# SWEET SORGHUM AS A COMPLEMENTARY BIOETHANOL FEEDSTOCK-FROM SOUTHERN AFRICA PERSPECTIVE

## COMPETE PROJECT

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## PRESENTATION OUTLINE

- Introduction
- Sweet sorghum characteristics
- Sweet sorghum agronomic performance field tests
- Results and analysis
- Conclusions and way forward

## INTRODUCTION

- Depending on the policy on blending ratio, potential bio-ethanol markets exist in Southern Africa.
- This potential is illustrated in Table 1 for E5(95% gasoline and 5% ethanol), and
- E10(90%gasoline and 10% ethanol)

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## INTRODUCTION

Potential Ethanol Markets based on E5 and E10

| Country | 2000 | | 2015 | |
|---|---|---|---|---|
| | E5 | E10 | E5 | E10 |
| Malawi | 4.81 | 9.62 | 6.54 | 13.07 |
| Mozambique | 3.33 | 6.66 | 4.71 | 9.41 |
| South Africa | 511.9 | 1,023.8 | 691.45 | 1,382.9 |
| Swaziland | 4.64 | 9.28 | 6.21 | 12.42 |
| Zambia | 8.89 | 17.7 | 19.0 | 25.31 |
| Zimbabwe | 23.46 | 46.91 | 28.89 | 57.78 |
| TOTAL | **557.03** | **1,113.97** | **756.8** | **1,500.89** |

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## INTRODUCTION

- The biggest challenge in Southern Africa is that although potential markets exist, and conventional technologies are available, feedstocks are not available in sufficient quantities.
- For example, at 10% blending, estimated ethanol demand was estimated at 1.0 billion litres at 2000levels, against a potential supply of 0.37 billion litres from C molasses-Assuming all sugar cane factories in Southern Africa convert most of the C molasses into ethanol.
- This scenario leaves a deficit of 0.74 billion litres. This deficit increases to 1.0 billion litres by the year 2015.

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## INTRODUCTION

- Even if existing sugar cane factories are allowed to expand between acceptable levels of between 2-3% per annum, the molasses will not be sufficient enough to offset the deficit
- Ethanol from lignocellulosic sources such as wood, grass and bagasse are promising,
- However, conversion technologies are currently uncompetitive, while feedstocks are abundant.
- For these reasons, in the short and medium term, it is advisable to seek for alternative sugar based feedstocks.
- In this case sweet sorghum stand out as a competitive complementary feedstock

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## SWEET SORGHUM CHARACTERISTICS

- Sugar cane and sorghum are C4 plants which have high photosynthesis potential and produce high biomass compared to other crops categories.
- The genus sorghum includes grain sorghum noted for their high yields and efficiency of manufacture, sweet sorghum.
- Sweet sorghum differs from grain sorghum by a few genes, those controlling plant height, and the presence of sugar in the stem.

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## SWEET SORGHUM CHARACTERISTICS

- Sweet sorghum accumulates sugars in the stem just as sugar cane.
- The main advantages of sweet sorghum are as follows:
  - Shorter growing period (100 to 130 days)
  - Low cost
  - Relatively drought resistant.

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## SWEET SORGHUM AGRONOMIC PERFORMANCE FIELD TESTS

- In the first phase of the field study, agronomic performance field tests of sweet
- Sorghum varieties, in three agro ecological regions of Zambia, were undertaken with respect to biomass production, sugar cane content, and accumulation and optimum time of sweet sorghum harvest.
- Eight exotic sweet sorghum varieties were compared to a local related sweet sorghum-SIMA.
- The exotic sweet sorghum varieties were TS1, Madhura, Praj-1, GE2, GE3, Wray, Cowley, and Keller.
- The second phase of the study involved agronomic performance of sweet sorghum under rain fed and irrigation conditions.

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## RESULTS AND ANALYSIS

- Results of biomass production of sweet sorghum varieties at different growth stages, and accumulation of sugar in different varieties are shown in figures 1 and 2 respectively

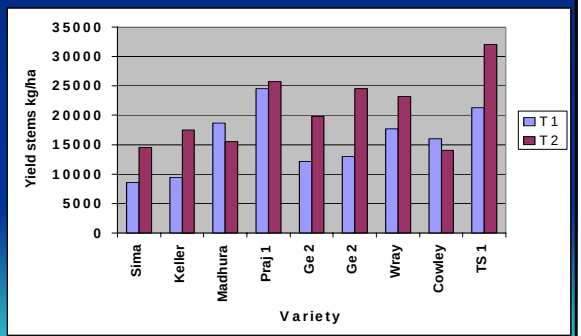


**Figure 1 Harvest of sweet sorghum at different growth stages**

**T1 - Boot stage**
**T2 - Soft dough stage**

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# RESULTS AND ANALYSIS

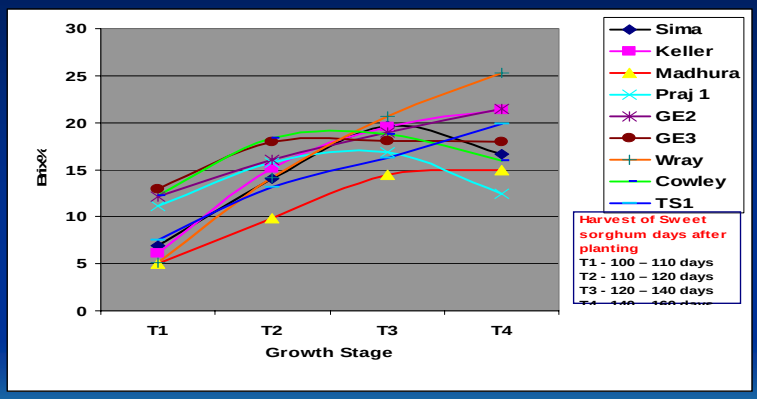


**Figure 2 Accumulation of sugar in different varieties of sweet sorghum at UNZA Farm.**

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# RESULTS AND ANALYSIS

- Results indicate that there was a tendency for the yields to be highest with TS1.
- Wray had similar yields with Praj-1,Madhura, GE3, GE3 and cowley averaging at 21.2 Mt/Ha.
- Sima had the lowest yield of 13.8 Mt/Ha.
- As part of phase 1, further analysis was undertaken to adapt varieties to soil types, and soil and crop management.

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# RESULTS AND ANALYSIS

- As regards soil types, adaptation of sweet sorghum varieties to soils resulted in ethanol production increase by 50%, and performance of yields production depending on variety and soils.
- For example TS1 performance was on Litsols, Keller on acrisols, GE" and Praj 1 on phaeozems, and Cowley and Madhura on vertisols
- Soil and crop management analysis involved investigating the degree of stem yield of sweet sorghum varieties on a particular soil type.
- The highest stem yield of sweet sorghum verities were obtained on phaeozems as shown on table 2

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# RESULTS AND ANALYSIS

**Table 2 Yield increase of Sweet Sorghum varieties on Phaeozems and lixisols compared to to Ferralsols and Vertisols**

| Variety | Minimum yield | Soil type | Maximum yield | Soil type | Yield Increase |
|---|---|---|---|---|---|
| Madhura | 4,816 | Ferralsols | 32,370 | Phaeozems | 85.1 |
| GE2 | 7,056 | Ferralsols | 43,030 | Phaeozems | 83.6 |
| Praj-1 | 6,545 | Ferralsols | 38,720 | Phaeozems | 83.1 |
| TS1 | 5,223 | Ferralsols | 29,690 | Lixisols | 82.4 |
| GE3 | 9,495 | Vertisols | 34,590 | Phaeozems | 72.5 |
| Cowley | 10,190 | Ferralsols | 32,370 | Phaeozems | 68.5 |
| Keller | 11,900 | Ferralsols | 33,430 | Phaeozems | 64.4 |
| Wray | 12,140 | Vertisols | 28,670 | Phaeozems | 57.7 |
| Sima | 9,293 | Ferralsols | 20,960 | Phaeozems | 55.7 |
| GE3 | 9,744 | Vertisols | 43,030 | Phaeozems | 77.4 |
| Wray | 22,340 | Vertisols | 28,670 | Phaeozems | 22.1 |

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## RESULTS AND ANALYSIS

To improve soil and crop management practices on sweet sorghum varieties will require the following:

- Addition of macro and microelements through fertilizer application;
- Application of irrigation during the dry season; timely planting and control of weeds and pests;
- Implementing cultural practices that increase soil organic matter content.
- Such practices also improve the stability of the highly erodible soils of Acrisols, Alisols and Arenosols.

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## RESULTS AND ANALYSIS

- Judicious application of lime to neutralize soil solution aluminum and render phosphate and other essential elements more available in order to produce high stem yields.
- This is particularly relevant for acidic soils.

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## RESULTS AND ANALYSIS

- As part of Phase II, field tests were undertaken to assess performance of rain fed
- and supplementary irrigation of sweet sorghum production. Much higher millable production sweet sorghum, and corresponding ethanol production were obtained as shown in Table 3

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## RESULTS AND ANALYSIS

**Table 3 Sweet Sorghum Production Under rain fed and supplementary irrigation**

| | Millable Stalk (Mt/ha) | | Ethanol production (m liters) | |
|---|---|---|---|---|
| Variety | Single crop | Double (ratoon) crop | Single crop | Double (ratoon) crop |
| GE3 | 82.5 | 165.0 | 38.2 | 76.3 |
| Cowley | 71.4 | 142.8 | 33.0 | 66.1 |
| Wray | 70.2 | 140.4 | 32.5 | 65.0 |
| TS1 | 51.7 | 103.4 | 23.9 | 47.8 |
| Madhura | 41.8 | 83.6 | 19.3 | 38.7 |
| Praj-1 | 40.7 | 81.4 | 18.8 | 37.7 |
| GE2 | 40.3 | 80.6 | 18.6 | 37.3 |
| Keller | 35.8 | 71.6 | 16.6 | 33.1 |
| Sima | 22.2 | 44.4 | 10.3 | 20.5 |

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- Based on the actual results, the yield of the ratoon crop of some varieties was similar to the first crop. In the case of Wray and Praj-1 the yield of the ratoon was greater than the initial yield.

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## CONCLUSIONS AND WAY FORWARD

Results obtained so far are encouraging, but more work is required to further improve on the yields. The following future work is recommended:

- Improved crop and soil management on the currently available sweet sorghum varieties.
- Appropriate agronomic packages for sustained agricultural production should be developed.
- The focus should also be on increasing the proportion of area grown to sweet sorghum.
- One of the potential limitations to sweet sorghum production is the control of pests, especially stem borers. Stem borers cause severe damage to the crop if not adequately controlled.

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## CONCLUSIONS AND WAY FORWARD

- Low cost control of stem borers should be explored
- Promising bio-control measures such as the use of nematodes should be evaluated.
- Diseases such as anthracnose, bacterial stripe, blight, gray leaf spot, sorghum rust, sooty stripe and sheath blight could pose severe limitations to the growth of the crop.
- In the longer term, the focus of the programme should be on crop improvement. Local and exotic sweet sorghum germplasm should be selected for yield and the materials also screened for tolerance to pests and diseases.
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## CONCLUSIONS AND WAY FORWARD

- To achieve higher stem yields, sweet sorghum should be grown under rain-fed and supplementary irrigation with single or double cropping especially for the better resourced farmers or those in irrigation schemes.
- Research should be conducted in an interdisciplinary framework involving all the important stakeholders

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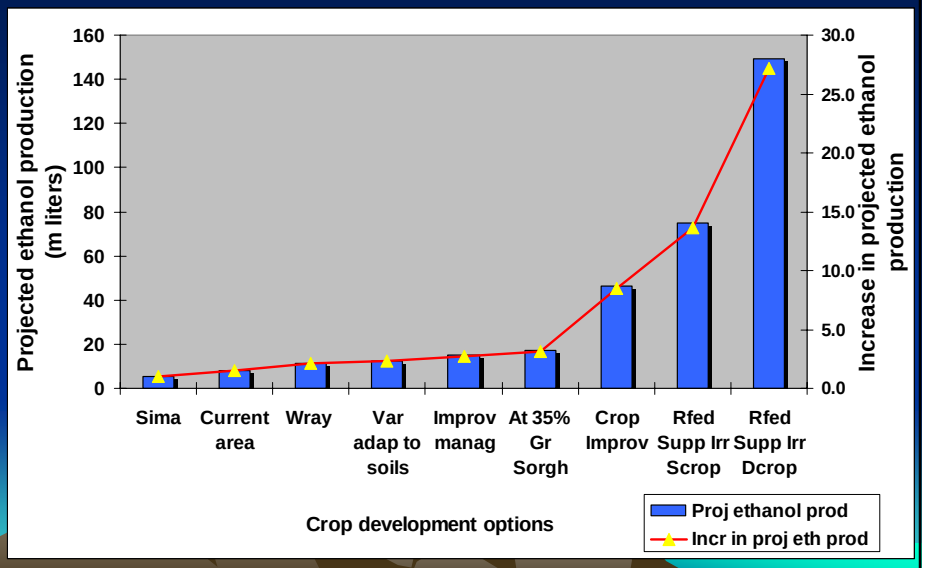
## From Different Crop Development Scenarios

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Sweet sorghum at unza farm