CHAPTER 3

QUALITY OF SWEET SORGHUM SEEDLOTS OF BOTSWANA LANDRACES

3.1 ABSTRACT

The seed quality of sixty five sweet sorghum seedlots of Botswana landraces was investigated. The standard germination test was performed on all of the seedlots and the Accelerated Ageing (AA) test was conducted for those seedlots that showed germination percentages around 90%. The standard germination test results indicated that the germination capacity of the seedlots ranged between 0 to 98.5% and only 66% of the seedlots had germination percentages in excess of 85%. Seedlots of landraces X and Gl showed the highest germination capacity of 98.5% and 98 % respectively, whereas seedlots of landraces Kll and Lll showed the lowest germination capacity of 0% and 0.5% respectively. The germination percentage obtained with accelerated aged seeds ranged from 58.0 to 87.8% with the mean 16.1 percentage points lower than that obtained with the standard germination test. Only 13 of the 26 tested landraces had a germination percentage above 80% after accelerated ageing. The results indicated that seed quality of the sweet sorghum seedlots was generally poor. The investigation also showed that the standard germination test results would be more informative when combined with the AA test, but the results need to be correlated with field emergence.

3.2 INTRODUCTION

Poor crop establishment of sweet sorghum is one of the major problems faced by Botswana farmers. It is well known that germination and seedling emergence results from a complex interaction of seed quality and the seedbed environment (Perry, 1983). However, poor crop establishment is often attributed to poor seed quality. Farmers typically use traditional varieties (landraces) and keep their own seed from one season to another. Seed is collected when stems are harvested for sale, often when the seed is between the milk and the dough stages. The immature heads are dried in the sun and threshed under ambient temperatures which could exceed 40°C. The seed is then stored in plastic bags, tins or any other container the farmer finds suitable, under environmental conditions which may not be conducive to seed longevity.

Seed of high quality results in rapid germination, emergence and root and shoot growth during the early stages of development. Hence a prerequisite for successful crop establishment is a seed of high quality because such seed will determine the ability to cope with suboptimal conditions (Halmer & Bewley, 1984; Harris *et al*, 1992).

For a long time seed quality was regarded as having three components which were routinely determined by means of laboratory tests, viz. purity, health and viability (germination) (Perry, 1983). However, seedlots showing a satisfactory performance in these tests do not necessarily produce satisfactory stands in the field. Hence, seed vigour appeared as an additional quality criterion. In this study, viability and vigour are the two components used to assess sweet sorghum landraces for seed quality.

Seed viability (germination) is defined by the Association of Official Seed Analysts (AOSA, 1983) as the emergence and development from the seed embryo of those essential structures which, for the kind of seed in question, are indicative of the ability to produce a normal plant under favourable conditions. Although the standard germination test approximates emergence under optimal field conditions, experience has shown its inadequacy as an indicator of seed performance in conditions which are less than optimum (Byrd & Delouche, 1971; Delouche & Baskin,1973; Tekrony & Egli,1977; Jonson & Wax, 1978; Yeklich & Kulik,1979). Because seed bed conditions are often sub-optimal, farmers require a more reliable indication of the emergence potential of a seed lot. Seed vigour is defined as those seed properties which determine the potential for rapid, uniform emergence and the development of normal seedlings under a wide range of field conditions (AOSA, 1983). This implies that two seed lots having similar germination percentages as determined under ideal laboratory conditions may perform quite differently under field conditions due to differences in vigour potential (AOSA, 1988).

Seed viability and vigour are affected by the environment and cultural conditions under which the seed developed, matured, was harvested and stored (Roberts, 1972; Abdullah, Powel & Matthews, 1992). Reduced viability was experienced in barley seeds when the parent plant was exposed to high temperature early after awn emergence (Khan & Laude, 1969). Harris, Parker & Johnson (1965) reported that high temperatures during the last 45 days of seed maturation for the 'Hill' cultivar of soybean were associated with low seedling vigour in the progeny. Early harvesting in sweet corn resulted in seeds with high germination and low vigour whilst leaving the sweet corn crop in the field longer resulted in consistent production of relatively high seed vigour (Wilson & Trawaths,

1991). Grain sorghum seeds harvested at full maturity were of higher vigour than early harvested seed (Shepard, Naylor & Stuchbury, 1996). Gane, Biiddi, Knott & Eglea (1984) reported that it is better harvesting pea seed at around 25% seed moisture content (SMC) than when harvested at 15% SMC. Mashauri, Coolbear & Hill (1992) recommended shelling at 20 - 24% SMC rather than at lower SMC's to reduce seed damage which result in poor seed quality of maize. High temperatures during drying, or drying too quickly or excessively, can also dramatically reduce viability (Bewley & Black, 1986) and vigour (Hampton & Colbear, 1990). After harvesting, seed viability has been observed to decline as a result of ageing (Roberts, 1972; Gelmond, Luria, Woodstock & Pearl, 1978), unsound seed handling procedures (Moore, 1972) and inappropriate storage conditions (Roberts, 1972).

Numerous vigour tests have been developed and classified into the following classes: seedling growth evaluation tests, stress tests and biological tests. Procedures for many of these vigour tests have been published by AOSA (1983) and ISTA (1987). Because of the variability in field conditions, vigour tests cannot predict the percentage emergence of a seedlot, but they allow identification of seedlots which will better tolerate adverse conditions and provide the best emergence possible under prevailing conditions. Researchers have reported successful use of various seed vigour tests for sorghum, such as the NH4Cl- test (Abdulahi & Vanderlip, 1972; Vanderlip, Mockel & Jan, 1973) and the soil cold test (Baskin, Palival & Delouche, 1989). The Accelerated Ageing test was used in this study because it is rapid, easy to conduct, inexpensive and easy to interpret. It has been reported to give the best results for predicting seed storeability (Delouche & Baskin, 1973). The Accelarated Ageing test has also been shown to correlate well with stand establishment in several crops such as French bean (Roos & Manalo, 1971), cotton

(Bishnoi & Delouche,1975) soybean (Tekrony & Egli, 1977), maize (Medina & Filho, 1991), peanut (Romkaew, 1996) and chickpea (Ram, Kumari, Singh & Sardana, 1989). Although the standard germination test overestimates seed performance in the field, it can not be replaced by seed vigour tests but can be supplemented by seed vigour test results. Thus the standard germination test was included in this study because it is still an important test as its value lies in the fact that it reassures seed buyers and producers of the percentage viability. Seed vigour tests are now conducted on a routine basis in some developed countries, but the practice is not yet established in the Botswana seed industry which relies solely on the standard germination test as the indicator of seed quality. However, since sweet sorghum seeds are not produced by the Botswana seed industry, there is no information even on the germination percentage of the seed. Thus seed samples from various landraces were collected from farmers to investigate seed quality in sweet sorghum. The objective of this study was to determine the seed quality of sweet sorghum seed as typically used by farmers in Botswana.

3.3 MATERIALS AND METHODS

Seedlots

Sixty five landraces of sweet sorghum were collected from farmers in the Kgatleng, Kweneng, Ngwaketse, Central and Northeastern districts of Botswana (Fig 3.1). Accessions collected from Kgatleng, Kweneng and Ngwaketse contributed 45% of the total collection, whilst the Central district contributed 30% and the Northeast 25%. Collecting trips lasted for about 6 weeks during August and September, 1997. During the collection some information was gathered from the farmers about various aspects of sweet sorghum production.

Fig 3.1 : Location where the 65 sweet sorghum landraces were collected

Most accessions were traditional landraces. There were no introduced cultivars available or distributed by the agricultural services in the districts. Collected landraces differed with respect to genotype, production locality, time and date of harvesting and storage conditions (see Table A3.1 of the appendix). Most of the landraces collected from the Central and Northeastern districts were tall, thick stemmed and late maturing, whilst in the other districts the early maturing landraces were more common. Dried, threshed seeds were often stored in metal or plastic containers or seed bags. Some farmers stored their seeds unthreshed by hanging the heads in the shade. Threshed seeds were either untreated or treated for storage pests with wood ash or cow dung. All collected seed lots were tested for their germination capacity and those that showed germination percentages above 90% were also tested for seed vigour.

Standard germination test

The standard germination test was conducted according to the rules of the International Seed Testing Association (ISTA, 1993), in rolled paper towels. Before germination 250 seeds per seedlot, were prechilled at 5°C for 5 days. Four sheets of germination paper were saturated with 100 cm^3 distilled water, and 50 seeds were placed in 5 rows of 10 seeds per row. The paper sheets were rolled loosely and placed in polyethylene bags. Seeds were incubated at 25°C in the dark for 7 days. After 7 days germination counts of viable, normal and abnormal seedlings were done according to the criteria of the ISTA rules (ISTA, 1985).

Accelerated Ageing test

The tray method described by Hampton and Tekrony (ISTA, 1993) was used. Plastic boxes (11 x 11 x 4 cm) containing wire mesh trays (10 x 10 x 0.3 cm) were used. A total

mass of 15 g of seed was placed on the wire tray to form a single layer. Distilled water (40 cm^3) was added to each plastic box after which they were covered with the lids and placed in a Labcon germination cabinet at 43°C for 72 h. After the 72 h ageing period, the seed samples were removed from each tray and seed moisture content was determined. Four 50 seed samples were removed and subjected to the standard germination test. Germination counts were made after 7 days of incubation.

The experimental design was a randomised block with four replicates. The analyses of variance (ANOVA) was performed by the SAS programme package and statistically significant differences between means were estimated by Tukey´s test (Steel & Torrie, 1985). Results of the standard germination and the Accelerated Ageing (AA) tests were correlated.

3.4 RESULTS AND DISCUSSION

The results of the standard germination test indicated that about 66% of the sweet sorghum landraces used in this study were of commercially acceptable seed quality with a germination percentage above 85% and (Table 3.2). The mean germination percentage of the 65 landraces was 77.2 % and the range was 0 to 98.5 % (Table 3.2). There were significant differences in the germination of the landraces, with landrace X and G1 having the highest germination percentages of 98.5% and 98.0%, respectively. Landraces with the lowest germination percentage were K11 and L11 with 0% and 0.5%, respectively. In most instances poor germination was due to low viability of the seed. Landraces V, J, F and E1 had low germination percentages due to high counts of abnormal seedlings. It is apparent from the results that there were large quality differences among the 65 samples. Seed quality was

generally good as there were about 66% of landraces with a germination percentage above 85%. It has been reported that the standard germination test is an excellent predictor of field emergence under ideal field conditions (Tekrony,1993; Tekrony, Egli & Phillips,1980), but under stress conditions emergence is overestimated by standard germination and hence, seed vigour becomes an important attribute in predicting field emergence (Tekrony & Egli, 1977; Johnson & Wax, 1978). All 26 landraces used in the Accelerated Ageing (AA) test had a germination percentage around 90% in the Standard Germination test (Table 3.3).

Table 3.2 Viability (radicle emergence) and germination (normal seedlings) of the 65 Botswana sweet sorghum landraces

Sweet sorghum code	Production area	Viability %	Normal seedling %
A	Moshana	50.5	49.0
B	Tlokweng	89.5	85.0
C	Kgagodi	91.0	85.5
D	Gobojango	95.0	90.5
E	Maunatlala	99.0	95.0
F	Kgagodi	92.5	78.5
G	Sefare	95.5	90.0
I	Semolale	82.0	73.5
J	Shakwe	87.5	74.0
K	Madinare	97.5	90.5
L	Machaneng	66.5	64.0
M	Sefare	68.0	62.5
N	Machaneng	10.5	9.0
O	Maunatlala	5.0	4.5
P	Tautsure	91.0	87.5
Q	Machaneng	45.5	36.0
R	Gobojango	93.0	92.5

Sweet sorghum code	Production area	Viability %	Normal seedling %
S	Gobojango	96.5	
T	Madinare	90.5	87.0
U	Sefophe	47.5	38.5
V	Sefophe	57.0	45.0
W	Sefophe	55.5	49.5
X	Matebeleng	99.0	98.5
Y	Otse	95.5	83.0
Z	Thamaga	95.5	90.5
Al	Thamaga	98.5	97.5
B1	Malolwane	87.5	84.5
C1	Mokgomane	96.0	93.0
D1	Iyaiyane	84.0	74.5
E1	Malolwane	91.0	82.5
F1	Matebeleng	79.0	73.0
G1	Logaganeng	99.0	98.0
H1	Tutume	90.5	90.0
I1	Zwenshambe	93.5	93.0
J1	Gabane	80.5	76.0
K1	Mapoka	95.5	95.0
L1	Siviya	88.0	84.5
M1	Logaganeng	99.5	93.0
N1	Mathubulukwane	96.0	90.0
O1	Mogobane	77.5	73.5
P1	Mokgomane	97.0	92.5
Q1	Siviya	94.5	91.5
R1	Tutume	92.5	89.5
S1	Mapoka	95.0	93.0
T1	Sibina	87.5	80.0
U1	Tutume	95.5	95.5
V1	Sviya	97.0	97.0

Sweet sorghum code	Production area	Viability %	Normal seedling %
X1	Gamagangwe	92.5	88.0
Y1	Malolwane	96.0	95.5
Z1	Matubulukwane	92.3	90.5
A11	Moroka	93.5	93.0
B11	Sebina	13.5	12.5
C11	Mogobane	83.5	82.0
D11	Sebina	26.0	26.0
E11	Tutume	97.0	91.0
G11	Mogobane	96.5	95.0
H11	Mogobane	94.0	91.5
I11	Thutayaseko	91.5	91.5
J11	Mmsebele	96.5	96.0
K11	Matebeleng	0.0	0.0
L11	Oodi	0.5	0.5
M11	Moshana	30.5	26.5
N11	Zwenshambe	75.0	70.0
O11	Moroka	97.0	97.0

The mean AA germination of the 26 landraces was 76.8%, and this was 16.1 percentage points lower than the standard germination results before the AA test (Table 3.3). Percentage germination in the AA test ranged between 58.0 and 87.3% and 13 of the 26 landraces had a germination percentage above 80%. Landraces with the highest germination percentages were R1 and E with 87.5% and 86.1% respectively and the lowest was landrace G with 58.0%. Landrace X was ranked the highest in the standard germination test at 98.5% but in the AA test it ranked number 22 at only 67.4%.Landrace I11 had 91.5% germination according to the standard germination test and in the AA test it was the highest with 87.5% germination (Table 3.3).

Table 3.3 Germination percentages of twenty six sweet sorghum landraces after the Accelerated Ageing test

Landraces	Germination % before the A A test	Germination % after A A test
D	90.5	75.4 bcdef
E	95.0	82.1 abc
G	90.5	58.0 g
K	90.5	65.0 efg
R	92.5	78.9 abcd
S	94.5	76.4 abcdef
X	98.5	67.4 defg
Z	90.5	79.0 abc
A1	97.5	84.0 abc
G1	98.0	82.8 abc
H1	90.0	76.1 abcdef
K1	97.0	73.6 cdef
N1	90.0	59.0 g
P1	92.5	77.8 abcd
Q1	91.5	64.8 fg
R1	89.5	86.1 ab
S1	93.0	84.8 ab
V1	93.0	85.0 abc
Z1	90.5	76.0 abcdef
A11	93.0	81.1 abc
C11	92.0	79.8 abc
E11	91.0	86.1 ab
H11	91.5	79.3 abc
L11	91.5	87.3 a
J11	96.0	67.4 defg
O11	96.0	82.6 abc
Mean	92.9	76.8
F value	1.97	15.3
LSDt (p=0.05)	11.31 (N.S.)	10.68*
C.V. (%)	4.26	5.55

Germination percentages followed by the same letter do not differ significantly at $p \leq 0.5$ *

There was no clear relationship between the results of the standard germination test and the Accelerated Ageing test. Some seed lots with high germination percentages in the standard germination test attained low germination percentages in the AA test. The AA results give a relative indication of emergence potential under stress.

According to the AA test results the seed samples of the sweet sorghum landraces were generally of low quality. It is therefore suggested that farmers be advised on harvesting, threshing and storage of sweet sorghum to improve seed quality. The seed industry can contribute by producing sweet sorghum seed. For assessment of seed quality a combination of the standard germination test, with the Accelerated Ageing test, gives more informative results but there is still a need to correlate the results with field emergence.

Although poor seed quality may be due to several factors as already stated, early harvesting time might be the major problem in sweet sorghum because farmers harvest seed before they reach physiological maturity. Harrington (1972) suggested that developing seed achieves maximum viability and vigour at physiological maturity and after that seed begins to age with viability and vigour declining. Thus, in the following chapter, results testing Harrington's hypothesis are presented, since it is not known when sweet sorghum seeds attain maximum quality during development and maturation.