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POST-HARVEST HANDLING PRACTICES OF PIGEON PEA SEEDS USED BY FARMERS IN NORTHERN TANZANIA AND RELATION TO QUALITY OF THE SEEDS

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ABSTRACT

Handling practice in traditional informal seed systems can have influence on quality of the seeds. An exploration was made of post-harvest handling of pigeon pea farmer saved seed in northern Tanzania and relation of the practices with measured quality of the seeds. Seed samples with their prior handling practices were collected from 40 farmers in each of the two pigeon pea production leading Districts in Tanzania, Babati and Karatu. Laboratory tests were performed to establish physical quality of the seeds, using ISTA procedures. The study found use of bags predominating container storage because it is easier and much more convenient. Some farmers in both bag and container stored seeds were treating their seeds against storage insects; few of them practiced seed sorting. Effect of storage practice on subsequent quality of seed was very pronounced, especially on germination capacity. Effects were generally variable with storage practice, insecticide seed treatment, sorting, and where practiced (District). It is important to appreciate what farmers consider their convenience in post-harvest seed handling, but efforts must also be encouraged to safeguard the seed against storage insect pests, to counteract quick deterioration by proper drying and avoiding moisture absorption during storage, and to elevate quality by sorting.

Keywords: Bag storage, Polypropylene bags, Farm saved seed, Seed treatment, Germination capacity

1. INTRODUCTION

Farmers' traditional practices predominate in the seed supply system of a crop like the pigeon pea whose commercial seed market, in Tanzania especially, is not very well established. The Tanzania Official Seed Certification Institute (TOSCI) terms such crops as the pigeon pea "orphan crops" (Anonymous, 2012), because commercial seed suppliers especially the private sector that now dominates the formalized seed distribution in the country, are not interested in multiplying seeds of such crops (legumes in general, and other non-legume less priority crops) because of low profitability. What remains for the crop farmers, then, is non-commercial, traditional seed saving usually from previous season of each subsequent season. Conventionally such saved seed is known as "farm saved seed". It is generally a huge category of the seed supply system especially for resource poor farmers worldwide. In Southern Africa, for example, the informal non-commercial seed sector where farm saved seed belongs serves over 90% (Monyo et al, 2003) of the Region's seed needs. In a more recent study by Binswanger-Mkhize and Savastano (2017), more than 82% of farmers in a group of surveyed African countries (Ethiopia, Nigeria, Niger, Malawi, Tanzania, Uganda) were not using improved seed (with exception of Malawi). In this context "improved seed" means certified seed of commercial varieties, which leaves a small proportion of farmers who use the same commercial varieties' un-certified seed (open pollinated varieties), which is an inclusive category of farm saved seed.

Most of current available literature on farm saved seed is focused on policy and legislation in relation to intellectual property rights. This rests on genetic quality of seed, which means the crop varieties. Beyond genetic quality, then, issues of quality of farm saved seed become slightly less stringent. There is even some advocacy arguing for research to establish added value of "certifying" against "truthfully labeled" seed beyond the proven genetic potential (Monyo et al 2003). Shortage of information in this area therefore presents a significant knowledge gap.

Beyond the crop genetics, quality of seed can generally be expressed in two categories: physical quality and sanitary quality. Sanitary quality, meaning freedom from seed-borne diseases, is a field phenomenon assured through rouging of plants infected with quality threatening disease during growth of the crop from which seed is harvested, through total exclusion (rejection) of field in which level of infection is above tolerance, and through avoiding planting the disease infected seed. Physical quality, on the other hand, is essentially a post-harvest phenomenon. It includes such attributes of seed like purity (absence of any inert non-seed matter, other crop or plant species seed), freedom from weed seed, germination capacity, vigour, moisture content, seed size and uniformity. Being post-harvest, much of the physical quality of seed can be improved after harvesting the seed crop even though some of the quality attributes may be influenced early during the preceding crop growth and development in the field. Methods to ensure physical quality of seed post-harvest include cleaning and sorting, upgrading, drying and subsequently proper storage.

Various damages and quality threatening phenomena can occur in seeds post-harvest. These include insect pest attacks and growth of moulds and other fungi. Generally, post-harvest handling practices are to be held responsible for post-harvest loss of seed quality (though some of the loss may indeed be from physiological causes such as natural ageing). Storage method of adequately dried seeds, treating the seeds against storage insect pests and seed sorting are among the post-harvest handling practices. Research culminating to this paper was targeted to establishing the post-harvest handling practices for pigeon pea farm saved seed in the crop's major growing area in Tanzania, and whether those practices could be implicated to observed quality performance of the seeds.

2. MATERIALS AND METHODS

2.1. Survey and sample collection

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The research was conducted first in the field in two Districts of northern Tanzania, Babati and Karatu, which constitute the leading area in pigeon pea production in Tanzania. During the survey about one kilogram of pigeon pea seed was collected from each of the farmers for subsequent laboratory testing.

2.1.1. Survey data source sampling

Sampling procedure used for the survey was purposive. All pigeon pea growing villages in the two districts were first listed and then twenty (ten from each district) villages selected to be representative, based on being most significant producers; but also based on accessibility or closeness to roads, for ease of transport logistics. In each village, then, four farmers were selected. Each of these farmers was interviewed so as to obtain information on seeds especially the post-harvest handling practices. The sampling overall involved 40 farmers and 40 seed samples from each District.

2.2. Laboratory seed testing

Seed testing was performed for the physical attributes of Purity, Germination capacity and Moisture content; at the African Seed Health Center (ASHC) laboratories in Morogoro. Tests were limited to those three attributes for convenience purposes. Tests were performed following the International Seed Testing Association (ISTA) procedures (ISTA, 2005).

2.3. Data analysis

Mean numerical data presented were analysed simply by computing averages. To relate quality and preceding post-harvest handling practices an analysis of variance was performed on groups of the quality test laboratory results based on the post harvest handling practices as treatment sources of variation. The treatments means were then separated using the Least Significant Difference (LSD) method.

3. RESULTS AND DISCUSSION

3.1. RESULTS

3.1.1. Handling practices

Table 1 shows the handling practices. From

the Table, generally bag storage dominated against container storage. Frequencies of farmers treating their seeds against storage insects against those who did not were almost equal, but majority of farmers indicated that they were not practicing seed sorting. The containers used in seed storage were such as drums, plastic buckets and metal or plastic barrels. Bags were mostly polypropylene woven bags. From the Table it shows that in Babati District 20% of farmers stored their seeds in containers, 52.5% treated their seeds with storage insecticide while 82.5% of the farmers did not sort the seeds they used for planting. In Karatu District, 35% of farmers stored their seeds in containers against 65% who stored in bags; 55% treated their seeds while 65% did not sort the seeds. Furthermore, the great majority of farmers who stored the seeds in containers in Babati District, for example, were also exercising treatment with storage insecticides; but in Karatu District the practice was not the same. While in Babati District almost 90% of farmers who stored their seeds in containers also treated the seeds, in Karatu District majority of the farmers (57.1%) who stored the seeds in containers did not treat them with insecticides

Table 1. Post-harvest handling practices of farmer used pigeon pea seed in Karatu and Babati Districts of northern Tanzania

Sample number	Practices Babati District			Practices Karatu District		
	Storage technique	Storage pesticide	Sorting	Storage technique	Storage pesticide	Sorting
1	Container	Treated	Sorted	Container	Treated	Unsorted
2	Bag	Untreated	Unsorted	Bag	Untreated	Unsorted
3	Bag	Untreated	Sorted	Bag	Treated	Unsorted
4	Bag	Untreated	Unsorted	Container	Treated	Sorted
5	Container	Treated	Unsorted	Bag	Treated	Sorted
6	Bag	Treated	Unsorted	Container	Untreated	Unsorted
7	Bag	Treated	Unsorted	Container	Untreated	Unsorted
8	Bag	Treated	Unsorted	Bag	Untreated	Unsorted
9	Bag	Untreated	Unsorted	Bag	Treated	Unsorted
10	Container	Treated	Unsorted	Bag	Treated	Unsorted
11	Bag	Untreated	Sorted	Bag	Untreated	Unsorted
12	Bag	Treated	Unsorted	Container	Untreated	Sorted
13	Bag	Treated	Unsorted	Bag	Treated	Unsorted
14	Bag	Untreated	Unsorted	Bag	Treated	Sorted
15	Bag	Untreated	Sorted	Bag	Untreated	Unsorted
16	Bag	Untreated	Unsorted	Container	Untreated	Unsorted
17	Bag	Untreated	Unsorted	Container	Treated	Sorted
18	Bag	Untreated	Unsorted	Container	Untreated	Unsorted
19	Bag	Treated	Unsorted	Bag	Treated	Unsorted
20	Bag	Treated	Unsorted	Bag	Untreated	Sorted

21	Bag	Untreated	Unsorted	Container	Untreated	Unsorted
22	Bag	Untreated	Unsorted	Bag	Treated	Unsorted
23	Bag	Untreated	Unsorted	Bag	Untreated	Unsorted
24	Bag	Treated	Unsorted	Container	Untreated	Sorted
25	Container	Untreated	Unsorted	Bag	Treated	Unsorted
26	Bag	Untreated	Unsorted	Bag	Treated	Unsorted
27	Bag	Untreated	Unsorted	Bag	Treated	Unsorted
28	Bag	Treated	Unsorted	Bag	Treated	Unsorted
29	Container	Treated	Unsorted	Container	Untreated	Sorted
30	Bag	Treated	Sorted	Container	Treated	Unsorted
31	Container	Treated	Unsorted	Bag	Untreated	Sorted
32	Bag	Treated	Unsorted	Bag	Untreated	Sorted
33	Bag	Treated	Sorted	Bag	Treated	Sorted
34	Bag	Treated	Unsorted	Bag	Treated	Unsorted
35	Bag	Treated	Unsorted	Container	Treated	Unsorted
36	Bag	Untreated	Unsorted	Bag	Treated	Unsorted
37	Bag	Untreated	Sorted	Bag	Untreated	Sorted
38	Container	Treated	Unsorted	Bag	Treated	Sorted
39	Container	Treated	Unsorted	Container	Treated	Unsorted
40	Bag	Untreated	Unsorted	Bag	Untreated	Sorted

3.1.2. Relation with quality

Tables 2 and 3 show relation of the post-harvest handling practices upon the farm-saved seed with corresponding physical quality status of the seeds. From the Tables there is extensive variation of quality with handling practice. Physical quality in both Districts combined ranged from 62 – 98% germination capacity, analytical purity 74.5 – 98% and moisture content from 7.7 – 11.7%. It is difficult, nevertheless, to discern the pattern of influence. Further scrutiny of the data to establish in-depth relationship is presented in subsequent Tables 4, 5, 6, 7, 8 and 9. This scrutiny involved strenuous grouping of the data according to handling practice to have groups that were subjected to analysis of variance to establish statistically verifiable handling practice effects on the seeds' quality attributes.

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Tables 4, 5, and 6 show summary of analysis of variance results to show effects of handling practice on the physical quality attributes of the seeds measured. Table 4 shows effect of storage practice on germination, purity and moisture content, which are important physical quality attributes. Beyond any statistical doubt, storage practice influenced the tested physical quality attributes of germination and purity. Level of confidence for effect on germination and percent moisture content was respectively higher than 99.9% ($P < 0.001$) and on purity it was higher than 95% ($P < 0.05$).

Table 5 shows effects of storage pesticide treatment of the seeds as practiced by the survey area farmers. The treatment had significant effects on germination capacity and also significantly ($P < 0.001$) influenced the moisture content of seeds

Table 6 shows effects of seed sorting. The practice effect was highly significant ($P < 0.001$) on germination capacity and moisture contents of the seeds but not on purity

Table 2. Post-harvest seed handling practices corresponding to laboratory physical seed quality test results in pigeon pea seed samples collected in Babati District

Sample No.	Storage	Treatment	Sorting	Germination %	Purity (%)	M.C. (%)
1	Container	Treated	Sorted	97	89.9	10.3
2	Bag	Untreated	Unsorted	97	74.5	9.3
3	Bag	Untreated	Sorted	82	87.4	10.3
4	Bag	Untreated	Unsorted	85	95.5	11.3
5	Container	Treated	Unsorted	96	89.4	10
6	Bag	Treated	Unsorted	93	93.4	8.3
7	Bag	Treated	Unsorted	82	92.5	11
8	Bag	Treated	Unsorted	94	90.6	10
9	Bag	Untreated	Unsorted	76	96.5	8.7
10	Container	Treated	Unsorted	94	91.2	11.7
11	Bag	Untreated	Sorted	87	84.9	11
12	Container	Treated	Unsorted	77	92.8	11
13	Bag	Treated	Unsorted	86	85.9	8.3
14	Bag	Untreated	Unsorted	96	92.9	10.3

15	Bag	Untreated	Sorted	76	89.9	10
16	Bag	Untreated	Unsorted	94	97.2	10
17	Bag	Untreated	Unsorted	85	94.3	8.7
18	Bag	Untreated	Unsorted	91	84.1	7.7
19	Bag	Treated	Unsorted	77	95.4	10.3
20	Bag	Treated	Unsorted	75	96.8	9.7
21	Bag	Untreated	Unsorted	83	93.2	10.7
22	Bag	Untreated	Unsorted	95	88	8.7
23	Bag	Untreated	Unsorted	93	90	9.3
24	Bag	Treated	Unsorted	62	92.7	8.7
25	Container	Untreated	Unsorted	97	94.8	8.3
26	Bag	Untreated	Unsorted	89	97.4	11.3
27	Bag	Untreated	Unsorted	70	88	9.3
28	Bag	Treated	Unsorted	95	86	9
29	Container	Treated	Unsorted	76	92.1	8.7
30	Bag	Treated	Sorted	76	85.2	9.7
31	Container	Treated	Unsorted	76	96.3	10.3
32	Bag	Treated	Unsorted	81	98	8.7
33	Bag	Treated	Sorted	74	86	9.7
34	Bag	Treated	Unsorted	93	98	12
35	Bag	Treated	Unsorted	84	97.8	11
36	Bag	Untreated	Unsorted	74	92.3	11.3
37	Bag	Untreated	Sorted	95	88	11.3
38	Container	Treated	Unsorted	82	92.5	9
39	Container	Treated	Unsorted	94	97.2	9.7
40	Bag	Untreated	Unsorted	75	91	9.7

Table 3. Post-harvest seed handling practices corresponding to laboratory physical seed quality test results in pigeon pea seed samples collected in Karatu District

Sample No.	Storage	Treatment	Sorting	Germination %	Purity (%)	M.C. (%)
1	Container	Treated	Sorted	98	97.7	9.3
2	Bag	Untreated	Unsorted	77	77.7	7.7
3	Bag	Untreated	Sorted	70	85.1	9.3
4	Bag	Untreated	Unsorted	86	94.1	11.3
5	Container	Treated	Unsorted	86	92.8	9.3
6	Bag	Treated	Unsorted	62	93.1	9.7
7	Bag	Treated	Unsorted	95	95.4	11
8	Bag	Treated	Unsorted	68	90	10.3
9	Bag	Untreated	Unsorted	84	95.9	10.3
10	Container	Treated	Unsorted	83	88.2	10.3
11	Bag	Untreated	Sorted	84	96.9	11.7
12	Cont	Treated	Unsorted	68	92.5	9.7
13	Bag	Treated	Unsorted	72	93.5	9.7
14	Bag	Untreated	Unsorted	81	97.3	8.7
15	Bag	Untreated	Sorted	70	84	11.3
16	Bag	Untreated	Unsorted	79	98.4	9
17	Bag	Untreated	Unsorted	66	89.7	11.7
18	Bag	Untreated	Unsorted	71	96.3	9
19	Bag	Treated	Unsorted	84	97.4	10.3
20	Bag	Treated	Unsorted	77	92.3	10.3
21	Bag	Untreated	Unsorted	67	94.2	11.7
22	Bag	Untreated	Unsorted	77	90	11
23	Bag	Untreated	Unsorted	89	82.7	9.7
24	Bag	Treated	Unsorted	95	89.4	9
25	Container	Untreated	Unsorted	69	94.7	10.3
26	Bag	Untreated	Unsorted	95	81.4	8.7
27	Bag	Untreated	Unsorted	75	97.7	10.7
28	Bag	Treated	Unsorted	81	89.9	9.7

29	Container	Treated	Unsorted	69	89.3	9
30	Bag	Treated	Sorted	90	92.7	10.7
31	Container	Treated	Unsorted	85	84.6	8.7
32	Bag	Treated	Unsorted	87	93.1	10.3
33	Bag	Treated	Sorted	87	93.5	9
34	Bag	Treated	Unsorted	75	94	11
35	Bag	Treated	Unsorted	72	95.1	8.7
36	Bag	Untreated	Unsorted	78	89.1	10.3
37	Bag	Untreated	Sorted	97	95.5	11
38	Container	Treated	Unsorted	98	89.3	9.3
39	Container	Treated	Unsorted	78	93.3	8.7
40	Bag	Untreated	Unsorted	92	88.9	9

Table 4. Mean sum of square Analysis of variance values for effects of storage practice on pigeon pea seed germination, purity and percent moisture content of the seeds

Source of variation	df	Germination	Purity	Moisture content
Sample	21	353.64***	118.94***	3.488***
Storage	2	1585.53***	186.06*	0.884
Sample x Storage	42	326.99***	42	3.424***
Replication	3	0.401	821	0.068
Error	197	2.586	56.02	0.559

*** Significant at 0.001 * Significant at 0.05

Table 5. Mean sum of square analysis of variance values for effects of storage insecticide application on pigeon pea seed germination and other physical attributes

Source of variation	df	Germination	Purity	Moisture content

Sample	20	330.96***	54.26	3.48***
Treatment	2	355.8***	102.36	7.53***
Sample x Treatment	40	457.33***	86.15**	2.98***
Replication	2	0.079	412.21**	0.643
Error	188	2.473	46.07	0.64

*** Significant at 0.001 ** Significant at 0.01

Table 6. Mean sum of square analysis of variance values for effects of seed sorting on pigeon pea seed germination and other physical attributes

Source of variation	df	Germination	Purity	Moisture content
Sample	20	330.74***	79.57*	3.64***
Sorting	2	801.24***	52.82	9.35***
Sample x Sorting	40	388.2***	68.71	2.92***
Replication	2	0.496	615.57	0.07
Error	188	2.549	46.38	0.55

*** Significant at 0.001 * Significant at 0.05

Throughout the analyses of variance presented in Tables 4, 5 and 6, the various samples collected from farmers demonstrated to be significantly different in the tested quality attributes, with some exceptions in purity. Interaction between sample and handling practice was also significant in most instances, again with some exceptions in purity

Tables 7, 8 and 9 show the patterns of influence of the handling practices on the quality attributes of the seeds. Table 7 present effects of storage where we see that bag storage was best practice in preserving germination capacity of the seeds, but this was only so in Babati. In Karatu District bag stored seeds were slightly poorer in germination capacity than seeds stored in containers.

Table 7. Mean physical quality test results of pigeon pea seeds as influenced by storage practice in Babati and Karatu Districts

Storage	Germination (%)	Purity (%)	Moisture content (%)
Container storage	80.8	93.6	10.1
Bag storage Babati	87.5	91.1	9.8
Bag storage Karatu	79.7	90.6	9.9
Mean	82.7	91.8	9.9
S.E. $\pm$	0.243	1.303	0.13
CV %	1.94	8.15	7.55
$LSD_{0.05}$	0.507	2.72	ns

Table 8 presents influence of storage insecticide dressing of the seeds on germination and the other tested attributes. Treated seeds in Babati District were significantly best ($P < 0.05$) in germination but these were awkwardly followed by the untreated seeds. Treated seeds in Karatu District were significantly poorer in germination capacity than untreated seeds. Perhaps there are issues of pesticide dosage and toxic chemical damage in the treated seeds. On moisture content, the untreated seeds were significantly poorer in quality than both of the treated seed categories. Was it perhaps because of insect infestation? Insects usually may raise moisture content of stored seeds because of their respiratory activities liberating water, and excretion.

Table 8. Mean physical quality test results of pigeon pea seeds as influenced by storage insecticide treatment of the seeds in Babati and Karatu Districts

Treatment	Germination (%)	Purity (%)	Moisture content (%)
Treated Babati	84.3	92.4	9.7
Treated Karatu	80.3	92.3	9.9
Untreated	82.6	90.2	10.3
Mean	82.4	91.6	10.0
S.E. $\pm$	0.281	1.21	0.14
CV %	1.91	7.41	8.0
$LSD_{0.05}$	0.59	ns	0.29

Table 9 presents influence of sorting on the physical quality expression of the seeds. Unsorted seeds in Babati were significantly best overall in germination but sorted seeds were significantly better ($P < 0.05$) in germination than the unsorted seeds in Karatu. Unsorted seeds of Karatu were also significantly poorer in moisture content based quality than the sorted seeds or unsorted seeds of Babati. Sorting did not show any significant effects on seed purity.

Table 9. Mean physical quality test results of pigeon pea seeds as influenced by practice of seed sorting in Babati and Karatu Districts

Sorting	Germination (%)	Purity (%)	Moisture content (%)
Sorted	81.6	90.2	9.7
Unsorted Babati	86.5	91.7	9.9
Unsorted Karatu	80.8	91.8	10.4
Mean	82.97	91.2	10.0
S.E. $\pm$	0.247	1.213	0.13
CV %	1.92	7.47	7.4
$LSD_{0.05}$	0.52	ns	0.27

4.DISCUSSION

Storage, insecticide dressing and sorting of seeds as variably practiced by farmers are indeed of paramount significance in safeguarding quality of seed or its potential worth for sowing. This study has shown that especially germination was consistently significantly influenced by the three post-harvest handling practices. Germination is a delicate quality component of seed that presents a biological threshold between aliveness and death of the alive tissues in the seed. Definitely, therefore, improper environment created by storage practice such as dampness, heating, access and multiplication of storage insect pests, will adversely influence ability of the seed to retain germination. Attack by storage insect pests is particularly important in maintaining seed value of grain. Insect damage on seed usually progresses towards destruction of the seed embryo. Once the embryo is damaged germination of the seed is at stake depending on extent of the damage. Treatment of seed with protective chemical substances as it has been demonstrated by majority of farmers in the study area is an un-avoidable practice.

There is evidence from data generated during this study that there is significant difference of influence of post-harvest handling practice between Karatu and Babati Districts. Even though purity and moisture content of seeds did not show significant differences between the two Districts no matter what was handling practice tested, germination capacities of seeds from the two Districts in relation to handling practice were consistently different ($P < 0.05$). Germination capacities of seeds from Babati were all the time statistically better than those from Karatu whenever there was comparison between the two Districts. That is, bag stored, treated and unsorted seeds in Babati respectively were significantly better in germination capacity than their counterparts in Karatu. Why Karatu samples germination capacities were lagging behind may not be easily explained. Perhaps there may also be significant environmental differences. When seeds were unsorted, which presents essentially no difference in intricate implementation of the practice; still seeds from Babati were significantly much better in germination.

As regards storage, bag storage was observed to predominate throughout the study area. Bags are cheaper and more convenient to handle. Bags need smaller space in the store and can be easily arranged and overlapping each other, something that is not easy for containers since they are of different shapes and need more space. It is important indeed to appreciate farmers' convenience not only in method of storage but in overall post-harvest practice. While no farmer would have measured and recorded moisture status of the seed at the onset of storage, however, seeds must be sufficiently and thoroughly dried before storage to counteract quick deterioration while in store. Likewise, it is best practice to store the "properly dried" seeds in airtight moisture proof containers to avoid moisture absorption from the storage environment. Seeds are hygroscopic and their moisture content will equilibrate with any air moisture content that builds in the storage environment. This means that moisture content of seeds kept in bags cannot be constant even if the seeds were sufficiently dry at the beginning. For this reason, containers that are moisture proof and can be closed airtight are superior to bags in seed storage. Additionally, such containers will not allow entry of storage insect pests into the stored seed and if the containers are filled completely even insects and their eggs that are already with the seeds inside the container are killed by suffocation. Inside an airtight stored seed environment, carbon dioxide concentration [CO2] usually builds up because of respiration by the seeds and any other living organisms with the seed. At the same time, there is gradual depletion of oxygen (O2) which is used by the respiring seeds and other organisms (insects and their eggs, moulds, etc). Depletion of [O2] kills the insects while at the same time it retards the rate of respiration in the airtight stored seeds and in so doing reducing deteriorative metabolic damage by respiration, therefore prolonging shelf life of the seeds.

Treating seeds against storage insect pests, and seed sorting, are other best practices in post-harvest handling of seeds. Retention of the sowing value of seed cannot be guaranteed if the seeds were not free from storage insect pests infestation while in store. In absence of insecticide treatment of stored seed in Nigeria, Mutungi et al (2015) found that seed damage and weight loss in woven polypropylene bags exceeded economic threshold just after one month of storage of bean seeds artificially infested with the bean bruchid Acanthoscelides obtectus. Germination of those seeds was also greatly reduced during the storage due to the insect damage. In Pakistan (Bakhtavar et al 2017), maize seed germination was reduced by 50% and weight loss by 35% when stored in woven polypropylene bags largely due to insect damage, while in hermetic bags (moisture and insect proof) no change in gerimination while weight loss was only 3%. A study in 60 crops in India (Sinha, 2017) reports that germination was on average 4.1% when storage insects damaged the embryo, 57.3% when damage was on the endosperm, against 96.6% germination in undamaged seeds. On the other hand, seed sorting has been reported to have improved germination and seedling emergence by as much as 60% (Marthur et al, 2006)

5.CONCLUSION

It has been shown from this study that post-harvest handling of pigeon pea seeds in the study area range from bag or container storage of the seeds, with some farmers treating the seeds with storage insecticides and a small proportion sorting the seeds they use for planting. Bag storage predominated while treating or not treating the seeds frequencies were almost equal. Handling practice very significantly influenced quality of the seed, especially germination capacity. This study recommends that it is important to appreciate what farmers consider to be convenient in handling the seeds, which means bag storage. Precautions however must be taken to ensure that the seeds that are so stored are at the best of their quality, generally by ensuring proper and prompt drying after harvest, storage before any significant insect pest attack, protecting with storage insecticides where possible and sorting the seed prior to storage or prior to sowing.

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