Chapter 11
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Physical Quality of Pigeon Pea Seeds used by Farmers and Related Production Characteristics of the Crop in Tanzania

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ABSTRACT

In Tanzania and elsewhere in the region, the majority of resource-poor farmers use their own non-commercial quality farm-saved seeds of lesser-priority crops like pigeon pea. Such seed is always suspect in terms of quality. A survey was conducted in northern Tanzanian districts of Karatu and Babati with objectives: i) to establish quality status of the farm-saved seeds of the pigeon pea crop, ii) to determine the crop's production characteristics in relation with seeds used. Farm-saved seeds from 80 farmers from the previous crop season were gathered for laboratory quality assessment. Only roughly 7.5 percent of the samples in both districts were of acceptable grade, based on three physical quality criteria of seed: germination capacity, purity, and moisture content. The majority of samples failed, particularly in terms of purity. Overall, 66.2 percent of the farmers employed local traditional kinds of the crop rather than improved versions, and the majority were sowing as many as four seeds per hill. Intercropping was employed by 88.7% of the farmers for the pigeon pea, 53.8 percent used store pest pesticides on their crop, and the vast majority did not sort the seeds they used for or prior to sowing. It is anticipated that production qualities are related to seed quality to some extent, although additional research is needed.

Keywords: Farm saved seed; germination capacity; purity; improved varieties; minimum standards.

1. INTRODUCTION

The pigeon pea [*Cajanus cajan* (L.) Millsp] is a popular legume crop in Eastern and Southern African smallholder farming systems [1]. The crop is multipurpose providing food, fodder and fuelwood [2], is drought-tolerant and a nutritious and cheap source of protein [3] for many poor rural families, with about 21% protein rich grains. It also fixes nitrogen and has a deep taproot system that not only absorbs nutrients and moisture deep into the soil but also lessens the impacts of soil hardpan. It's a great crop for cash-strapped farmers, especially those in dry areas who can't afford fertilizer. World production of pigeon peas is dominated by India (> 50%) and distantly Myammar, with considerably significant production from Africa especially Tanzania, Malawi, Uganda and Kenya. In 2016 India produced slightly more than 63.4% of the world's estimated 4,489,874 tons of pigeon pea [4], with Myammar (13.98 %), Malawi (8.27 %) and Tanzania (6. 05 %) collectively with India producing well above 90 % of the world production.

Among pulse crops cultivated in Tanzania the pigeon pea holds a third position in importance after common beans and cowpea. The leading producers of pigeon pea in Tanzania is the northern Region of Manyara mostly Babati followed by Hanang Districts respectively [5]; and also Karatu and Arumeru Districts in the neighboring Arusha Region. Kondoa District in Dodoma Region, Kilosa District in Morogoro Region; and Lindi and Mtwara are also important producers. The crop is generally cultivated under subsistence production systems dominated by risk aversion strategies such as mixed or intercropping; and low input use.

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Seed is one of the critical requirements for successful crop production. Good quality seed greatly compliments improved field crop management practices such as timely planting or irrigation, fertilizer application, weeding etc in increasing crop yields. There is genetic quality of seed which determines the biological upper limits of crop productivity. This is achieved in seed through crop varieties. According to Evenson and Gollin [6], about 50% of the more than doubled cereal crop yields worldwide and in developing countries between 1961 and 2005 [7, 8] was attributable to improved genetic quality of seed (use of better varieties). There is then physical quality of seed which is an expression of the dynamic attributes of a seed sample after it has been harvested and perhaps processed and stored. Then again we may conveniently categorize "pathological quality" so that physical quality of seed remains with attributes such as germination capacity, purity, moisture content, uniformity *et cetera*. The physical quality attributes of seed can influence subsequent performance of the seed drastically or not (mildly), depending on the attribute and the extent to which quality limits of each attribute are provoked. Germination capacity, for example, is a critically important quality attribute. Failure of seed to germinate cancels any other quality attribute.

Yield of pigeon pea in Tanzania is generally said to have stagnated at < 1.0 ton/ha [9]. The farming systems in which the crop is produced are reasons for this stagnation. One of important farming system characteristics is agricultural input use patterns. Generally, most of smallholder resource poor farmers produce under "no additional input" conditions, investing solely on labour, land and seed. For veterans in the production, seed is no additional input at all because it is simply recycled from previous crop harvest, the so-called farm saved seed. According to Shiferaw *et al* [1], about 96 % of pigeon pea farmers in Tanzania used their own farm saved seeds of unknown quality status. This is an informal seed supply system which could also involve, as described by Monyo and Laxmipathi [10], borrowing from neighbours or relatives, exchanging or purchasing stored food grains to be used as seed. Genetic and overall quality of seed is usually compromised under the informal seed supply system. Even when superior genetic materials have been adopted, use of farm saved seed is still extensive in resource poor systems, due to cost saving on commercial standard certified seed. Under farmers' conditions such seed is also likely to be poorly handled leading to mixtures with other varietal types including landraces, and physical deterioration due perhaps to insect damage, poor processing and post-harvest handling practices. Deteriorated seed then becomes a source of low and unreliable yields. According to Kimani [11], pigeon pea has demonstrated a potential to yield up to 4.6 tons/ha for improved varieties on-farm [12]. Current study being reported was interested to know extents of physical quality attributes notably germination, purity and moisture content of farm saved pigeon pea seeds in the crop's major production area in Tanzania and relevant production characteristics of the crop. Such information compliments in-depth knowledge of the crop production constraints and avenues for improvement.

2. MATERIALS AND METHODS

The research involved a survey in the two Districts of northern Tanzania, Babati and Karatu, which constitute the leading area in pigeon pea production in Tanzania. From the survey, information on pigeon pea production, and seed samples, were collected. 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 easy sampling. In each village, then, four farmers were selected. Each of these farmers was interviewed so as to obtain information on seeds concerning varieties (whether local or improved), cropping system (sole or intercropping), type of storage used and other related information. One kilogram of seeds was collected from each of the farmers for subsequent laboratory testing. The sampling overall involved 40 farmers and 40 seed samples from each District. Seed testing was performed at the African Seed Health Center (ASHC) laboratories in Morogoro, Tanzania. Tests were performed following the International Seed Testing Association (ISTA) procedures.

3. RESULTS AND DISCUSSION

3.1 Physical Quality of the Seeds

Results of the various physical quality attributes of the pigeon pea farm-saved seeds in the survey area are presented in Tables 1 and 2. Table 1 shows quality test results for samples collected from

Babati District. Table 2 shows results for Karatu District samples. Each sample was collected from an individual farmer. Overall in both Babati and Karatu Districts, about 7.5% of the samples (6 samples) were of acceptable quality based on all the three quality attributes combined. In terms of individual quality attributes, however, majority of the samples were of acceptable germination capacity quality, that was exceeding the Tanzania Official Seed Certification Institute - TOSCI [13] minimum of 70%. Out of 40 samples in Babati District, for example, it was only one sample that was sub-standard in germination, meaning that about 97.5% of the samples' germination capacity were TOSCI acceptable. In Karatu District, however, 17.5% of the samples were sub-standard in germination. Three samples in Babati District and five samples in Karatu District passed the purity test ($\geq$ 97%)

As regards moisture content, in Babati District 24 samples equivalent to 60% of the samples had moisture content not exceeding 10% therefore they were of acceptable quality. Karatu samples were slightly poorer in moisture content standard, with about 55% of the samples meeting the moisture quality standard.

It seems from the study results that farmers can hardly achieve certification quality standard for purity and to variable extent moisture content of their seeds. It is more natural however, that, so long as they save the seeds for subsequent season planting, they strive and are experienced to safeguard germination capacity of the seeds. This may explain why the tested seeds samples were better in achieving minimum standards for germination (example 97.5% of samples in Babati District). Many farmers, however, may not be aware that proper drying of seeds is one of strategies to safeguard germination otherwise high certification standard for germination would be always alongside high standard for moisture content. One important characteristic of moisture content is, however, equilibrial fluctuation with weather (exposure to air moisture content) and this depends on storage practice and packaging containers of the seed.

Combining germination, purity and moisture content; certification declaration for the farmers' seeds across the study area would therefore be that about 92.5% of the samples were sub-standard, most of them due to failure in purity. Among the three quality attributes, however, germination can be considered to be more critical. Under normal circumstances the level of germination reached in a seed test (for non-dormant seeds) cannot be improved. It is a biological threshold phenomenon. In the contrary, quality of seed based on purity and moisture content can be easily improved by cleaning (purity) and drying (moisture content)

3.2 Production Characteristics

Results for the pigeon pea crop production and seed handling characteristics according to the study survey are summarized in Table 3. Overall, majority of farmers were using seeds of local varieties, to the tune of 66.2% of the farmers interviewed. In Karatu district as many as 70% of the farmers indicated that they were using local varieties, against 30% that were using improved variety of the pigeon pea seeds. In Babati district, 62.5% used local varieties.

Sowing practice for pigeon pea was usually multiple seeds per hole, the number of seeds sown per hole was found to range from 3 to 5 seeds. Overall, majority of farmers were planting 4 seeds per hill (38%) but this was so true in Karatu district where 45% of the farmers were planting 4 seeds per hill. In Babati districts it was farmers planting 3 seeds per hill that were majority (35%). When sowing was 3 seeds per hill Karatu farmers economized seeds much more than Babati farmers but when sowing was 5 seeds per hill it was Karatu farmers that were much more economizing (22.5% of farmers).

One of the commonest features of pigeon pea cultivation is sowing the crop as an intercrop companion, usually with maize. Overall, about 88.7% of the farmers were practicing intercropping when sowing the pigeon pea crop, against only 11.3% who practiced sole cropping. As many as 95% of farmers in Babati district were sowing the crop intercropped. In contrary about 17.5% of the farmers in Karatu district practiced sole cropping system (Mono cropping) against 5% of farmers in Babati district.

The study has shown that insect pest control in the field is a remote activity in pigeon pea cultivation in the study area. Overall, only about 18.8% of farmers indicated they were spraying with insecticides in the field, this was as small as 5% in Karatu district. In Babati district however, 32.5% of the farmers sprayed the crop in the field with insecticides. Post harvest, on the other hand, majority of farmers generally (53.8%) treated their crop with storage insect pest insecticides. There was still however, quite a sizable proportion (46.2%) of these farmers who were not practicing any storage insecticide application to their harvested grains. The predominant storage technique of harvested grains was use of bags against the alternative using containers such s drums, metal tins or plastics buckets.

As regarding farm saved seeds, the study found that the majority of farmers (82.5%) in Babati district and 65% in Karatu district were not sorting their seeds for or before sowing (Table 3).

Table 1. Test results for physical quality attributes of pigeon pea seeds collected from the crop farmers in Babati District

Sample No.	Purity (%)	Moisture (%)	Germination (%)	Quality status	Overall standard
1	89.9	10.3	97	xx√	Sub-standard
2	74.5	9.3	97	x√√	Sub-standard
3	87.4	10.3	82	xx√	Sub-standard
4	95.5	11.3	85	xx√	Sub-standard
5	89.4	10	96	x√√	Sub-standard
6	93.4	8.3	93	x√√	Sub-standard
7	92.5	11	82	xx√	Sub-standard
8	90.6	10	94	x√√	Sub-standard
9	96.5	8.7	76	x√√	Sub-standard
10	91.2	11.7	94	xx√	Sub-standard
11	84.9	11	87	xx√	Sub-standard
12	92.8	11	77	xx√	Sub-standard
13	85.9	8.3	86	x√√	Sub-standard
14	92.9	10.3	96	xx√	Sub-standard
15	89.9	10	76	x√√	Sub-standard
16	97.2	10	94	√√√	Standard
17	94.3	8.7	85	xx√	Sub-standard
18	84.1	7.7	91	xx√	Sub-standard
19	95.4	10.3	77	xx√	Sub-standard
20	96.8	9.7	75	xx√	Sub-standard
21	93.2	10.7	83	xx√	Sub-standard
22	88	8.7	95	xx√	Sub-standard
23	90	9.3	93	xx√	Sub-standard
24	92.7	8.7	62	x√√	Sub-standard
25	94.8	8.3	97	x√√	Sub-standard
26	97.4	11.3	89	√x√	Sub-standard
27	88	9.3	70	x√√	Sub-standard
28	86	9	95	x√√	Sub-standard
29	92.1	8.7	76	x√√	Sub-standard
30	85.2	9.7	76	x√√	Sub-standard
31	96.3	10.3	76	xx√	Sub-standard
32	98	8.7	81	√√√	Standard
33	86	9.7	74	x√√	Sub-standard
34	98	12	93	xx√	Sub-standard
35	97.8	11	84	xx√	Sub-standard
36	92.3	11.3	74	xx√	Sub-standard
37	88	11.3	95	xx√	Sub-standard
38	92.5	9	82	x√√	Sub-standard
39	97.2	9.7	94	√√√	Standard
40	91	9.7	75	x√√	Sub-standard
Minimum Standard [a]	97	10	70	[a] = TOSCI standard [13]	

√ = Passed or (x) not passed in purity, moisture content and germination in that order

Table 2. Test results for physical quality attributes of pigeon pea seeds collected from the crop farmers in Karatu District

Sample No.	Purity (%)	Moisture (%)	Germination (%)	Quality status	Overall standard
41	97.7	9.3	98	√√√	Standard
42	77.7	7.7	77	x√√	Sub-standard
43	85.1	9.3	70	x√√	Sub-standard
44	94.1	11.3	86	xx√	Sub-standard
45	92.8	9.3	86	x√√	Sub-standard
46	93.1	9.7	62	x√x	Sub-standard
47	95.4	11	95	xx√	Sub-standard
48	90	10.3	68	xxx	Sub-standard
49	95.8	10.3	84	xx√	Sub-standard
50	88.2	10.3	83	xx√	Sub-standard
51	96.9	11.7	84	xx√	Sub-standard
52	92.5	9.7	68	x√√	Sub-standard
53	93.5	9.7	72	x√√	Sub-standard
54	97.3	8.7	81	√√√	Standard
55	84	11.3	70	xx√	Sub-standard
56	98.4	9	79	√√√	Standard
57	89.7	11.7	66	xxx	Sub-standard
58	96.3	9	71	x√√	Sub-standard
59	97.4	10.3	84	xx√	Sub-standard
60	92.3	10.3	77	xx√	Sub-standard
61	94.2	11.7	67	xxx	Sub-standard
62	90	11	77	xx√	Sub-standard
63	82.7	9.7	89	x√√	Sub-standard
64	89.4	9	95	x√√	Sub-standard
65	94.7	10.3	69	xxx	Sub-standard
66	81.4	8.7	95	x√√	Sub-standard
67	97.7	10.7	75	√x√	Sub-standard
68	89.9	9.7	81	x√√	Sub-standard
69	89.3	9	69	x√x	Sub-standard
70	92.7	10.7	90	xx√	Sub-standard
71	84.6	8.7	85	x√√	Sub-standard
72	93.1	10.3	87	xx√	Sub-standard
73	93.5	9	87	x√√	Sub-standard
74	94	11	75	xx√	Sub-standard
75	95.1	8.7	72	x√√	Sub-standard
76	89.1	10.3	78	xx√	Sub-standard
77	95.5	11	97	xx√	Sub-standard
78	89.3	9.3	98	x√√	Sub-standard
79	93.3	8.7	78	x√√	Sub-standard
80	88.9	9	92	x√√	Sub-standard
Minimum standard [a]	97	10	70	[a] = TOSCI standard [13]	

√ = Passed or (x) not passed in purity, moisture content and germination in that order

Production characteristics reported from the survey relate to some extent with quality of the seed. It was found from the study, for example, that majority of farmers were using seeds of local varieties. Use of local informal varieties is an important avenue towards use of sub-standard quality seed, because there usually are no any measures to control quality of such seed. Such are the same farmers who plant several seeds per hill because of suspicion of quality status of the seed. When majority of the farmers plant as many as 4 seeds/hill, it is a reflection of bad occasional experiences of poor germination of the seeds in the field.

Having majority of farmers using local varieties or if not so, farm saved seed, is common especially for a crop like pigeon pea. Such crops like pigeon pea whose quality controlled seed can hardly be multiplied are termed “orphan crops” according to TOSCI in Annon. [9]. Many commercial seed companies cannot profitably invest in such crop seeds because of low and unpredictable demand of the seeds. Low demand on the other hand can be attributed to popularity of the crop among

consumers and low adoption rate of released improved varieties. With exception of the export market and a limited purchase by local domestic commercial food processors; pigeon pea in Tanzania is essentially a subsistence crop. Important strategies of subsistence crop producers include ability to source the seed on their own therefore local traditional varieties or at most seed saving. This greatly accounts for low adoption rates of improved crop varieties in subsistence or predominantly subsistence economies.

Table 3. Percent distribution of various pigeon pea production characteristics among different growers in Babati and Karatu

Characteristics	Characteristics variables	Distribution in Babati District	Distribution in Karatu District
Variety used	Improved	37.5	30
	Local	62.5	70
Sowing practice of seeds	3 seeds per hill	35	32.5
	4 seeds per hill	32.5	45
	5 seeds per hill	32.5	22.5
Cropping system	Intercropping	95	82.5
	Sole cropping	5	17.5
Insecticide spraying	Sprayed	32.5	5
	Unsprayed	67.5	95
Storage techniques	Container	77.5	67.5
	Bag	22.5	32.5
Treatment against storage insects	Treated	52.5	55
	Not treated	47.5	45
Sorting farm saved seeds	Sorted	17.5	35
	Unsorted	82.5	65

Another very important production characteristic reported from the survey was intercropping, which almost all farmers (nearly 90%, averaged over both districts) were practicing. Perhaps unknowingly and predominantly based on other benefits of intercropping (increased land productivity, increased diversity of products thus meeting dual demand of both intercrop components [or in other words more nutritional security], improving soil fertility), farmers exercising intercropping were also averting potentials of disease infestation of the crop; and especially infection with *Fusarium udum*. Sheela [14] reports that intercropping pigeon pea with cereals specifically sorghum reduces the wilt problem caused by *F. udum*. This means it potentially reduces seed-borne inoculum of the disease. Similar results have been reported by Natarajan *et al* (1985), alongside other cultural control [15,16]; chemical control [17, 18, 19] and even biological control [15, 20, 21].

Post-harvest handling practices reported as production characteristics are much more directly related with seed quality. Usually, 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 is an un-avoidable practice. Sorting when practiced will usually remove insect damaged, shriveled, broken or disease symptomatic seeds, which will individually or collectively increase quality of the sorted seed.

4. CONCLUSION AND RECOMMENDATION

Results of the physical quality of the tested seeds suggest that perhaps quality of farm saved seed as used by majority of the pigeon pea farmers can hardly be totally acceptable, standard-wise. Individual attributes like germination capacity, however, did not indicate great quality threat, and based on this, overall quality of the seed can be easily improved by more thorough cleaning and drying the seeds to elevate their quality based on purity and moisture content. There is, nevertheless, need to safeguard also health of such seed by testing presence of seed-borne pathogens in the seeds. Further

information on this, therefore, would enable more concretely conclusive statement of quality of the farmer used seed. On the other hand, production practices such as storage methods that enable moisture and insect pest proofing of properly dried seeds, treating stored seed grains with storage insecticides and seed sorting prior to storage or sowing can improve and safeguard quality of the seeds

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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