeks	Variety	Germination %					Moisture content / %
		1	2	3	4	Average	
0	Local 1	92	93	87	90	90.5	27.1
4	Local 1	86	87	83	87	85.8	10.9
8	Local 1	84	81	84	84	83.3	12.5
12	Local 1	84	86	76	81	81.8	14.3
16	Local 1	73	78	77	75	75.8	14.2
20	Local 1	70	68	75	72	71.3	13.0
0	Local 2	96	89	91	95	92.8	23.9
4	Local 2	89	92	92	90	90.8	11.1
8	Local 2	90	91	89	90	90.0	12.3
12	Local 2	90	90	90	87	89.3	14.1
16	Local 2	74	72	74	80	75.0	13.1
20	Local 2	45	50	47	48	47.5	12.0
0	Local 3	97	97	98	98	97.5	22.2
4	Local 3	92	90	89	90	90.3	10.7
8	Local 3	88	87	88	87	87.5	13.2
12	Local 3	82	84	82	80	82.0	14.6
16	Local 3	87	82	77	79	81.3	14.4
20	Local 3	65	72	60	65	65.5	14.1
0	Abeleehi	96	98	95	97	96.5	18.1
4	Abeleehi	87	90	88	90	88.8	11.2
8	Abeleehi	92	89	85	87	88.3	13.2
12	Abeleehi	82	84	80	90	84.0	14.6
16	Abeleehi	80	82	82	84	82.0	14.0
20	Abeleehi	65	60	60	54	59.8	13.4
0	Obatanpa	98	95	90	92	93.8	16.6
4	Obatanpa	89	93	83	89	88.5	10.9
8	Obatanpa	79	90	90	80	84.8	12.7
12	Obatanpa	83	88	80	84	83.8	14.6
16	Obatanpa	79	80	83	76	79.5	13.9
20	Obatanpa	74	77	73	65	72.3	13.5
0	Okomasa	98	98	99	97	98.0	20.3
4	Okomasa	94	94	90	89	91.8	11.9
8	Okomasa	93	85	87	88	88.3	13.2
12	Okomasa	77	80	83	78	79.5	14.5
16	Okomasa	80	77	80	84	80.3	14.0
20	Okomasa	77	70	68	70	71.3	13.5

Annex 2 - Storage conditions

Constant (cool room) conditions

Stage / weeks	Variety	Germination %					Moisture content / %
		1	2	3	4	Average	
0	Local 1	92	93	87	90	90.5	27.1
4	Local 1	86	87	83	87	85.8	10.9
8	Local 1	85	85	86	84	85.0	11.4
12	Local 1	86	87	86	82	85.3	11.8
16	Local 1	85	88	84	83	85.0	11.7
20	Local 1	84	86	85	86	85.3	12.4
0	Local 2	96	89	91	95	92.8	23.9
4	Local 2	93	92	92	90	91.8	11.1
8	Local 2	90	92	90	95	91.8	11.3
12	Local 2	93	92	91	89	91.3	12.4
16	Local 2	90	87	92	93	90.5	12.5
20	Local 2	93	91	89	91	91.0	12.3
0	Local 3	97	97	98	98	97.5	22.2
4	Local 3	92	90	89	90	90.3	10.7
8	Local 3	93	90	88	88	89.8	10.7
12	Local 3	90	90	91	90	90.3	11.5
16	Local 3	91	88	91	90	90.0	11.4
20	Local 3	90	90	91	90	90.3	12.2
0	Abeleehi	96	98	95	97	96.5	18.1
4	Abeleehi	87	90	88	90	88.8	11.2
8	Abeleehi	92	89	85	87	88.3	11.4
12	Abeleehi	90	84	90	87	87.8	12.0
16	Abeleehi	89	86	88	90	88.3	12.6
20	Abeleehi	89	88	86	88	87.8	12.5
0	Obatanpa	98	95	90	92	93.8	16.6
4	Obatanpa	89	93	90	83	88.8	10.9
8	Obatanpa	86	91	90	88	88.8	11.2
12	Obatanpa	90	90	90	87	89.3	11.4
16	Obatanpa	90	88	89	90	89.3	11.6
20	Obatanpa	90	88	88	90	89.0	12.2
0	Okomasa	98	98	99	97	98.0	20.3
4	Okomasa	94	94	90	89	91.8	11.9
8	Okomasa	93	93	92	89	91.8	12.1
12	Okomasa	91	88	95	90	91.0	12.5
16	Okomasa	94	90	92	88	91.0	12.6
20	Okomasa	92	90	90	92	91.0	13.0

Annex 3 - Maize treatments

Maize variety - ABELEEHI

Variant / stage	Date	Germination %					m.c.		
		1	2	3	4	Average	1	2	Average
SHELLED / UNTREATED									
Drying (D) *	22/12/94	95	93	94	97	94.8	11.6	11.7	11.7
D + 4 wks	19/1/95	90	95	92	92	92.3	13.0	13.0	13.0
D + 8 wks	16/2/95	89	87	92	88	89.0	14.4	14.4	14.4
D + 12 wks	16/3/95	88	89	88	89	88.5	14.5	14.5	14.5
D + 16 wks	13/4/95	85	80	83	77	81.3	13.7	13.7	13.7
D + 20 wks ##	11/5/95	16	18	17	22	18.3	13.9	14.0	14.0
SHELLED / ACTELLIC 'S'									
Drying (D) *	22/12/94	95	93	94	97	94.8	11.6	11.7	11.7
D + 4 wks	19/1/95	91	94	94	93	93.0	13.3	13.4	13.4
D + 8 wks	16/2/95	91	93	93	91	92.0	14.4	14.4	14.4
D + 12 wks	16/3/95	89	91	90	96	91.5	14.4	14.5	14.5
D + 16 wks	13/4/95	93	91	92	91	91.8	13.2	13.2	13.2
D + 20 wks	11/5/95	78	80	83	86	81.8	14.4	14.3	14.4
COBS / UNTREATED									
Drying (D) *	22/12/94	95	93	94	97	94.8	11.6	11.7	11.7
D + 4 wks	19/1/95	92	95	95	95	94.3	13.2	13.2	13.2
D + 8 wks	16/2/95	96	94	93	92	93.8	14.6	14.7	14.7
D + 12 wks	16/3/95	92	93	90	88	90.8	14.4	14.4	14.4
D + 16 wks	13/4/95	69	71	80	80	75.0	13.1	13.1	13.1
D + 20 wks #	11/5/95	73	74	72	76	73.8	14.4	14.4	14.4

* Drying to <13%   # Slight insect infestation   ## Heavy insect infestation

Annex 3 - Maize treatments

Maize variety - OBATANPA

Variant / stage	Date	Germination % 1	2	3	4	Average	m.c. 1	2	Average
SHELLED / UNTREATED									
Drying (D) *	22/12/94	88	91	94	91	91.0	11.9	11.6	11.8
D + 4 wks	19/1/95	89	90	88	94	90.3	12.9	13.1	13.0
D + 8 wks	16/2/95	88	87	95	90	90.0	14.6	14.8	14.7
D + 12 wks	16/3/95	90	93	90	88	90.3	14.4	14.4	14.4
D + 16 wks	13/4/95	89	89	90	87	88.8	13.4	13.3	13.4
D + 20 wks ##	11/5/95	34	35	33	44	36.5	14.0	14.1	14.1
SHELLED / ACTELLIC 'S'									
Drying (D) *	22/12/94	88	91	94	91	91.0	11.9	11.6	11.8
D + 4 wks	19/1/95	89	89	90	92	90.0	13.3	13.3	13.3
D + 8 wks	16/2/95	90	89	89	91	89.8	14.5	14.4	14.5
D + 12 wks	16/3/95	87	90	92	90	89.8	14.0	14.0	14.0
D + 16 wks	13/4/95	90	89	90	91	90.0	14.4	14.0	14.2
D + 20 wks	11/5/95	83	83	88	84	84.5	14.3	14.4	14.4
COBS / UNTREATED									
Drying (D) *	22/12/94	88	91	94	91	91.0	11.9	11.6	11.8
D + 4 wks	19/1/95	92	90	89	89	90.0	13.4	13.3	13.4
D + 8 wks	16/2/95	89	91	90	87	89.3	14.5	14.5	14.5
D + 12 wks	16/3/95	94	90	89	85	89.5	14.2	14.1	14.2
D + 16 wks	13/4/95	89	89	90	87	88.8	13.5	13.3	13.4
D + 20 wks #	11/5/95	70	66	60	70	66.5	14.0	14.2	14.1

* Drying to <13%   # Slight insect infestation   ## Heavy insect infestation

Annex 4 - Cowpea treatments

Cowpea variety - ASONTEM (Improved variety)

Variant / stage	Date	Germination %					m.c.				
		1	2	3	4	Average	1	2	3	4	Average
THRESHED / SACK											
Drying (D) **	1/11/94	88	90	92	90	90.0	12.9	12.6	12.4	12.6	12.6
D + 4 wks	29/11/94	90	89	87	91	89.3	12.4	12.5	12.5	12.6	12.5
D + 8 wks	28/12/94	87	88	88	89	88.0	12.3	12.2	12.6	12.5	12.4
D + 12 wks	24/1/95	76	79	81	79	78.8	12.1	12.1	12.3	12.1	12.2
D + 16 wks	21/2/95	78	77	75	76	76.5	12.0	12.1	12.1	12.0	12.1
D + 18 wks	9/3/95	75	76	75	74	75.0	12.0	12.0	12.0	11.9	12.0
UNTHRESHED / SACK											
Drying (D) **	1/11/94	89	93	94	93	92.3	13.1	13.0	12.9	13.1	13.0
D + 4 wks	29/11/94	92	92	96	94	93.5	12.9	12.7	12.8	12.7	12.8
D + 8 wks	28/12/94	90	88	91	89	89.5	12.8	12.7	12.7	12.6	12.7
D + 12 wks	24/1/95	87	86	89	86	87.0	12.7	12.6	12.7	12.6	12.7
D + 16 wks	21/2/95	85	84	84	86	84.8	12.5	12.5	12.6	12.5	12.5
D + 18 wks	9/3/95	83	82	80	84	82.3	12.4	12.4	12.4	12.5	12.4
THRESHED / POLYTHENE BAG											
Drying (D) **	1/11/94	95	91	90	88	91.0	12.9	12.7	12.7	13.0	12.8
D + 4 wks	29/11/94	90	87	91	86	88.5	12.9	12.8	12.7	12.9	12.8
D + 8 wks	28/12/94	88	83	79	85	83.8	12.8	12.7	12.6	12.7	12.7
D + 12 wks	24/1/95	90	86	83	80	84.8	12.7	12.6	12.6	12.6	12.6
D + 16 wks	21/2/95	87	87	89	84	86.8	12.4	12.3	12.2	12.4	12.3
D + 18 wks	9/3/95	83	84	85	81	83.3	12.3	12.3	12.2	12.3	12.3
UNTHRESHED / POLYTHENE BAG											
Drying (D) **	1/11/94	96	96	93	94	94.8	13.0	13.1	12.8	12.9	13.0
D + 4 wks	29/11/94	91	93	95	93	93.0	13.0	13.0	12.8	12.9	12.9
D + 8 wks	28/12/94	90	88	89	91	89.5	12.9	12.8	12.8	12.8	12.8
D + 12 wks	24/1/95	87	86	88	86	86.8	12.8	12.8	12.8	12.7	12.8
D + 16 wks	21/2/95	86	87	85	84	85.5	12.8	12.7	12.7	12.7	12.7
D + 18 wks	9/3/95	85	86	85	83	84.8	12.7	12.7	12.7	12.6	12.7

** Drying to < 13%