CHAPTER 2

LITERATURE REVIEW

Sweet sorghum belongs to the *Sorghum bicolor* L. Moench species (Harlan & de Wet, 1972). The genus Sorghum belongs to the tribe *Andropogoneae* of the family *Poaceae*. Sweet sorghum and the other cultivated species have a chromosome number of n = 10 and is primarily self-pollinated with about 2 to 5% cross-pollination. It is accepted that cultivated sorghum originated in Africa in the zone south of the Sahara Desert where several closely related wild species are found and the cultivated species are very diverse (Martin, Leonard, & Stamp, 1975).

2.1 CROP USES

Sorghum is a major crop of the world with various uses. The estimated world area of sorghum in 1972 was 40 Mha, the largest areas being in India (16 Mha) and Africa (10.3 Mha). By 1980, sorghum production had spread throughout most parts of the world (Hume & Kebede, 1981). Sorghum grain is used for stockfeed in the New World, Japan and Europe. It provides human food and beer in India and Africa. Sweet sorghum has sweet juicy stems which may be used for forage and silage or to produce syrup. The juicy stems are often chewed as a snack by humans in southern Africa. In China sugar is produced from sweet sorghum (Doggett, 1988). Brazil currently relies on sugarcane for the production of ethanol but cassava and sweet sorghum are also being evaluated as source crops. Sweet sorghum appears to be suitable for the production of alcohol, and researchers have shown that this crop can yield up to 45 tons of biomass per hectare in 110 days. Fermentable solids in the stalks amount to 2.5 to 5 tons per hectare. One ton of sweet sorghum stalks has the potential to yield 74 litres of 200 proof alcohol (Anonymous, 1996). This shows that sweet sorghum may become an important crop for fuel alcohol production in future. Sweet sorghum bagasse is a suitable source of paper pulp The pulp is used to manufacture kraft paper, newsprint and fibre boards. Currently in France broomcorn stalks are used for paper production. Danish scientists have also made a good panelling using the chips from internodes of sorghum. Similar products are being explored in Zimbabwe as well (Anonymous, 1996).The stems are fed to livestock and is used for fencing, while the plant bases provide fuel for cooking. Sorghum may be grown for forage like the modern Sudan grasses which are developed from wild sorghum.

2.2 CROP DESCRIPTION

Sweet sorghum stems are generally taller (1.5 to 3.0 m) and juicier than grain sorghum. The diameter of the stems varies from 10 mm to 50 mm. The height of the stem depends upon the number of nodes which equals the number of leaves produced. It also depends upon the internode length, peduncle length and panicle length. All these factors contributing to height are under separate genetic control (Doggett, 1988).

The central part of the stalks contains the most sugar, followed by the lower and then the upper parts (Jansen, McClelland & Metzger, 1930). Assimilates in the stems start accumulating during the development of the inflorescence (McBee & Miller, 1982). During this period there is no competition between grain development and sugar accumulation (Lingle, 1987). Before anthesis, sugar accumulation in the stem becomes the preferential sink at the expense of growth of apical internodes (Massacci, Battistelli & Loreto, 1996). Eastin (1972) reported that after anthesis assimilates generally move down from the leaves for one to four internodes before moving upward in the central stem. The sucrose content increases and once the seed reaches the hard dough stage, sucrose content of the stem is at its maximum (Eastin, 1972; Webster, Benefiel & Davies, 1953; Stokes, Coleman & Dean, 1957; Ventre, 1948). Changes in the assimilates and proportions of sugars in sweet sorghum stems with increasing maturity were observed by Stokes *et al, (*1957) (see Table A2.1 of the Appendix). According to Ventre, Byall & Walton (1939) there is more glucose in the lower portion and more sucrose and starch in the upper part of the stem. Under conducive field conditions plants will maintain their sucrose content for about one month after reaching the hard dough stage (Coleman, 1970; Broadhead, 1972a). On the stem of sweet sorghum there is a single bud at each node. On the lowest nodes these buds may develop to form tillers and prop roots, while those on the upper nodes may produce branches (Doggett, 1988). In sorghum the normal pattern of tiller bud outgrowth in the field is the production of some tillers during the vegetative growth period followed by more extensive tiller production during and after anthesis of the main shoot (Isbell & Morgan, 1982).

Sorghum leaves are similar to corn leaves in shape but generally narrower than those of corn. Sweet sorghum leaves differ from those of grain sorghum with a dull midrib due to the presence of juice in the air spaces of the pitting tissue (Martin *et al,*1975). The total number of leaves on the stalks, including those formed during the seedling stage, ranges from 7 to 27. Leaf number is influenced by temperature and photoperiod. It is reported that leaf number tend to increase with increasing temperature and increasing daylength (Heskerth, Chase & Nanda, 1969). Leaves vary in their length and usually mature leaves reach a length of 30 to 135 cm and a width of between 1.5 and 13 cm (Dogget, 1988). Like other sorghums, sweet sorghum leaves have numerous bulliform cells near the midrib on the upper side of the leaf. During drought stress these cells result in a longitudinal rolling of the leaf that reduces transpiration and stress associated with wilting (Stoskopf, 1985). Similarly the stomatal closure occurs during drought to reduce transpiration and stress associated with wilting. Stomatal sensitivity, however, is gradually lost after flowering (Ackerson, Krieg & Sung, 1980). As a consequence, the water use efficiency is reduced and drought stress may negatively affect grain filling and development (Premachandra, Hahn & Joly, 1994).

The roots of sweet sorghum are adventitious with numerous branched lateral roots (Doggett, 1988). Roots emerge from the coleoptile node and from several leaf nodes above the coleoptile node, as an individual whorl of roots associated with each node. Root density in two grain sorghum hybrids was found to increase until grain filling, followed by a decline towards maturity (Zartman & Woyewodzic, 1979).

Flower initiation is promoted by short days although not independent of temperature (Wilson & Eastin, 1982). Like other members of the genus, anthesis begins when the peduncle has completed elongation although occasionally flowering starts earlier. The first flower to open is either the terminal one or the second flower of the uppermost panicle branch. During anthesis a typical panicle of sorghum may have an upper region of the spikelets with dried anthers that have dehisced pollen (post flowering), a middle region of the spikelet with yellow-coloured anthers shedding fresh pollen (flowering) and a basal portion of immature florets (pre-flowering) (Pendleton, Teetes & Peterson, 1994). Flowering may continue over a period of 3 to 15 days depending on the size of the panicle, temperature and the variety, with 6 - 9 days being typical (Ayyangar & Rao, 1931; Quinby, Hesketh & Voight, 1973).

Although there are varietal differences, pollen is shed freely after sunrise and may be delayed on cloudy, damp mornings. The stigmas are receptive for a day or two before blooming of the flower (Maunder & Sharp, 1963). The length of sweet sorghum panicles varies from 2 to 25 cm or more and the width from 2 to 22 cm or more. A single panicle may carry between 800 and 30,000 seeds. Although it is reported that sweet sorghum is self- pollinated, the upper part of the panicle has more outcrosses than the lower part (Maunder & Sharp, 1963).

Seeds from a panicle vary up to 10% in weight according to their position on the panicle. For some hybrids the top kernels are larger, for others the bottom kernels are larger (Weibel, 1982). In grain sorghum physiological maturity is reached at a moisture content of approximately 30 % (Bovey & McCarthy, 1965). It occurs from 25 to 55 days after flowering in tropical zone areas, and from 34 to 70 days in the temperate. The hilum frequently turns dark at about the time the seed reaches physiological maturity (Eastin, Hultquist & Sullivan, 1973). In sweet sorghum the area of the grain covered by glumes at maturity varies from one cultivar to another. Some sweet sorghum cultivars have seeds that remain enclosed by the glumes even after threshing and other cultivars are 25 to 75 % enclosed and easy to thresh (Stoskopf, 1985). The seed colour varies from light brown to black with tannins usually being present in seeds which are dark in colour.

2.3 CULTIVARS

There are readily available cultivars of sweet sorghum in many sorghum growing areas. Some of these cultivars have been selected and developed as a source of animal feed, for chewing or for syrup and sugar production. In the USA the most common cultivars are those for syrup and sugar production and most of these originated from South Africa, Sudan and Malawi. Various selections have been made from these introductions. Breeding programmes emphasized early maturity, disease resistance and sugar content.

There are considerable varietal differences in sugar content in sweet sorghum (Jonson, Sperow & Mclaren,1961). Delay in juice extraction after the stalks have been harvested is associated with reduction of the sucrose content as it is converted to reducing sugars. The variation that can occur in sugar content and quality with variety, maturity stages and delay in milling have been demonstrated by Stokes *et al*, (1957) (see Table A2.1 of the Appendix). Varieties have different rates of converting sucrose to reducing sugars, and the variety with the slowest rate of conversion tends to be the best choice for sugar production such as variety Brawley (see Table A2.2 of the Appendix). Jonson *et al*, (1961)observed that for all varieties, except Brawley, harvested at the soft dough stage, the sucrose had completely inverted to reducing sugars when milled 10 days after cutting. Due to the differences in sugar content it has been possible to classify sweet sorghum into syrup and sugar varieties. According to Coleman (1983) a good syrup cultivar must have the following characteristics:

- ability to produce high yields of medium to large stalks per hectare;

- a high percentage of extractable juice;
- strong erect growth not prone to lodging ;
- excellent juice quality capable of producing high quality syrup;
- resistance to drought and to water logging;
- relatively short growing period;
- resistance to damage by insecticides and herbicides;
- seeds that germinate well and produce vigorous seedlings; and
- adaptation to a wide range of soil and climatic conditions.

Syrup varieties such as Brawley and Sart have strong stalks and will not lodge except under adverse weather conditions (Coleman, 1983). The desirable characteristics of sweet sorghum varieties for sugar production are similar to those of syrup varieties. The differences are that sugar varieties must have extracted juice with high purity of at least 75% sucrose and a low rate of sucrose inversion. The juice of a good variety of sweet sorghum grown under suitable conditions contains 10 to 14 % of sucrose and 13 to 17 % total sugar (Cowley & Lime, 1976). Starch and aconitic acid should not be present or the concentration should be low enough not to interfere with crystallization of sucrose (Coleman, 1983). Rio is a sugar cultivar which was released to farmers in USA in 1965 as a selection from the cross of MN1048 and Rex. Rex was selected in Kansas in about 1891 whilst MN1048 was introduced from equatorial Africa in 1945. Rio is highly resistant to leaf anthracnose, red rot and rust and also tolerant to most of the other important diseases (Coleman, 1983). Characteristics of sweet sorghum varieties for chewing should be the same as the varieties for syrup and sugar production.

There are early maturing and late maturing varieties of sweet sorghum. Late maturing varieties typically mature within 135 to145 days from emergence whilst early maturing varieties mature from 82 days to 124 days after emergence (Ferraris & Stewart, 1979). Late maturing varieties usually have higher yields of stalks per hectare than early maturing ones. It also has been hypothesized that high sugar yields can be expected from late maturing, tall and thick stemmed cultivars with a relatively small grain yield, but large leaf area carried low on the stem (Ferraris, 1981a). Sweet sorghum varieties are open pollinated and hybrids are readily produced. This shows that there is a potential for rapid advances from breeding and selection programmes.

2.4 LODGING

Lodging in sweet sorghum is one of the major problems. Like in most sorghums it is affected by diseases like root and stalk rot, movement of reserves out of the culms into the grain, morphologically thin stalk walls, long internodes, and whether the pith remains strong and alive (Stoskopf, 1985). Lodging can be aggravated by high plant population which reduces stem thickness, drought occurring during ripening, or by wet and windy weather. Identification of the optimum plant population to encourage thicker and stronger stems is necessary. Breeding for lodging resistance would be another challenge. Lodging resistance in some sweet sorghum cultivars is inherited as a single dominant gene and can easily be recovered in a segregating population, such as in cultivar Sart (Coleman & Stokes, 1958). In cultivars like Branders, lodging resistance is due to plants having superior flexible stalks that sway with the wind, and a very good root system that holds the plant erect even under adverse conditions. Some cultivars have strong stalks but brittle nodes and internodes with excessive heights, such as in cultivar Wiley, which makes them prone to lodging (Coleman & Stokes, 1958).

2.5 ENVIRONMENTAL EFFECTS

Sweet sorghum grows well on a variety of soils from heavy clay to light sandy soils but best growth is achieved on loams and sandy loams. Adequate soil moisture and good drainage are important for good yields, and application of organic matter may improve soil water holding capacity. Soil acidity is seldom important and sweet sorghum can grow within a pH water range of 5.0 to 8.5. A problem with acid soils is that Al, Mn and Fe become toxic and result in ions like P, Zn, Mg, and Mo becoming deficient (Clark, 1982). Generally, sorghum tolerates salinity better than maize (Doggett, 1988). Most of the arable soils of Botswana fit the soil requirements and are suitable for the production of sweet sorghum.

Sweet sorghum is a perennial crop which prefers growing in warm conditions. In frost affected areas sweet sorghum needs to mature before the frost (Webster *et al*, 1953). Sweet sorghum can be grown year round in the tropics and in the subtropics, but in the temperate areas it is managed as a summer crop. The average growing temperature should be between 20 and 35°C, though varietal differences in temperature tolerances occurs (Doggett, 1988). The optimum germination temperature is 23°C (Kanemasu, Bark & Chinchoy, 1975). Therefore planting must be delayed until a soil temperature of 21 to 23°C is reached. Soil temperatures above 45°C inhibit the emergence of seedlings, resulting in poor crop stands (Peacock, 1982). Usually, temperature variation in the soil is responsible for differences in sorghum emergence and early seedling development (Kassam & Andrews, 1975; Kanemusu *et al*, 1975).

Sweet sorghum is a short day photoperiod sensitive plant, though large genotypic differences exist in daylength requirements for floral initiation (Ferraris & Stewart, 1979). It was reported by Ferraris & Stewart (1979) that mild photoperiod sensitive to virtually insensitive varieties existed in Australia. Varieties originally selected in the USA had a higher critical photoperiod than tropical sorghums (Ferraris & Stewart, 1979), requiring day lengths greater than 11.6 h in order to delay flower initiation (Miller, Quinby & Cruzado, 1968). The range in photoperiod sensitivity in sweet sorghum helps in its adaptation. Early maturing types can be grown in short seasons such as in areas where the growing season is limited by rainfall, temperature or other factors. Another advantage of cultivar differences in photoperiod response is that it provides flexibility in planting time, allowing manipulation of harvest schedules.

Sweet sorghum is well adapted to summer rainfall regions but in theUSA and Australia it has been shown that for commercial yields to be obtained, sweet sorghum requires more humid growing conditions than grain sorghum (Coleman, 1970; Hansen & Ferraris, 1985). However, elsewhere, good yields are realized in areas where rainfall is limited because sweet sorghum is more tolerant to drought than maize (Coleman, 1970; Doggett, 1988). During periods of drought plants remain dormant and resume growth as soon as there is sufficient soil moisture availability. Massaci *et al*, (1996) observed that in sweet sorghum juice quality was not affected by drought although photosynthesis was slightly affected.

2.6 PRODUCTION ASPECTS

Land preparation and planting

Early planting is often recommended as the yield of sweet sorghum in terms of sucrose production tends to decline with delay in sowing (Maheshwari, Prasad, Singh & Sharma,

1974; Inman-Bamber, 1980; Ferraris& Charles-Edwards, 1986b. Land preparation is similar to that used for grain sorghum. Sweet sorghum is propagated either by seed or by setts as in sugarcane (Karve, Ghanekar & Kshirsagar, 1975). In warm and moist conditions sweet sorghum can be regrown as ratoons. Planting is by drill seeding or hill planting into a well prepared seed bed. Plant population studies indicated that populations ranging from 46 000 to 65 000 ha^{-1} were optimum for stem yield and juice quality (Broadhead, Stokes & Freeman, 1963). Broadhead *et al*, (1963) observed that total dry matter and water soluble carbohydrate (WSC) yield increased with increased plant populations from 8 to 16 plants m^{-2} (80-160 000 plants/ha), whilst wider row spacing resulted in taller and thicker stems. Narrower rows resulted in high dry matter content reduced water soluble carbohydrate (WSC) yield, thinner stems which matured unevenly and increase the risk of lodging (Broadhead *et al*, 1963; Martin & Kelleher, 1984; Ferraris& Charles-Edwards, 1986(b). Cowley (1969) reported that sucrose and purity (juice quality) values are not significantly affected by spacing.

Fertilizers

It has been found that under dry conditions fertilizer application is often uneconomic. This has lead to the incorrect conclusion that sorghum does not respond to fertilizer and can be grown under low fertility conditions. Under adequate moisture conditions sorghum responds very well to fertilizers, particularly to nitrogen. In sweet sorghum it is recommended that fertilizers be applied during planting to promote early growth. Late applications of farm yard manure or fertilizers high in nitrogen may interfere with juice quality (Ferraris & Stewart, 1979). Although moderate levels of soil nitrogen are required for maximum yields, Cowley & Smith (1972) did not find any correlation between nitrogen levels and sucrose content and purity.

Total yield increased with increased nitrogen applications and the increase was experienced in stem dry matter yield rather than increase in sugar content (Ferraris, 1981). High phosphate levels in sorghum juice have been found to affect juice clarification during the processing (Smith, Smith, Romo, Cruz & Griffiths, 1970).

Weed control

Thinning should be done as early as possible before the young plants begin to tiller, usually at 7 to 10 cm in height. Weed control is advisable until canopy closure. Use of herbicides in sorghums is less satisfactory than with many other field crops, as sorghum plants are more sensitive to herbicides (Martin *et al*,1975). Effective control of weeds in the Republic of South Africa was achieved by pre-emergence application of atrazine at the rate of 3 kg ha^{-1} (Inman-Bamber, 1980). Propazine as a pre-emergence herbicide at the rate of 2.2 to 3.6 kg per hectare was used experimentally to control broadleaf and grass weeds in sweet sorghum in Mississippi and Texas and was found to be effective (Freeman *et al*, 1973). The above mentioned rates of atrazine and propazine herbicides should be lower on lighter soils (Santo & Nalamwar,1991). Post-emergence applications of atrazine, bendioxide and bromfenoxin have also been found to give excellent control of broadleaf weeds but have little effect on grasses (Coleman, 1972; Inman -Bamber, 1980). Cultivation is an important weed control measure as it minimizes weed competition until canopy closure (Cowley, 1969).

Pests and diseases

Sweet sorghum is subject to a range of insects and diseases but there is little published information available on the occurrence or severity of insects or diseases of this crop.

In Botswana there are no serious disease problems experienced either on grain sorghum or sweet sorghum. However, important pests of sorghum in Southern Africa are sorghum aphids (*Melanaphis sacchari*), Lesser false wireworms (*Mesomorphus spp.* larvae), false wireworms (*Somaticus spp.*), sorghum shoot fly (*Anatrichus erinaceus* Loew) and stalk borer (*Busseola fusca*) (van den Berg & Drinkwater (1997). In South Africa Inman-Bamber (1980) observed the chilo borer *(Chilo partellus)* and maize aphids (*Rhopalosiphum maidis)* as common insects of sweet sorghum. In the USA it has been reported that insects of importance are the lesser corn stalk borer *(Elasmopalpus lignosellus)*, sorghum midge (*Stenodiplosis sorghicola),* sugarcane borer *(Diatraea saccharalis)*, aphids, armyworms (*Spodoptera frugiperda*) and wireworm (*Heteroderes spp)*. Reported seed pests in USA are the grain moth (*Sitotroga cerealella*) and rice weevil (*Sitophilus oryzea),* (Coleman, 1970).

It is reported that disease resistant varieties have been developed but these are often highly resistant to some diseases and may be susceptible to other diseases. For example, Rio is resistant to rust (*Puccinia purpurea*), leaf anthracnose (*Colletotrichum graminicolla*)and red rots and moderately resistant to downy mildew (*Peronosclerospora sorghi)* whilst Roma is resistant to downy mildew, rust and leaf anthracnose (Cowley & Smith, 1972). In South Africa common diseases of sorghum are covered kernel smut (*Sphacelotheca sorghi*), ergot *(Claviceps africana*), fusarium rot (*Fusarium spp*)and stalk disease complex and antracnose stalk rots (*Colletotrichum graminicola*) (McLaren & Smit, 1996). Maize dwarf mosaic (MDM) and sugarcane mosaic (SCM) virus have been observed occasionally in Mississippi, Georgia, Kentucky and Texas as a destructive disease in fields of sweet sorghum. Rust was commonly found in moist humid areas while anthracnose, zonate leaf spot (*Gleocercospora sorghi*) and other leaf diseases are reported to occasionally develop readily on susceptible varieties.

Downy mildew is reported as an important disease of sweet sorghum in parts of Texas (Coleman, 1970). There are no reports of insecticidal use on sweet sorghum. However, it has been reported that sweet sorghum varieties are sensitive to certain insecticides and defoliants applied to cotton (Coleman & Dean, 1964).

Yields and harvesting

The optimum harvesting period is when the soluble carbohydrate content is at its highest level (Ferraris, 1981b). Broadhead, (1972) reports this period to be between the soft dough and ripe grain stages depending on variety or ripening conditions. As the stem reaches maturity, total sugars increase, the ratio of reducing sugars to non-reducing sugars changes and the quantity of starch present in the juice increases (Doggett, 1988). Reduction in stem-sugar content occurs after grain ripening. The optimum estimated time of harvesting sweet sorghum should be between the soft dough stage and late dough stage. Varieties such as Wiley can be harvested from as early as flowering time until the seeds are in the dough stage of maturity according to Coleman (1983). Inman-Bamber (1980) and Ferraris (1981b) recommend harvesting at the hard-dough stage because at this stage the sucrose content level is fairly consistent and stems have reached an acceptable quality for milling. Harvesting can be done by hand or by sugarcane or forage harvesters, cutting the plants at the base. Stems harvested 3 to 4 weeks after the seeds had matured, had significantly decreased Brix and sugar values (Broadhead, 1969, 1972).

Literature on sweet sorghum is inconclusive regarding post-harvest changes in sugar content and quality. Broadhead (1969) found that stems of cultivar Rio could be stored outdoors up to 48 hours without a decrease in sucrose content, while Hansen & Ferraris (1985) found that in the first 48 hours sucrose decreased from 34 to 19 % of the dry matter. It is therefore advisable to process sweet sorghum stems within 24 hours of harvesting to retain maximum sucrose content. In Texas experimental plantings of Rio yielded 36 to 45 tonnes of millable stalks per hectare (Broadhead, 1969). According to Coleman (1983), in Texas yields ranging from 45 to 112 t ha^{-1} (fresh mass) were possible. It is possible to obtain yields of sugar that vary between 2.5 to 5.9 t ha^{-1} from the first crop, and from the ratoon crop 1.5 to 5.9 t ha^{-1} (Cowley & Smith, 1972).

In the Republic of South Africa in the Midlands Mistbelt (Dalton) Inman-Bamber (1980) observed stalk yields between 14 and 37 t ha^{-1} in a growth period of about five months (see Table A2.3 of the Appendix). In North Queensland, highest sugar yields were obtained from cv. Rio, which produced 3.6 and 1.6 t ha^{-1} over 145 and 79 days from the first and ratoon crops respectively (Ferraris, 1981a). Sweet sorghum is also an excellent producer of grain (Hesker, 1966). Grain yield of 5.7 t dry matter per hectare was reported in Ayr, North Queensland (Ferraris, 1981a).

2.7 FUTURE PROSPECTS OF THE CROP IN BOTSWANA

Soil and climatic conditions in most parts of Botswana are suitable for the production of sweet sorghum. The fertilizer requirement of the crop is relatively low with very few pest and disease problems. The major production constraints experienced in Botswana are late planting, poor crop establishment, availability of seed, inferior varieties, droughts and lodging.

Sweet sorghum needs a long growing season and yield declines with late sowing (Broadhead, 1972b). Early planting is generally a problem to farmers because they must wait for adequate rains before attempting to plough. Typically small scale farmers rely on animal draught power or rented tractors which may not be available when farmers are ready to plough. Consequently, early maturing cultivars need to be introduced.

Difficulties in establishing good stands of healthy seedlings in Botswana are associated with unsuitable planting depths and sub-optimal soil moisture levels during germination and emergence. Therefore, high seed quality is a prerequisite.

Botswana farmers keep their own seed which is collected when the stems are ready for sale and not when the seeds have reached physiological maturity. The quality of seed is not monitored because sweet sorghum is considered a minor crop. Cultivar improvement is not a priority. However, harvesting seeds when they are physiologically matured and selection of genotypes for fast germination and seedling growth could improve crop establishment.

Sweet sorghum is susceptible to lodging and this is accelerated by high plant populations which reduce stem thickness (Broadhead et al,1963; Ferraris, 1988). In Botswana farmers typically broadcast seeds when planting. This results in high plant populations in some parts of the field and low crop density in other parts. In sweet sorghum production this encourages lodging and results in low stem yields. Planting in rows at a low population of 6 to 9 plants per metre is suggested as it encourages thicker and stronger stems, with high stem yields, high sucrose production, early maturity and disease and lodging resistance (Ferraris & Stewart, 1979). Currently there are no introduced or improved cultivars in Botswana to provide farmers with a range of varieties adapted to different areas.

Sweet sorghum stalks are sold as delicacies at roadside stalls. These are sold only when they are in season between March and May. Production practices resulting in a longer marketing season and in higher yields of better quality stalks can contribute greatly to the welfare of numerous small scale farmers. However, farmers must be certain of the market demands before increasing production. There are possibilities of developing sweet sorghum into an industrial crop. Sweet sorghum can be processed for sugar and its components can be used for many products (Ferraris &

Stewart, 1979). Should the need arise of industrialising sweet sorghum, then farmers could be encouraged to increase production scales.