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ACHIEVEMENTS AND BOTTLENECKS IN DEVELOPING SUNFLOWER HYBRIDS FOR UGANDA

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SUMMARY

Sunflower (*Helianthus annuus* L.) has become the most important oil crops in Uganda. The area under production has increased dramatically since the mid 1990s. In the 1970s and 1980s, sunflower breeding research was based on evaluating imported hybrids. This did not show any impact in commercial production. Recent evaluation of hybrids led to the release of PAN 7351 from South Africa which is now in full production and being imported by Mukwano Seed Company. Serere Agricultural Research Institute (SAARI) received a few hybrid parental lines for hybrid development. Some bottlenecks like branching and fertility of female lines led to slow development of hybrids from these parental lines. A few crosses have been made and yields of over 2,000 kg/ha have been attained. Uganda is now in position to produce her own hybrid seed.

Key words: sunflower, agronomic practices, seed yield, oil content, hybrid development

INTRODUCTION

Sunflower (*Helianthus annuus L.*) has become the most important oil crops in Uganda especially in the eastern and northern parts of the country. The area under production had increased from the mid 1990s till the present. This is partly due to the number of potential oil mills installed in areas where sunflower is intensively grown and the market is ready. For example, in Lira district, there are over 26 oil mills.

Despite the increasing production of sunflower in the country, the yield remained low at farmers' level. The main factors that have caused low yields in the country are lack of high yielding varieties/hybrids and poor agronomic practices. The average yield in farmers' fields is about 750-900 kg/ha and yields of the best open-pollinated varieties at the Institute are about 1,500-1,800 kg/ha.

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Not a single sunflower hybrid has been developed in Uganda although sunflower research started as early as 1960/70s. The first imported hybrid to be officially released was PAN 7351 in 2003. This hybrid was developed by PANNAR Seed Company in South Africa. Before this, the leader in the commercial production was an open pollinated variety called "Sunfola", which originated from Australia and which was released in Uganda in 1991 under the USAID underproject (1988-1993).

The main aim of sunflower breeding program is to increase seed yield and oil content and to develop varieties resistant to the prevailing diseases. Much emphasis is presently placed on hybrid development. According to Fick (1975), single cross hybrids give 20-30% higher yield than the varietal populations. Giriraj (1998) also observed that one of the approaches for increasing productivity of sunflower is to cultivate high yielding hybrid cultivars replacing low yielding open pollinated varieties. The main advantages of introducing hybrids into production are utilization of heterosis, uniformity of the F1 generation, and easier incorporation of resistance to diseases and other desirable traits.

One of the most effective ways of increasing the yield of sunflower per unit area is the usage of heterosis through single-cross hybrids. To develop single-cross hybrids with high genetic potential for yield and other agronomic characters, it is essential to have inbred lines with high values of combining ability. Sunflower hybrid breeding is based on cytoplasmic male sterility (*cms*), its maintainer (B-line) and restorer line. Emphasis is placed on single- and three-way crosses.

The objective of this paper is to give a long-term overview of the dynamics of sunflower hybrid evaluation and development of sunflower research in Uganda.

MATERIALS AND METHODS

In the 1970s and early 1980s, sunflower hybrids imported from other countries were tested Serere Research Station based in the eastern part of Uganda. Since these materials were already developed hybrids and not parental lines that produce a hybrid, it was possible only to evaluate these hybrids but we could not make our own hybrids.

In the period 1987-1989, the insurgence raged in a greater part of eastern and northern Uganda in which most of the germplasm of Serere Research Station was either lost or destroyed.

In 1988, the USAID funded a project on sunflower research at Namulonge Research Station. The breeding program at Namulonge comprised basically the testing of hybrids imported from USA. Three parental inbred lines: *cms*HA89, HA89 and HA821 (maintainers or B-lines), RHA271 (restorer line) were imported in bulk from USA for commercial seed production. Hybrid seed was produced from these lines. As the project came to an end in 1993, that was the end of hybrid parental line evaluation and hybrid production since reliance was on the imported seed only.

From 1994 to 1997 sunflower research was limited. NARO supported research for only 2 years and then stopped the funding. The Vegetable Oil Development Project (VODP) under the Ministry of Agriculture, Animal Industry and Fisheries concentrated on adaptive research and showed little interest in breeding. The breeding program was very slow and in some seasons, no work at all has been done. Whenever the funding flagged, a bottleneck would occur. New germplasm had to be assembled from the beginning. This time, new germplasm was collected at Serere as the work in Namulonge came to an end.

In the year 2000, collaboration started afresh between Serere Agricultural Research Institute (SAARI), Uganda's Investment in Developing Export Agriculture Project (IDEA) and PANNAR Seed Company in South Africa, to evaluate hybrids from this seed company. Out of the seven PANNAR hybrids tested against some open-pollinated varieties in 2001 (Table 1), the hybrid PAN7351 was officially released in 2003 and it is being imported by Mukwano Seed Company. It is sold to Uganda farmers at the price of about 4 US$ (7,000 Uganda Shillings) for one kilogram of hybrid seed. This is quite expensive for the resource-poor farmers in Uganda.

During 2000-2002, hybrid parental lines were acquired from United States Department of Agriculture (USDA) facility at Fargo, North Dakota. Some of these new lines were found to be producing pollen in the female rows and some exhibited also the branching habit. Due to inadequate knowledge in maintaining line purity of these materials, the branching habit and pollen shedding among these lines increased. This was a blow to our breeding program. Sometimes new lines when planted for the first time also showed pollen fertility and branching in female lines, which meant that the problem occurred where the line was developed. These problems arose due to the fact that, sometimes, the parental lines sent to you are not sufficiently pure. Another possibility is that the problems occurred due to modifier genes coming to expression as a result of environmental effects. The half-sib mating method was used. For pollination, pollen was collected from all maintainers and bulked. The problem comes if one or more of those maintainer plants possess restoration genes which, after pollinating the female plants, produce progenies that are fertile. This means that the breeding material has been contaminated somewhere during the breeding procedure, either through outcrossing or seed mingling.

In 2003-2004, another approach was tried, through full sib mating or pair-wise mating of the maintainer and the female lines. Here, a particular maintainer plant is crossed to a particular female plant and three to five pairs per parental line are crossed and then the progenies monitored to observe whether there is pollen production among the female plants. If pollen production is observed in the progenies, either these plants are discarded or screening and selection continues until pure male sterile progenies are observed.

RESULTS AND DISCUSSION

Table 1 shows the performance of the hybrids imported from PANNER Seed Company in South Africa compared with some open-pollinated varieties. The best hybrids were PAN7351 and PAN7371. PAN7351 was officially released in 2003 and, from 2004 to 2006, over 100 metric tons were imported annually by Mukwano Seed Company.

Table 1: Yield performance of sunflower hybrids from South African Pannar Seed Company and other open-pollinated varieties in five centres in Uganda during 2001

	Entry	Serere 2001A	Kumi 2001B	Aduku 2001B	Kuju 2001B	Ngetta 2001B	Mean
1	7351	1982 (3)	1456(5)	1284(1)	1667(1)	1853(1)	1648(1)
2	7355	1783(7)	1407(6)	703(8)	1120(7)	847(10)	1172(7)
3	7371	1886(5)	1485(3)	1095(2)	1472(2)	1620(2)	1512(2)
4	7392	1839(6)	1634(1)	849(4)	1464(3)	1591(4)	1475(4)
5	7001	2038(2)	1406(7)	982(3)	1337(5)	1543(6)	1461(5)
6	7352	2072(1)	1553(2)	756(5)	1454(4)	1592(3)	1485(3)
7	7353	1916(4)	1482(4)	747(6)	1132(6)	1587(5)	1373(6)
8	Local Stripe	-	-	538(10)	1057(9)	1191(8)	929(11)
9	Sunfola	1578(8)	1188(8)	719(7)	969(10)	1247(7)	1140(8)
10	Record Romania	1260(10)	-	632(9)	812(11)	-	901(12)
11	Kolos	1262(9)	1000(10)	509(11)	1103(8)	969(9)	969(10)
12	Saluit Serere	-	1065(9)	-	-	-	1065(9)
	Mean	1762	1368(9)	801	1235	1404	1314
	CV	20	16.6	42	18.5	21	
	SED	NS	184.8	276.6	187	247	
	LSD	NS	*	NS	***	**	

NB. * A and B are first and second rainy seasons, respectively.

Table 2: Evaluation of Serere crossed hybrids during second rains of 2003

	Lines	Yield kg/ha	Rank	No heads/ plot	Days 50% flowering	Days maturi- ty	1000 seed weight	Head diame- ter (cm)
1.	*cms* HA371-2A × RHA271-1-1	1594	5	12	59	98	76	23
2.	*cms* HA371-2A × RHA271-1-3	1700	3	11	61	100	79	24
3.	*cms* HA371-1A × RHA271-1-1	1033	8	11	60	96	78	23
4.	*cms* HA89-2A × R632-2	1672	4	13	60	98	77	22
5.	*cms* HA89-2A × R632-3	2021	2	13	61	100	67	25
6.	*cms* HA89-1A × R632-3	1251	7	8	64	101	69	23
7.	*cms* HA89-1A × R632-1	2195	1	12	62	101	72	27
8.	Sunfola	1282	6	10	62	100	76	23
	Mean	1594		11	61	99	74	24
	CV%	38		44.9	2.5	1.3	10.8	10.4
	SED	504.8		4.1	1.2	1.0	6.5	2.0
	LSD	NS		NS	*		NS	NS

The first crossing program to produce single-cross hybrids was performed in the first rainy season of 2003 where some of the purified female lines were crossed to a few restorers. During the second rainy season of 2003 (Table 2), the hybrids were planted at Serere Agricultural Research Institute to observe their performance and find whether we were on the right track to start producing hybrids. Table 2 shows that yields of over 2,000 kg/ha were recorded. One hybrid performed well but it had so many branches which meant that there was still a problem with one of the parental lines when it was being crossed.

From 2004, most parental lines were observed to be pure with a few that showed pollen fertility and branching habit, which are not desirable characters in sunflower hybrids production. These problems was also observed and reported by Muralidharan (1998). New lines were again requested from USDA (USA) and these are presently being maintained using full-sib or pair-wise method and observing their progenies for pollen fertility. This procedure for the maintenance of parental lines was also published by Virupakshappa *et al.,* 1998. During the first rainy season of 2005, over 320 hybrids were made by crossing 80 female lines with 4 restorers *viz*: RHA271, RHA373, CM632 and R694. A few were evaluated in a replicated trial as seen in Table 3 and 4.

Table 3: Evaluation of sunflower hybrids at SAARI during 2005A

	Treatment	Yield, kg/ha	Rank
1.	*cms* 89-1A-1 × RHA271	1733	11
2.	*cms* 371-1A × R694	1933	9
3.	*cms* 371-1A × CM632	2083	3
4.	*cms* 371-2A-1 × CM632	1692	14
5.	DK 4040	1650	17
6.	*cms* 371-2A-1 × RHA271	1667	16
7.	*cms* 371-2A-2 ×RHA271	2275	1
8.	SUNFOLA	2025	6
9.	*cms* 371-2A-2 × CM632	1833	10
10.	*cms* 371-21-3 × R694	1708	13
11.	*cms* 371-3A × RHA271	1608	19
12.	PAN7351	1567	20
13.	*cms* 372-1A × CM632	2083	3
14.	*cms* 372-2A × CM632	1983	8
15.	*cms* 372-1A × R694	2275	1
16.	DKF 68-22	1650	17
17.	*cms* 412-1A-2 × R694	1692	14
18.	*cms* 412-1A-2 × CM632	1733	11
19.	*cms* 412-1A-2 × RHA271	2025	6
20.	*cms* 412-2A-1 × RHA271	2042	5
	Mean	1863	

Yields of over 2,000kg/ha were recorded among some hybrids developed at Serere. According to Škorić and Jocić (2004), they test over 3,000 new experimental hybrids each year and therefore our number of tested hybrids is still modest.

Table 4: Evaluation of sunflower hybrids at SAARI during 2005A

	Treatment	Yield, kg/ha	Rank
1.	89-1A-1 × CM632	1583	8
2.	371-2A × R694	1217	17
3.	371-2A × R694	1717	4
4.	371-21-2 × R694	1217	17
5.	37-2A-3 × CM632	1417	12
6.	DK 4040	2167	2
7.	372-1A × RHA271	917	29
8.	372-2A × RHA271	1133	20
9.	372-2A ×R694	1050	24
10.	DKF 68-22	1717	4
11.	403-1A-2 × R694	1333	13
12.	412-5A-1 × R694	1633	7
13.	412-4A-4 × R694	2417	1
14.	412-6A-1 × R694	1050	24
15.	PAN 7351	1550	9
16.	433-3A × RHA271	1667	6
17.	433-3A × CM632	1333	13
18.	SUNFOLA	1500	10
19.	434-1A × RHA271	1467	11
20.	432-1A × CM632	1000	27
21.	432-1A × R694	1217	17
22.	431-1A-3 × R694	1050	24
23.	431-4A-3 × CM632	583	30
24.	431-4A-2 × RHA271	1083	22
25.	431-3A-5 × RHA271	1133	20
26.	371-1A × CM632	1000	27
27.	412-3A-2 × RHA271	1800	3
28.	432-2A-2 × RHA271	1250	16
29.	432-3A-2 × RHA271	1083	22
30.	Sironko White	1333	13
	Mean	1354	

Another constraint that we are facing is that the restorer lines that are used for crossing with female inbred parental lines are very short and early maturing. Sometimes they do not produce enough pollen during dry conditions and have also fewer branches that could produce pollen as they continue growing. This makes synchronization of flowering difficult and therefore less seed produced for testing across locations.

As we are developing our own hybrids through collaboration with other national institutes, we are also evaluating other imported hybrids for the private seed companies in Uganda which can afford to import hybrid seed.

CONCLUSION

Uganda has a potential to start producing sunflower hybrids which are sustainable and cheaper compared with imported ones. To attain this, some bottlenecks in hybrid development have to be mitigated. In order to achieved production stability of a hybrid, high genetic purity of basic seed should be ensured in the parental lines involved in hybrid combinations. Improvement can be attained only through collaboration with other national institutes, those who are willing to share their germplasm with others.

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ALCANCES Y DIFICULTADES EN EL DESARROLLO DE HÍBRIDOS DE GIRASOL EN UGANDA

RESUMEN

Girasol (*Helianthus annuus* L.) se ha vuelto el cultivo oleaginoso más importante en Uganda. Las superficies de producción han tenido una subida dinámica, a partir de mediados de los años 90. Durante los años 70 y 80, la selección de girasol se limitaba en valoración de los híbridos importados. Ello no tenía ninguna influencia en la producción comercial. Una reciente valoración de los híbridos llevó hasta la introducción en la producción del híbrido PAN 7351 de América del Sur, que por el momento se encuentra en plena producción, y al que importa la Compañía Mukwano Seed Company. El Instituto de Investigaciones Agrícolas en Serere (SAARI), obtuvo varias líneas parentales para el desarrollo de los híbridos. Las dificultades como ramificación y fertilidad de las líneas femeninas, han condicionado un desarrollo lento de los híbridos de esas líneas parentales. No obstante, fueron creados varios cruzamientos y se obtuvieron rendimientos por encima de 2.000 kg/ha.

SUCCÈS ET DIFFICULTÉS DANS LE DÉVELOPPEMENT D'HYBRIDES DE TOURNESOL EN OUGANDA

RÉSUMÉ

Le tournesol (*Helianthus annuus* L.) est devenu la culture oléagineuse la plus importante d'Ouganda. Les surfaces de production se sont agrandies de façon spectaculaire à partir du milieu des années 90. Au cours des années 70 et 80, la sélection du tournesol se limitait à l'évaluation d'hybrides importés. Ceci n'avait aucun effet sur la production commerciale. Une évaluation récente des hybrides a conduit à la production de l'hybride PAN 7351 d'Afrique du Sud qui se trouve maintenant en pleine production et est importé par la firme Mukwano Seed Company. L'institut de recherches en agronomie de Serere a reçu quelques lignées parentales pour le développement d'hybrides. Des difficultés comme la ramification et la fertilité des lignées femelles ont provoqué la lenteur du développement des hybrides de ces lignées parentales. Cependant, quelques croisements ont tout de même été faits et des rendements de plus de 2,000 kg/ha ont été atteints. L'Ouganda peut maintenant produire sa propre semence hybride.