ACHIEVEMENTS AND BOTTLENECKS IN DEVELOPING SUNFLOWER HYBRIDS FOR UGANDA

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Abstract

Sunflower (*Helianthus annuus* L.) has become the most important oil crops in Uganda. The area under production has been increasing drastically since the mid 1990s. In the 1970s and 1980s, sunflower breeding research was basically 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 the hybrids from these parental lines. A few crosses have been made and yields of over 2,000 kg/ha have been attained. Uganda now is in a position to producing her own hybrid seed.

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 been increasing from the mid 1990s up to present. This is partly due to the number of potential oil mills installed in areas where sunflower is highly grown and therefore ready market. 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.

Since time immemorial, no sunflower hybrids have been developed locally and yet research on sunflower started as early as 1960/70s. The first imported hybrid to be officially released was PAN 7351 in 2003. This hybrids was developed from PANNAR seed company in South Africa. Before this, it was an open pollinated variety called 'Sunfola' which originated from Australia which was released in Uganda in 1991 under the USAID under project between 1988-1993.

The main aim of sunflower breeding programme is to increase seed yield, high oil content and to develop resistant varieties to the major prevailing diseases. Much emphasy is now 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 area is the usage of heterosis through two line 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. Emphasy is on single and three way crosses.

The objective of this paper is to give an overview of the dynamics of sunflower hybrid evaluation and development for the many years of sunflower research in Uganda.

Materials and Methods

In 1970s and early 1980s, sunflower hybrids imported from other countries were also tested a Serere Research Station based in the eastern part of Uganda. Since these lines were already developed hybrids not the parental lines that produce a hybrid, only evaluation could be done and it was not sustainable because the parental lines were not available.

The period between 1987-1989 was the time of insurgency in most of eastern and northern Uganda whereby most of the germplasm at Serere Research Station got lost or destroyed.

In 1988, the USAID sunflower funded project funded sunflower research at Namulonge research station. The breeding research at Namulonge was basically also on testing hybrids imported from USA. Three parental inbred lines: CMSHA 89), HA 89 and HA 821 (maintainer or B-line), RHA 271 (restorer line) were imported in bulk from USA for commercial seed production. Hyrid 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.

From 1994 to 1997 showed no much research in sunflower NARO supported research for only 2 years and stopped the funding. Vegetable Oil Development Project (VODP) under the ministry of agriculture animal fisheries but with little interest in breeding except adaptive research. This has made the breeding programme very slow and some seasons, no work is done completely. Unless funding is improved, there is a bottleneck. New germplasm had again to be assembled. This time at Serere under a different staffing as the work in Namulonge came to an end.

Starting from the year 2000, another collaboration started between Serere Agricultural Research Institute (SAARI), Uganda's Investment in Developing Export Agriculture (IDEA) project and PANNAR seed company in South Africa to evaluate hybrids from this seed company. Out of the seven hybrids tested from this seed company together with some other open-pollinated varieties in 2001 (Table 1), hybrid PAN 7351 was officially released in 2003 and it is being imported by Mukwano seed company which cost Uganda farmers about 4 US$ (7,000 Uganda Shillings.) for one kilogramme of hybrid seed.. This is quite expensive for the local resource poor farmers in Uganda.

During 2000-2002, hybrid parental lines were acquired from United States Department of Agriculture (USDA) at Fargo, North Dakota State. Some of these new lines were found to be producing pollen in the female rows and also branching habit. Due to inadequate knowledge in maintaining pure lines of these materials, the branching habit and pollen shedding among these lines increased. This was a blow to our breeding programme. Sometimes new lines when planted for the first time also show pollen fertility and branching in female lines meaning that the problem occurred where the line was developed. This problem arose due to the fact that sometimes when parental lines are sent to you, they are not pure. It is also thought that possibly it is due to modifier genes which may come about as a result of environmental effects. We were using half-sib mating method for pollination whereby you collect pollen from all the maintainers of that female line and you bulk them together and pollinate it to that female line. The problem comes if one or more of those maintainer plants are possessing genes for restoration which after pollinating the female plants, produce progenies that are fertile. Since a maintainer has no restorer genes if fertile progenies are produced when a cms is crossed to its maintainer, that means that it must have been contaminated somewhere during its breeding procedure through out crossing or seed mixtures.

By 2003-2004, another approach was designed. This was 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, you either discard both those individual female plant and the maintainer or you continue with further screening and selection until pure male sterile progenies are observed.

Results and discussion

In Table 1 is shown the performance of the imported hybrids from PANNER Seed Company in South Africa compared to the open pollinated varieties. The best hybrids were PAN 7351 and PAN 7371. PAN 7351 was officially released in 2003 and from 2004 up to 2006, over 100 metric tonnes have been imported annually by Mukwano Seed Company.

The first crossing programme to produce single cross hybrids was done 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 direction to start producing hybrids. Results (Table 2) showed that yields of over 2,000 kg/ha were recorded. One hybrid performed well but it had so many branches which means there was still a problem with one of the parental lines when it was being crossed.

From the year 2004, most parental lines were observed to be pure with a few that showed pollen fertility and branching habit, which is not a desirable character in producing sunflower hybrids. This problem was also observed and recorded by Muralidharan (1998). More new fresh lines were again requested from USDA (USA) and these are being maintained now using full-sib or pair-wise method and observing their progenies in case of pollen fertility. This procedure for the maintenance of parental lines is also published by Virupakshappa *et al* (1998). During the first rainy season of 2005, over 320 hybrids were developed 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. Yields of over 2,000kg/ha were recorded among some hybrids developed at Serere. According to Skoric and Jocic (2004), they test over 3,000 new experimental hybrids every year and therefore our number of hybrids for testing are still few.

One other 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 who can afford to import hybrid seed.

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 maturity	1000 seed weight	Head diameter (cm)
1. CMS HA 371-2A X RHA 271-1-1	1594	5	12	59	98	76	23
2. CMS HA 371-2A X RHA 271-1-3	1700	3	11	61	100	79	24
3. CMS HA 371-1A X RHA 271-1-1	1033	8	11	60	96	78	23
4. CMS HA 89-2A X R632-2	1672	4	13	60	98	77	22
5. CMS HA 89-2A X R632-3	2021	2	13	61	100	67	25
6. CMS HA 89-1A X R632-3	1251	7	8	64	101	69	23
7. CMS HA 89-1A X 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

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

Treatment	**Yield/Ha**	**Rank**
1. CMS 89-1A-1 X RHA 271	1733	11
2. CMS 371-1A X R694	1933	9
3. CMS 371-1A X CM 632	2083	3
4. CMS 371-2A-1 X CM632	1692	14
5. DK 4040	1650	17
6. CMS 371-2A-1 X RHA 271	1667	16
7. CMS 371-2A-2 XRHA 271	2275	1
8. SUNFOLA	2025	6
9. CMS 371-2A-2 X CM632	1833	10
10. CMS 371-21-3 X R694	1708	13
11. CMS 371-3A X RHA 271	1608	19
12. PAN 7351	1567	20
13. CMS 372-1A X CM 632	2083	3
14. CMS 372-2A X CM 632	1983	8
15. CMS 372-1A X R694	2275	1
16. DKF 68-22	1650	17
17. CMS 412-1A-2 X R 694	1692	14
18. CMS 412-1A-2 XCM 632	1733	11
19. CMS 412-1A-2 X RHA 271	2025	6
20. CMS 412-2A-1 X RHA 271	2042	5
Mean	**1863**	

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

Treatment	Yield Kgha	Rank
1. 89-1A-1 XCM 632	1583	8
2. 371-2A X R694	1217	17
3. 371-2A X R694	1717	4
4. 371-21-2 X R694	1217	17
5. 37-2A-3 X CM632	1417	12
6. DK 4040	2167	2
7. 372-1A X RHA271	917	29
8. 372-2A X RHA271	1133	20
9. 372-2A X R694	1050	24
10. DKF 68-22	1717	4
11. 403-1A-2 X R694	1333	13
12. 412-5A-1 X R694	1633	7
13. 412-4A-4 XR 694	2417	1
14. 412-6A-1 XR 694	1050	24
15. PAN 7351	1550	9
16. 433-3A X RHA271	1667	6
17. 433-3A X CM632	1333	13
18. SUNFOLA	1500	10
19. 434-1A X RHA271	1467	11
20. 432-1A X CM632	1000	27
21. 432-1A X R694	1217	17
22. 431-1A-3 X R694	1050	24
23. 431-4A-3 XCM 632	583	30
24. 431-4A-2 X RHA271	1083	22
25. 431-3A-5 X RHA271	1133	20
26. 371-1A X CM632	1000	27
27. 412-3A-2 X RHA271	1800	3
28. 432-2A-2 X RHA271	1250	16
29. 432-3A-2 X RHA271	1083	22
30. Sironko White	1333	13
Mean	**1354**	

Conclusion

Uganda has the potential to start producing sunflower hybrids which is sustainable and cheaper compared to the imported ones if the bottlenecks in the hybrid development can be mitigated. In order to ensure production stability of a hybrid, the parental lines involved in hybrid combination should have high genetic purity of nucleus (basic) seed. Better improvement can only be attained through collaboration with other national institutes who are willing to share their germplasm with others.

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