The Status and Prospects of Sunflower (*Helianthus Annus L.*) Breeding in Uganda*

Walter O. ANYANGA  
Sunflower Breeder  
Serere Agricultural and Animal Production Research Institute, P.O. Soroti, Uganda  
e-mail: corsu@infocom.co.ug

Abstract

Sunflower is a crop of comparatively recent introduction in Uganda but it is becoming the most important oil crop in the country since it is the only crop that can be used for extracting oil directly. Despite its demand for oil extraction, there has been lack of sufficient seed and better varieties. High input farmers prefer hybrids while the resource farmers prefer open-pollinated varieties. A number of constraints hinder sunflower research in Uganda. The most important being lack of high yielding varieties with high oil content. Research is geared towards achieving high yielding and high oil content varieties with good agronomic characters. The breeding lines include open-pollinated varieties and hybrids. These lines have been tested over seasons and locations. Most hybrids performed better than open-pollinated varieties. Yields of over 2500 kg/ha have been achieved in the hybrid lines while the open pollinated varieties have yields less than 2000 kg/ha.

Introduction

Sunflower (*Helianthus annus L.*) is a relatively new oil-seed crop in Uganda. Although it is a rather new crop in production, it is becoming the main source of vegetable oil in the country. Uganda’s annual need for edible oil has been estimated to be 54,740 metric tonnes (Thompson 1988). Other possible sources of vegetable oil are sesame (*Sesamum indicum L.*), soybean (*Glycine max L.*) and groundnuts (*Arachis hypogea L.*). However, these crops are processed much more for other food products than for their oil.

Uganda showed interest in the crop in 1947 and established first trial and seed increase plots were laid out in the western Uganda (Former Ankole and Kigezi Districts). It spread rapidly northward through Toro, West Nile and other areas of the country. Marketing of the crop was first reported in 1950 from Kigezi and West Nile as being 51 and 31 tons respectively (Bua and Molo 1985).

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Despite the initial interest and research efforts put in, sunflower production later on fluctuated considerably because of poor market structure, very low prices, few oil mills and lack of backing up on the research through training and funding. In 1975, a recommendation was passed by the Research Development Committee (RDC) that sunflower programme should emphasize straight forward selection without conventional breeding methods of crossing and indirect selection which takes several years. This selection approach also did not yield any success.

By the late 1980, Uganda was importing 98% of the total edible oil in the country. By 1996, Uganda was importing 75% of its vegetable oil and fats worth over USD 62.5M (VODP Project profile). Self sufficiency in vegetable oil production would yield major savings in foreign exchange. The potential for producing oil seeds in Uganda is tremendous, but considering the high oil content and rapid expansion ratio for sunflower compared to other oilseeds, sunflower shows the greatest short run potential in reducing Uganda’s dependency on imported edible oil.

When the potential for sunflower to solve the edible oil problem was identified, there was a deliberate campaign to popularise the growing of the crop both by government department of Agriculture, Research and NGOs. This was in the early 1990s. However, there was a severe lack of sufficient seed of acceptable varieties to meet the demand for required plantings. There were no improved varieties available and no improved varietal release had ever occurred in Uganda until 1991 when an open-pollinated variety ‘sunfola’ originating from Australia was released officially.

Recently, due to the installation of a number of oil mills in areas where sunflower is highly grown like Lira, Apac, Gulu, Kitgum, West Nile and Tororo, the production has improved a great deal (Table 1). The principal production area of sunflower in the country has been the semi-arid parts of Northern and North Eastern regions. It is a zone of low rainfall (<1000 mm per annum) and low humidity. However the interest in sunflower production has risen in the southern and western region of the country which is a wetter region of the country (> 1000 mm per annum) and more humid than the traditional production area. Mukwano oil industry (An Indian backed ) and local oil millers are having high competition now in the buying of sunflower seeds which will definitely lift the morale of the poor farmers in producing sunflower when the price is increased higher and higher.

**Table 1: Area (ha) planted and production (Ton) of sunflower in Uganda**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ha</td>
<td>38926</td>
<td>42817</td>
<td>47100</td>
<td>51812</td>
<td>56993</td>
</tr>
<tr>
<td>Ton</td>
<td>31140</td>
<td>34847</td>
<td>38993</td>
<td>43633</td>
<td>48825</td>
</tr>
</tbody>
</table>

Source: Appraisal Report of Vegetable Oil Development Project (VODP) working paper 11 1997
**Constraints to Production:**

The following constraints need to be solved under short and long term research efforts to allow increased production:-

1. Identification and provision of improved sunflower varieties/hybrids with potential for high seed yields and of high oil contents. The traditional production areas had depended all along on seeds saved from introduction brought in the 1960-70s of Russian origin like Peredovik, saluit etc. Some of these had low oil content because they were mainly for feeds while there has been lost in identity through out crossing among themselves.

2. Determination of agronomic packages for the improved varieties. Less adoption of agronomic practices like plant population, fertilizer rates, control of weeds, time of thinning are some of the factors leading to low yields.

3. Fitting the production of sunflower into the farming systems along with other crops and intercropping.

4. Long maturity period of the existing varieties with tall architecture.

**Research strategies**

A research programme on sunflower improvement was revised in 1988 at Namulonge Agricultural Research Institute located in the wetter southern zone of the country and then transferred to Serere Agricultural Research Institute based in the eastern part of the country in 1994/95. There were two approaches: short term and long term objectives.

**Short term objectives**

Work was started by testing hybrid and open pollinated varieties obtained from other countries. This was intended to identify suitable lines for the characteristics of:

- Adaptability to various environmental conditions and seasons.
- Uniform plant habits and periods to maturity i.e. early, mid and late maturity to fit in varying seasons and localities.
- Tolerance to drought and bird damage.
- High potential for yields and oil content.

**Long term objectives**

The long-term objectives were aimed to start a proper breeding programme. This is by the development of our own lines of open pollinated varieties in which suitable lines would be used for developing hybrid parental lines. So far hybrid parental lines including male steriles, maintainers and restorers have been acquired from North Dakota State University (USA). Although these objectives have been set, there are still limitations basing on the following:

- Immediate acquisition of germplasm and collaboration projects especially in form of International trials for testing materials in advanced stages of development. These would help in identifying appropriate materials for Uganda.
• Training of Research personnel in sunflower breeding approaches. This has just been started in 2001.
• There is still lack of proper machine for oil analysis at the institute.

Materials and Methods

1. Evaluation of hybrids and open-pollinated varieties.


Breeding lines were received from Interstate Seed Company, Fargo and North Dakota (USA); Cargil Ltd (Kenya), Australia, Romania, Tanzania, etc. These consisted both of open-pollinated varieties and hybrids. The plots measured 3 x 5 m² and 4 rows at a spacing of 0.75 x 0.5 m with 3 replications.

At the seedling stage of about 15 cm in height, the seedlings were thinned to one plant/hill. The experiments were kept weed free by hand hoeing. To reduce yield loss by birds, bird scarers were deployed during physiological maturity period.

Parameters recorded apart from yield included head diameter, days to 50% flowering, oil content, plant height, maturity, vigour etc. During harvest, only the middle rows were harvested leaving the outer rows due to competition with the neighbouring varieties.

1.2) Evaluation at Serere Agricultural Research Institute 1996-2001

At Serere Agricultural Research Institute, testing started in 1996 after acquiring some germplasm from other countries, multiplying them for testing with few materials obtained from Namulonge.

1.2.1) Evaluation of open-pollinated varieties for high yield and other desirable attributes

Plots in Serere for the open pollinated varieties measured 3.75 x 4 m² and spacing of 0.75x0.5m with 4 replications for the open-pollinated varieties. All these experiments were laid in a randomized complete block design. The experiment started in 1996 to present.

1.2.2) Evaluation of sunflower hybrids from Zimbabwe

During the first season of 2001, the experiment was laid only at Serere Agricultural Research Institute. In the second season of 2001, it was planted at five centres in five districts viz: Serere, Ngetta, Aduku, Kuju and Kumi trial verification centres.
Seven hybrids namely: PAN 7351, 7355, 7371, 7392, 7001, 7352, 7353 and three open-pollinated varieties were tested in each location. In some locations, the open-pollinated varieties were not the same. The varieties included were: sunfola (released variety), Record Romania, Kolos, Saluit Serere and Local stripe.

The experiment was laid out in a Randomised Complete Block Design (RCBD) with three replications at a spacing of 0.75 x 0.5 cm leaving one plant per hill. For the first season experiment at Serere, each plot had 6 rows and 4 m long. For the second season trials there were 4 rows and 4 m long.

1.2.3) Evaluation of sunflower hybrids and varieties from South Africa

These trial was planted only at serere since there was little seed available. The experiment was planted on 29/5/2001. Twenty two entries were tested comprising of 16 hybrids, 4 open-pollinated varieties from South Africa and two other open-pollinated varieties, that is; Sunfola and Record Romania used as checks.

The experiment was laid in a Randomised Complete Block Design (RCBD) with three replications and spacing at 0.75 x 0.5 m leaving plant/hill. Each plot had 4 rows and three meters long.

2. Multiplication and Purification of hybrid parental lines

Recently, hybrid parental lines totalling to eleven (A and B lines) and also eleven restorer lines have been introduced from USDA North Dakota (USA). Each A-line was pollinated with its maintainer for routine maintenance and multiplication.

3. Multiplication of nucleus and breeder seed production of open-pollinated variety ‘sunfola’.

Three methods are being used to maintain purity of ‘sunfola’ variety and two methods for other varieties.

i) Half-Sib method

Here, pollen from plants that look phenotypically desirable and do not show symptoms of disease, branching, off-types are collected together and dusted on the heads of each of the selected bagged plants. Pollination is done manually and all the selected heads are bagged using cloth bags. During harvest, only the bagged heads are harvested in bulk for further planting.

ii) Mass selection method

This is the Phenotypic (visual) selection of individual plants for the improvement of a cultivar or population for specific traits.
A variety is planted in isolation (spatial) and selection is applied without the control of pollination, that is, selection is done after flowering especially during maturity when cross-pollination has already taken place. This has been done for the production of breeder seed.

iii) Pustovoit method of seed Reserves (Remnant seed)

This has been the recent approach after realising that mass selection does not purify seed completely. It is a method that has been successful in improving sunflower cultivars especially in Russia and other central Europe. Pustovoit method is a form of recurrent selection that includes progeny evaluation and subsequent cross-pollination of only the desirable progenies using remnant seed descent.

Thousands of heads are harvested individually through positive mass selection of desirable plants. The individual heads are threshed and their seeds are screened in the laboratory so that only heads with better seeds and true to type to that variety are selected and planted as progeny rows and progeny rows that show better performance are continued with through their remnant seed.

4. Development of inbred lines for hybrid production.

Selfing for individual heads of the open-pollinated varieties and hybrids in our germplasm are being undertaken in order to come up with uniform inbred lines. This is to take six generations of selfing and selection before their combining ability (general and specific) are evaluated.

5. On-farm evaluation of elite promising open-pollinated varieties

Four promising elite open-pollinated varieties saluit serere, kolos, Record Romania, Sunfola were evaluated in six districts where sunflower is mainly grown in Uganda. Four farmers per district were selected for the testing of these varieties. Each farmer per district was used as a replicate.

Each plot measured 6.75 x 30 m and had ten rows at a spacing of 0.75 x 0.5 m. The trials were managed by the farmers themselves but monitored by the extension staff of agriculture.

Results and Discussion

1. Namulonge Research Institute

In 1988 hybrid S405 had the highest yield ant Mubuku in western Uganda with 2,277 kg/ha while at Kabanyolo hybrid S430 had the highest yield of 2,588 kg/ha (Table 2). In 1989, hybrid U33282 was the highest with 1,870 kg/ha (Table 3). In 1990, hybrid S400 yielded the highest with 1,650 kg/ha (Table 4) in the two locations of Ngetta (Northern Uganda) and Nakabango (Southern Uganda). Perededovik and Sunfola which are open pollinated varieties yielded least. Hybrids were found to be better than the open
pollinated varieties and they provided better standability, higher yields and were uniform in maturity and plant height.

Table 2. Performance of Hybrids and an open pollinated variety at Mubuku and Kabanyoro during the first rains of 1988.

<table>
<thead>
<tr>
<th>Entry</th>
<th>Yield kg/ha</th>
<th>Oil content</th>
<th>Days to 50% flowering</th>
<th>Yield kg/ha</th>
<th>Oil content</th>
<th>Days to 50% flowering</th>
</tr>
</thead>
<tbody>
<tr>
<td>S400</td>
<td>2142</td>
<td>49.9</td>
<td>58</td>
<td>1947</td>
<td>44.0</td>
<td>66</td>
</tr>
<tr>
<td>S401</td>
<td>2162</td>
<td>44.6</td>
<td>61</td>
<td>1824</td>
<td>43.6</td>
<td>66</td>
</tr>
<tr>
<td>S405</td>
<td>2277</td>
<td>39.7</td>
<td>58</td>
<td>2071</td>
<td>40.7</td>
<td>61</td>
</tr>
<tr>
<td>S430</td>
<td>2104</td>
<td>-</td>
<td>66</td>
<td>2588</td>
<td>-</td>
<td>66</td>
</tr>
<tr>
<td>Peredovik</td>
<td>1557</td>
<td>45.9</td>
<td>58</td>
<td>1767</td>
<td>45.1</td>
<td>62</td>
</tr>
<tr>
<td>C.V.%</td>
<td>1.64</td>
<td></td>
<td></td>
<td>16.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Evaluation of some introduced hybrids and open-pollinated varieties tested at Namulonge Agricultural Research Institute in 1989.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Yield kg/ha</th>
<th>Days to 50% flowering</th>
<th>Plant height (cm)</th>
<th>Head diameter (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>U33282</td>
<td>1870</td>
<td>68</td>
<td>158</td>
</tr>
<tr>
<td>2</td>
<td>E31007</td>
<td>1780</td>
<td>68</td>
<td>170</td>
</tr>
<tr>
<td>3</td>
<td>U61461</td>
<td>1760</td>
<td>72</td>
<td>181</td>
</tr>
<tr>
<td>4</td>
<td>U33085</td>
<td>1760</td>
<td>20</td>
<td>1136</td>
</tr>
<tr>
<td>5</td>
<td>U62190</td>
<td>1710</td>
<td>68</td>
<td>137</td>
</tr>
<tr>
<td>6</td>
<td>S33076</td>
<td>1690</td>
<td>70</td>
<td>154</td>
</tr>
<tr>
<td>7</td>
<td>S430</td>
<td>1690</td>
<td>75</td>
<td>185</td>
</tr>
<tr>
<td>8</td>
<td>U400</td>
<td>1640</td>
<td>73</td>
<td>174</td>
</tr>
<tr>
<td>9</td>
<td>U51015</td>
<td>1560</td>
<td>74</td>
<td>219</td>
</tr>
<tr>
<td>10</td>
<td>U61120</td>
<td>1410</td>
<td>64</td>
<td>135</td>
</tr>
<tr>
<td>11</td>
<td>Sunfola</td>
<td>1360</td>
<td>63</td>
<td>146</td>
</tr>
<tr>
<td>12</td>
<td>U65101</td>
<td>1360</td>
<td>67</td>
<td>160</td>
</tr>
<tr>
<td>13</td>
<td>U33141</td>
<td>11310</td>
<td>72</td>
<td>177</td>
</tr>
<tr>
<td>14</td>
<td>IS7000</td>
<td>1270</td>
<td>58</td>
<td>127</td>
</tr>
<tr>
<td>15</td>
<td>U51010</td>
<td>1270</td>
<td>66</td>
<td>139</td>
</tr>
<tr>
<td>16</td>
<td>U33241</td>
<td>1270</td>
<td>69</td>
<td>126</td>
</tr>
<tr>
<td>17</td>
<td>IS3312</td>
<td>1240</td>
<td>66</td>
<td>136</td>
</tr>
<tr>
<td>18</td>
<td>E41226</td>
<td>1220</td>
<td>65</td>
<td>139</td>
</tr>
<tr>
<td>19</td>
<td>U52017</td>
<td>1110</td>
<td>64</td>
<td>133</td>
</tr>
<tr>
<td>20</td>
<td>Record (Tanzania)</td>
<td>1020</td>
<td>76</td>
<td>239</td>
</tr>
<tr>
<td>21</td>
<td>Peredovik</td>
<td>1000</td>
<td>73</td>
<td>180</td>
</tr>
<tr>
<td>22</td>
<td>IS7111</td>
<td>1000</td>
<td>64</td>
<td>130</td>
</tr>
<tr>
<td>23</td>
<td>U61289</td>
<td>700</td>
<td>75</td>
<td>176</td>
</tr>
</tbody>
</table>
Table 4. Evaluation of hybrids and open-pollinated varieties at Nakabango and Ngetta during the first rains of 1990

<table>
<thead>
<tr>
<th>Variety</th>
<th>Nakanago Yield kg/ha</th>
<th>Ngetta</th>
</tr>
</thead>
<tbody>
<tr>
<td>S400</td>
<td>1650a</td>
<td>1650a</td>
</tr>
<tr>
<td>GX 533</td>
<td>1420ab</td>
<td>-</td>
</tr>
<tr>
<td>Peredovik (Zimbabwe)</td>
<td>1400ab</td>
<td>1450abc</td>
</tr>
<tr>
<td>GX 115</td>
<td>1310ab</td>
<td>-</td>
</tr>
<tr>
<td>GX 116</td>
<td>1160ab</td>
<td>-</td>
</tr>
<tr>
<td>Vympel</td>
<td>1060ab</td>
<td>600c</td>
</tr>
<tr>
<td>Sunfola</td>
<td>740b</td>
<td>930abc</td>
</tr>
<tr>
<td>Peredovik (Interstate)</td>
<td>740b</td>
<td>580c</td>
</tr>
<tr>
<td>Local stripe</td>
<td>-</td>
<td>1510</td>
</tr>
<tr>
<td>Mean</td>
<td>1185</td>
<td>1120</td>
</tr>
<tr>
<td>CV%</td>
<td>36</td>
<td>41</td>
</tr>
</tbody>
</table>

2. Serere Research Institute

2.1 Evaluation of open-pollinated varieties

In table 5 during the first rains of 1996, saluit serere had the highest yield of 1,547 kg/ha followed by Vniimk 883 with 1,308 kg/ha and the local stripe with 1,277 kg/ha at Ngetta while during first rains at serere, Vniimk 8883 had the highest yield of 2,000 kg/ha followed by saluit serere with 1547 kg/ha. The yield of most varieties fluctuated yearly and in positions. Saluit serere, Record Romania, sunfola, local stripe and Kolos did comparatively better than other varieties.

From the yield data in table 5, the elite lines of open-pollinated varieties that can go into commercial production are Saluit (Serere), Record Romania, Local stripe and Sunfola. Local stripe is being widely grown in the Northern part of the country as a commercial variety for oil production. Although it has less oil content (29), farmers prefer it to sunfola (46%) due to its seed weight.
Table 5. Yields kg/ha at Ngetta and Serere from 1996 to 1999

<table>
<thead>
<tr>
<th>Variety</th>
<th>Ngetta</th>
<th>SAARI</th>
<th>SAARI</th>
<th>SAARI</th>
<th>SAARI</th>
<th>SAARI</th>
<th>SAARI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1547(1)</td>
<td>11694(2)</td>
<td>1458(5)</td>
<td>1823(1)</td>
<td>92194(4)</td>
<td>1420(3)</td>
<td>1253(4)</td>
</tr>
<tr>
<td>Record (Tanzania)</td>
<td>770(8)</td>
<td>1222(5)</td>
<td>1375(6)</td>
<td>677(8)</td>
<td>369(9)</td>
<td>865(9)</td>
<td>705(7)</td>
</tr>
<tr>
<td>Vniumk 8883</td>
<td>1308(2)</td>
<td>2000(1)</td>
<td>1625(4)</td>
<td>1073(6)</td>
<td>598(8)</td>
<td>913(8)</td>
<td>846(6)</td>
</tr>
<tr>
<td>Record Arapai</td>
<td>829(7)</td>
<td>1278(4)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Record (Romania)</td>
<td>1136(4)</td>
<td>1083(6)</td>
<td>1667(3)</td>
<td>990(7)</td>
<td>974(3)</td>
<td>1360(5)</td>
<td>1386(3)</td>
</tr>
<tr>
<td>Record (Kenya)</td>
<td>1105(5)</td>
<td>778(8)</td>
<td>1146(7)</td>
<td>1250(5)</td>
<td>892(5)</td>
<td>1548(2)</td>
<td>624(9)</td>
</tr>
<tr>
<td>Local stripe</td>
<td>1277(3)</td>
<td>833(7)</td>
<td>1771(2)</td>
<td>552(9)</td>
<td>1004(2)</td>
<td>1613(1)</td>
<td>1543(1)</td>
</tr>
<tr>
<td>Sunfola</td>
<td>869(6)</td>
<td>1444(3)</td>
<td>1833(1)</td>
<td>1354(4)</td>
<td>729(7)</td>
<td>1094(7)</td>
<td>1517(2)</td>
</tr>
<tr>
<td>Fedha large</td>
<td>-</td>
<td>-</td>
<td>833(8)</td>
<td>552(9)</td>
<td>282(10)</td>
<td>525(10)</td>
<td>654(8)</td>
</tr>
<tr>
<td>Kolos</td>
<td>-</td>
<td>-</td>
<td>333*(9)</td>
<td>1406(3)</td>
<td>1031(1)</td>
<td>1413(4)</td>
<td>604*(10)</td>
</tr>
<tr>
<td>Saluit (Lira)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1458(2)</td>
<td>879(6)</td>
<td>1276(6)</td>
<td>1099(5)</td>
</tr>
<tr>
<td>Mean</td>
<td>1105</td>
<td>1292</td>
<td>1338</td>
<td>1114</td>
<td>768</td>
<td>1203</td>
<td>1023</td>
</tr>
</tbody>
</table>

* Low yields due to poor germination
( ) Figures in parenthesis are ranking of positions
A&B Are first and second season respectively
SAARI Serere Agricultural and Animal Production Research Institute

2.2 Evaluation of sunflower hybrids from Zimbabwe

In table 6 hybrid PAN 7351 had the highest yield across locations with 1,648 kg/ha and it was also the best in three sites of Ngetta, Kuju, Adukyu with 1853 kg/ha, 1667 kg/ha and 1284 kg/ha respectively. Hybrid PAN 7371 had the second highest yield across locations with 1,512 kg/ha.

The performance of the hybrids/varieties was best at serere with mean yield of 1762 kg/ha. PAN 7352 had the highest yield in serere with 2,072 kg/ha followed by PAN 7001 with 2,038 kg/ha.

Ngetta had the second highest performance of the hybrids/varieties, with PAN 7351 and PAN 7371 having the highest yields of 1853 kg/ha and 1620 kg/ha respectively.

The yield performance in Aduku was the lowest with average mean of 801 kg/ha. This is also reflected by the high C.V.

Significant difference among hybrids/varieties were observed in three centres of Ngetta, Kumi and Kuju.
The hybrids generally did better than the open-pollinated varieties although in serere Aduku, no significant difference was observed between hybrids and varieties. In Aduku, variety ‘sunfola’ had better performance than PAN 7355.

Table 6: Yield Performance Of Sunflower Hybrids From Zimbabwean Pannar Seed Company In Five Centres In Uganda

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7351</td>
<td>1982(3)</td>
<td>1456(5)</td>
<td>1284(1)</td>
<td>1667(1)</td>
<td>1853(1)</td>
</tr>
<tr>
<td>2</td>
<td>7355</td>
<td>1783(7)</td>
<td>1407(6)</td>
<td>703(8)</td>
<td>1120(7)</td>
<td>847(10)</td>
</tr>
<tr>
<td>3</td>
<td>7371</td>
<td>1886(5)</td>
<td>1485(3)</td>
<td>1095(2)</td>
<td>1472(2)</td>
<td>1620(2)</td>
</tr>
<tr>
<td>4</td>
<td>7392</td>
<td>1839(6)</td>
<td>1634(1)</td>
<td>849(4)</td>
<td>1464(3)</td>
<td>1591(4)</td>
</tr>
<tr>
<td>5</td>
<td>7001</td>
<td>2038(2)</td>
<td>1406(7)</td>
<td>982(3)</td>
<td>1337(5)</td>
<td>1543(6)</td>
</tr>
<tr>
<td>6</td>
<td>7352</td>
<td>2072(1)</td>
<td>1553(2)</td>
<td>756(5)</td>
<td>1454(4)</td>
<td>1592(3)</td>
</tr>
<tr>
<td>7</td>
<td>7353</td>
<td>1916(4)</td>
<td>1482(4)</td>
<td>747(6)</td>
<td>1132(6)</td>
<td>1587(5)</td>
</tr>
<tr>
<td>8</td>
<td>Local Stripe</td>
<td>-</td>
<td>-</td>
<td>538(10)</td>
<td>1057(9)</td>
<td>1191(8)</td>
</tr>
<tr>
<td>9</td>
<td>Sunfola</td>
<td>1578(8)</td>
<td>1188(8)</td>
<td>719(7)</td>
<td>969(10)</td>
<td>1247(7)</td>
</tr>
<tr>
<td>10</td>
<td>Record Romania</td>
<td>1260(10)</td>
<td>-</td>
<td>632(9)</td>
<td>812(11)</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>Kolos</td>
<td>1262(9)</td>
<td>1000(10)</td>
<td>509(11)</td>
<td>1103(8)</td>
<td>969(10)</td>
</tr>
<tr>
<td>12</td>
<td>Saluit Serere</td>
<td>-</td>
<td>1065(9)</td>
<td>-</td>
<td>-</td>
<td>1065(9)</td>
</tr>
<tr>
<td>Mean</td>
<td>1762</td>
<td>1368(9)</td>
<td>801</td>
<td>1235</td>
<td>1404</td>
<td>1314</td>
</tr>
<tr>
<td>CV</td>
<td>20</td>
<td>16.6</td>
<td>42</td>
<td>18.5</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>S.E.D</td>
<td>NS</td>
<td>*</td>
<td>NS</td>
<td>***</td>
<td>**</td>
<td></td>
</tr>
</tbody>
</table>

2.3 Evaluation of Sunflower hybrids and varieties from South Africa

Sixteen hybrids and four open-pollinated varieties from south Africa were tested alongside two varieties from Uganda (Table 7). Hybrid KS 61-3-1 had the highest yield with 2,513 kg/ha followed by hybrid KS 189-2-1 with 2436 kg/ha. Ten hybrids had yields above 2,000 kg/ha.

Among the open-pollinated varieties, Record Romania had the highest yield of 1634 kg/ha followed by sunfola (the released variety) with 1419 kg/ha.

No significant difference was observed among the genotypes for head diameter while significant difference was observed among all other characters. Hybrid CLTCY 2-3-2-1 had the best resistance against leaf spot disease. H55-9-1-2 and H55-2-2 had very good vigour. Most of the good performing hybrids had maturity above 110 days while the early maturity genotypes were poor yielder except RK 74C-1-55-2.

The open-pollinated varieties (OP) from South Africa had low plant height and they could be used in the breeding programme to reduce the plant height of other varieties in our gene pool.

The ten hybrids that yielded over 2,000 kg/ha could be further tested under different conditions like spacing and fertilizer rates.
Table 7. Yield Performance of sunflower hybrids and varieties from South Africa evaluated at Serere during first season of 2001

<table>
<thead>
<tr>
<th>Entry</th>
<th>Yield kg/ha</th>
<th>Head diameter (CM)</th>
<th>Leaf spot disease</th>
<th>Vigour</th>
<th>Plant height (Cm)</th>
<th>Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 KS 189-2-1</td>
<td>2436(2)</td>
<td>21</td>
<td>2.7</td>
<td>2.0</td>
<td>165</td>
<td>113</td>
</tr>
<tr>
<td>2 KB 16-17-1-1</td>
<td>2115(6)</td>
<td>21</td>
<td>4.0</td>
<td>3.0</td>
<td>156</td>
<td>114</td>
</tr>
<tr>
<td>3 KS 61-3-1</td>
<td>2513(1)</td>
<td>22</td>
<td>2.7</td>
<td>2.3</td>
<td>170</td>
<td>115</td>
</tr>
<tr>
<td>4 HA 89</td>
<td>1326(18)</td>
<td>17</td>
<td>4.7</td>
<td>4.0</td>
<td>125</td>
<td>104</td>
</tr>
<tr>
<td>5 H55-9-1-1</td>
<td>2216(4)</td>
<td>21</td>
<td>2.0</td>
<td>1.7</td>
<td>168</td>
<td>117</td>
</tr>
<tr>
<td>6 H52-6-3</td>
<td>2115(6)</td>
<td>21</td>
<td>3.0</td>
<td>3.3</td>
<td>157</td>
<td>110</td>
</tr>
<tr>
<td>7 H55-2-2</td>
<td>1641(15)</td>
<td>20</td>
<td>2.7</td>
<td>1.7</td>
<td>159</td>
<td>116</td>
</tr>
<tr>
<td>8 CMS 482</td>
<td>2095(8)</td>
<td>21</td>
<td>3.0</td>
<td>2.0</td>
<td>153</td>
<td>119</td>
</tr>
<tr>
<td>9 CLTCY 2-3-2-1</td>
<td>1830(11)</td>
<td>21</td>
<td>1.7</td>
<td>2.3</td>
<td>170</td>
<td>119</td>
</tr>
<tr>
<td>10 HV 3037</td>
<td>1742(13)</td>
<td>21</td>
<td>4.3</td>
<td>3.0</td>
<td>157</td>
<td>112</td>
</tr>
<tr>
<td>11 AP 841-35-1-2</td>
<td>1673(14)</td>
<td>20</td>
<td>3.3</td>
<td>3.0</td>
<td>155</td>
<td>116</td>
</tr>
<tr>
<td>12 AP 822-158-3</td>
<td>2046(9)</td>
<td>23</td>
<td>3.3</td>
<td>2.0</td>
<td>159</td>
<td>110</td>
</tr>
<tr>
<td>13 PC-4-19-2</td>
<td>1821(12)</td>
<td>20</td>
<td>2.3</td>
<td>2.7</td>
<td>146</td>
<td>111</td>
</tr>
<tr>
<td>14 PC-4-31-1</td>
<td>2265(3)</td>
<td>21</td>
<td>2.3</td>
<td>2.3</td>
<td>154</td>
<td>117</td>
</tr>
<tr>
<td>15 RK74C-1-55-2</td>
<td>2142(5)</td>
<td>19</td>
<td>3.0</td>
<td>2.3</td>
<td>144</td>
<td>108</td>
</tr>
<tr>
<td>16 HYSUN 333</td>
<td>2028(10)</td>
<td>21</td>
<td>3.0</td>
<td>2.3</td>
<td>166</td>
<td>111</td>
</tr>
<tr>
<td>17 OP1</td>
<td>986(20)</td>
<td>21</td>
<td>2.7</td>
<td>3.3</td>
<td>134</td>
<td>117</td>
</tr>
<tr>
<td>18 OP2</td>
<td>919(22)</td>
<td>18</td>
<td>3.3</td>
<td>4.3</td>
<td>115</td>
<td>105</td>
</tr>
<tr>
<td>19 OP3</td>
<td>1266(19)</td>
<td>23</td>
<td>5.0</td>
<td>4.3</td>
<td>133</td>
<td>111</td>
</tr>
<tr>
<td>20 OP4</td>
<td>920(21)</td>
<td>18</td>
<td>3.7</td>
<td>4.3</td>
<td>129</td>
<td>113</td>
</tr>
<tr>
<td>21 Sunfola (c)</td>
<td>1419(17)</td>
<td>17</td>
<td>3.7</td>
<td>3.3</td>
<td>154</td>
<td>104</td>
</tr>
<tr>
<td>22 Record Romania (c)</td>
<td>1634(16)</td>
<td>19</td>
<td>4.0</td>
<td>4.0</td>
<td>171</td>
<td>112</td>
</tr>
<tr>
<td>Mean</td>
<td>1779</td>
<td>20</td>
<td>3.2</td>
<td>2.9</td>
<td>152</td>
<td>112</td>
</tr>
<tr>
<td>C.V %</td>
<td>23.7</td>
<td>11</td>
<td>29.9</td>
<td>25</td>
<td>6.1</td>
<td>2.1</td>
</tr>
<tr>
<td>LSD</td>
<td>***</td>
<td>NS</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>S.E.D</td>
<td>344.5</td>
<td>1.8</td>
<td>0.8</td>
<td>0.60</td>
<td>7.6</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Scale
1. Leaf spot disease 1 = No disease   9 = completely diseased
2. Vigour 1 = very vigorous   9 = very low vigour

C = Check varieties
() = Ranking of positions in yield

3. Multiplication and purification of hybrid parental lines

3.1 Multiplication of female and maintainer lines

During the first season (April-July) of year 2000, the female parental lines were pollinated with their maintainers in order to increase seed for further testing and crossing to other lines to produce either single cross or three way cross hybrids. It was realised
that in some female lines, the number of plants with pollen shedders were almost one quarter of the population and there were also branching types among both female and maintainer lines. This defect made us to go for full-sib progeny testing.

3.2 Purification of parental lines using full-sib progeny testing
Due to the production of unwanted pollen shedders and branching type in the female lines, each female plant of a particular hybrid line was crossed to a particular male plant that synchronized in flowering period and had no defects like branching or disease.

During the first rains of year 2001, the individual pollinated female plants of different hybrids with their male partners were planted as progeny rows to monitor any pollen shedders so that such a particular female line and its maintainer would be discarded. Remnant seeds were used for further evaluation and multiplication.

In the line CMSHA 89 and HA 89, CMSHA 372 and HA 372, half of the male plants were used for pollinating their female lines while the remaining half were selfed for selection of uniform plants that would be used for future production of male counter parts of CMSHA 89 and CMSHA 372.

3.3 Purification of Restorer lines
The two methods used to maintain the restorer lines were half-sib and selfing. Morphologically, no difference was observed in the growth of the restorers.

4. On-farm evaluation of elite promising open-pollinated varieties
During the second season of 2000, three varieties were tested at farmer level (Table 8) and for the first season of 2001, four varieties were tested (Table 9).

The performance of varieties at Lira during the second season of 2000 was the best and it was also the second best in first season of 2001, with 1,476 kg/ha and 1,237 kg/ha respectively. Soroti district followed with 1,150 kg/ha and 1,237 kg/ha for year 2001 and 2002 respectively.

For the varieties, Record Romania had the highest yield of 1,664 kg/ha in Lira. Sunfola generally performed well in most of the districts normally being the first or second in position.
Table 8. On-farm performance of elite open-pollinated varieties in some districts of Uganda during second season 2000

<table>
<thead>
<tr>
<th>Variety</th>
<th>Lira</th>
<th>Apac</th>
<th>Soroti</th>
<th>Katakwi</th>
<th>Kumi</th>
<th>Pallisa</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Saluit Serere</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2 Kolos</td>
<td>1,215(3)</td>
<td>1,560(1)</td>
<td>1,000(2)</td>
<td>1,100(2)</td>
<td>-</td>
<td>850(2)</td>
</tr>
<tr>
<td>3 Record Romania</td>
<td>1,664(1)</td>
<td>662(3)</td>
<td>-</td>
<td>1,200(1)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4 Sunfola</td>
<td>1,550(2)</td>
<td>996(2)</td>
<td>1,300(1)</td>
<td>900(3)</td>
<td>-</td>
<td>1,200(1)</td>
</tr>
<tr>
<td>Mean</td>
<td>1476</td>
<td>1073</td>
<td>1150</td>
<td>1067</td>
<td>-</td>
<td>1025</td>
</tr>
</tbody>
</table>

Table 9. On-farm performance of elite open-pollinated varieties in some districts of Uganda during first season 2001

<table>
<thead>
<tr>
<th>Variety</th>
<th>Lira</th>
<th>Apac</th>
<th>Soroti</th>
<th>Katakwi</th>
<th>Kumi</th>
<th>Pallisa</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Saluit Serere</td>
<td>1,267(2)</td>
<td>1,238(2)</td>
<td>1,148(3)</td>
<td>1,252(1)</td>
<td>1,111(1)</td>
<td>641(3)</td>
</tr>
<tr>
<td>2 Kolos</td>
<td>1,219(3)</td>
<td>820(4)</td>
<td>1,081(4)</td>
<td>667(4)</td>
<td>741(4)</td>
<td>769(1)</td>
</tr>
<tr>
<td>3 Record Romania</td>
<td>962(4)</td>
<td>1,026(3)</td>
<td>1,385(1)</td>
<td>889(3)</td>
<td>963(3)</td>
<td>538(4)</td>
</tr>
<tr>
<td>4 Sunfola</td>
<td>1,390(1)</td>
<td>1,334(1)</td>
<td>1,333(2)</td>
<td>1,244(2)</td>
<td>1,037(2)</td>
<td>718(2)</td>
</tr>
<tr>
<td>Mean</td>
<td>1210</td>
<td>1,105</td>
<td>1237</td>
<td>1013</td>
<td>963</td>
<td>667</td>
</tr>
</tbody>
</table>
Discussion

Despite the good return from hybrids, most of the farmers in Uganda are still at subsistence level who may not afford to buy hybrid seed and therefore there is need to promote also higher yielding open pollinated varieties that are cheaper to buy the seeds and can be planted for some few years without losing much yield compared to second and subsequent generation hybrids. Oil seed crushers are also encouraging hybrid production and better open pollinated varieties by giving them premium for these better lines and low prose for the local cultivars. Since these lines of hybrids which were tested from 1989 to 1990 were not in form of parental lines or inbreds, no more seeds could be availed anymore and therefore the testing of these hybrids stopped. It is therefore necessary to acquire hybrids in form of parental lines or inbreds.

Hybrids are observed generally to be superior to the open-pollinated varieties in terms of yield, resistance, uniformity and seed quality as seen from the evaluation of Zimbabwean and south African hybrids compared to the varieties.

Although hybrids perform well, it is unfortunate that yearly importation of these hybrid seeds is not sustainable taking into account the cost. The evaluation and testing the combining ability of different parental lines could be a better alternative if some countries could accept to release their parental lines.

Since most Uganda farmers are still at low level of farming, better open-pollinated varieties with high oil content can still be cultivated. Hence evaluation of both hybrids and open-pollinated varieties will continue until we start developing and multiplying our own hybrid parental lines.

References:

Bua A. and Molo R. A review of Research on oil crops in Uganda. In proceedings of the second oil crops Network workshop held in Hyderabad, India.