SOME ASPECTS OF SWEET POTATO BREEDING AT THE KABANYOLO UNIVERSITY FARM

— *by* —

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The sweet potato (Ipomoea batatas) has received little research attention in East Africa, apart from variety trials (15), some fertilizer experiments (16) and work on virus diseases (4, 8, 9, 10, 11, 12).

In 'Agriculture in Uganda' (13) Biggs gives a general review of the crop, Hargreaves has a comprehensive section on the more important pests and Hansford covers briefly the diseases, (it is interesting to note that virus diseases are not mentioned in this section, which was published in 1940). Nye recorded in 1937 the names of forty seven sweet potato varieties grown at Bukeka mutala, Bulemezi, Buganda (7), of which only sixteen were included in a variety trial of fifty six varieties at Kawanda Research Station in 1955 (15).

Virus diseases of sweet potatoes have received some attention. Hansford first reported virus disease on sweet potatoes in Uganda in 1944 and suggested that it was transmitted by Bemisia spp (4). More recent work has been done by Sheffield at Muguga in Kenya (8, 9, 10, 11, 12). There is a useful review of this aspect by Martin in 1957 (6).

At Makerere, Aldrich worked on sweet potatoes from 1957 to 1960 and produced an extensive review of the crop in Uganda (2). Aldrich also produced a paper (1) on sweet potato field experiments which recorded his work at Kabanyolo on tuber formation, virus effects, spacing and fertilizers.

The work on sweet potatoes carried out by the writer commenced in 1961 when it was decided to continue Aldrich's husbandry investigations and also, after discussions with the Senior Botanist (G. Thomas) at Kawanda, to investigate the apparent deterioration and replacement of varieties.

After some time the emphasis changed from the husbandry to the breeding aspects.

MUTATIONS

Prior to 1961 it was assumed in Uganda that mutation was the source of new varieties and that virus diseases were the cause of deterioration of the existing varieties.

In 1961 examination was made of the sweet potato clone Bitambi, which is grown on a field scale at Kabanyolo, to determine whether the clone was genetically pure and to detect possible mutants. No significant morphological variations were observed either in the flower or the leaf. Records were kept of fifty-two parent plants and their progeny, but there was no evidence of any mutants in the selected material, although the individual plants responded markedly to environment.

During the investigation into mutations it was found that the variety Bitambi produced seed and consequently further observations on mutations were discontinued.

SEED

After the discovery of seed producing plants, in a thirteen acre field of sweet potatoes, it was decided to determine the extent and possible importance of this observation. It was found that most of the seeds were around the perimeter of the field, although seeds were to be found within the field itself, particularly on some Kalebe plants which were included by error in the original planting material. In the sweet potato museum block at Kabanyolo the following varieties were also observed to produce seed :—

1. Chai No. 12
2. Early Port
3. Kanena No. 19
4. Sekolya
5. Introduction No. 53
6. Kiwoko No. 13
7. Mulalama No. 31
8. No. 61 Amani 834 E
9. Caroline Lea
10. Bitambi
11. Introduction No. 76
12. Kyebandula
13. Kalebe
14. Magabali
15. Kawungezi
16. Namujuna

The only variety in the museum plots that has not produced seed is Introduction No. 46, although varieties Kanena, Mulalama, No. 61 Amani and Namujuna produced seed only sparingly.

Flowering sweet potatoes growing in peasant farmers' plots were examined at every opportunity to see if they produced seed. Seed production was observed frequently in peasant cultivators plots growing in Buganda. Flowering sweet potatoes have been examined in Zanzibar, Tanganyika and Kenya, but no seeds have been found. Recently Tribe, (14) working at Serere in the short grass northern part of Uganda, has reported the production of a few seeds on some varieties in old museum blocks.

Sweet potato seeds resemble small morning glory seeds and are produced in capsules containing one to three seeds. There are approximately 18,000 Bitambi seeds to the pound.

PRODUCTION OF SEED AT KABANYOLO

Some observations have been made of the seeding characteristics of the varieties in the Kabanyolo museum plots. Moveable cages of dexion and nylon mosquito netting were constructed which completely covered the individual variety plot. The plots inside the cages were sprayed with insecticide at regular intervals.

After a period of observation to see that no natural seed setting occurred in the variety in the cage, the variety was selfed. Production of seed by selfing was found to occur in the varieties Bitambi and Magabali.

Although the characteristic of self fertility is definite, care must be taken in assuming that the other varieties are not self-fertile. Experience with Bitambi

indicated that one may have a run of unsuccessful 'sets' of pollinations before one is successful. For example, of the fifteen 'sets' of self pollinations the first three 'sets' produced no seed and of the next twelve 'sets' a further three set no seed. A 'set' of pollinations was made up of between ten to twenty five individual flowers, being more or less the total production of flowers in the cage which were all pollinated at the same time on the same day. Further selfing studies are necessary before the other varieties can be difinitely stated to be self sterile.

Details of the cross pollinations carried out at Kabanyolo are shown in Table I. Each variety was first tested for self fertility and when it was found to be self sterile then crossings were carried out. Work on Bitambi and Magabali indicate that more detailed work will be required before it can definitely be stated that any variety is in fact self sterile, and as the crossings were done without emasculation then the chance of some selfing occurring cannot be ignored, particularly with the varieties Bitambi and Magabali. Of the 191 Bitambi flowers selfed in seventeen 'sets' only 39 set seed i.e. 20% successful compared to 32% for the 'crossed' successes; whether this is a significant difference cannot be determined unless further studies are initiated.

Observation at Kabanyolo shows that unfertilized flowers fall off from five to ten days after pollination.

There would seem to be a suggestion that the older plants produce seed more readily e.g. the museum plots at Kabanyolo have been grown continuously on the same land for six years.

Almost all the flowers of the varieties in the Kabanyolo area are more or less homostylic and only one variety, Caroline Lea, was found to be pin-heterostylic (no anther level with the stigma).

NATURAL SEEDLINGS

Observations were made to see if naturally produced seed germinated in the field. On the Kabanyolo Farm it was possible to find sweet potato seeds that had germinated to the two cotyledon stage, but usually they were smothered by the parent plant and died. For a long period no established seedlings were found, until 1963 when about one hundred vigorous seedlings were found growing in a field in which sweet potatoes had just been harvested. No established seedlings have been observed on plots outside Kabanyolo, although mature plants that may have arisen from seed have been seen.

GERMINATION

No difficulty has been experienced in germinating fresh sweet potato seeds, but if the seed is old and well dried chipping of the seed coat is necessary. At Kabanyolo chipping was done with a scalpel or razor blade and one 'nick' was made per seed. The seeds were then soaked over night on very wet blotting paper and those that had imbibed water were planted into compressed peat pots. Germination was usually between 60-80%.

DETERIORATION OF VARIETIES

That deterioration occurs within cultivated varieties is a generally held belief, but it is difficult to prove. It would also seem that the deterioration is

associated with a virus or virus diseases. In 1957 Sheffield (10, 11) reported that two viruses, attacking sweet potatoes in East Africa, had been identified. Virus A is transmitted by aphids and is a mild disease. Virus B is transmitted by white flies, is widespread and exists in several strains some of which cause severe diseases. Hansford (4) stated that "the symptoms vary widely with the host variety". In another paper (9) Sheffield reported than "in some cases no obvious stunting is shown, the symptoms being confined to mottling, or one runner only may be affected or one branch only of one runner. It is probable that the stunted forms are primary infections (i.e. they arose from infected vines), the milder forms being secondary (or new) infections". Aldrich (1) suggested that the virus problem is major in any work on sweet potatoes; he found that in his husbandry experiments, the error was greatly increased due to virus attack. Aldrich also stated that a plant showing severe virus symptoms yielded only 33% of the crop obtained from a virus free plant. Moderate and light infections resulted in yields of 50% and 95% respectively. Gooding (3) also suggests that there has been "widespread degeneration of clones as a result of virus infection" in Trinidad.

In a later report (12) Sheffield refers to suspected internal cork material from Uganda and reported (a) failure to transmit the disease and (b) that non-transmissable abnormalities similar to those seen in Uganda (material ex-Kabanyolo) occur in Louisiana, but their cause is unknown.

The position regarding virus disease and its effect on yields is confused due to several factors such as differences due to altitude effects (8), variation in symptoms between varieties and variation in symptoms on one variety.

The deterioration picture in Uganda is even more confused due to the fact that the peasant cultivators seem to have sources of new varieties, which, if it is similar to an old variety, they then name as the old variety with the prefix "new". For example on farms around the Kabanyolo Farm boundary there are to be found the following varieties:— New Bitambi, New Kawungezi and New Namujuna. This could suggest the occurrence of bud mutations, as has been inferred by Gooding (3) in the West Indies, but the writer is not of this opinion. On one occasion a visiting party of women, who are the main cultivators of household plots of sweet potatoes, were taken to see a plot of 96 sweet potato seedlings growing at Kabanyolo and on observing them they gave names to about fourteen of the plants in spite of the fact that the plants were seedlings and thus genetically distinct.

Presumably if the new variety is better than the old variety it will replace it and the prefix 'new' will be dropped by the cultivators after a period of time. This must then cast doubt on the length of time that any one variety has been in cultivation.

It is of interest to note the results of two surveys that have been carried out on peasant holdings adjoining the Kabanyolo Farm boundary to determine the names of the varieties being grown locally. The varieties are:—

Surveyed 29.11.65	9.3.62
1. Kyebandula*	Kyebandula*
2. Bupenge	Bumpenge
3. Kalingu	Kalingu

4.	Mukutula*	Mukutula*
5.	Bitambi	Bitambi
6.	New Kawungezi*	New Kawungezi*
7.	Kalebe	Kalebe
8.	Ntudebuleko	Ntudde Buleku
9.	Gavana	Gavana
10.	Nyindo-za-mulalu	Nyindo-zabalaalo
11.	New Namujuna*	New Namujuna*
12.	Kifuku	Kituku
13.	Kashoga*	Kasoga*
14.	Stephen	Stephen
15.	New Bitambi	New Bitambi
16.	Namwezigumu	Namwezigumu
17.	Sifumbanga najaba	Sifumba nangajuba
18.	Musanyusa meza*	Katumba
19.	Kitikya mbazi*	Kayulu
20.	Nkajega)	Kyasa
21.	Kojemundege) Ex	Mikayiri
22.	Mpakatebo) Rwanda	Bukasi-Bunzize
23.	Ntungaboro)	New Kalebe
24.	Ntumbwe	Gafa e Congo
25.	Kiwoko*	

* Similar to those recorded by Nye (7).

SWEET POTATO BREEDING POTENTIAL

The growing of sweet potato seedlings and their variability is described in a paper by the writer (5). The experience gained in growing some 558 seedlings, of which 325 were further propagated vegetatively, indicates that the Ugandan sweet potato seed has very great variability over a range of characteristics and that the breeding potential is high. Not included in the paper, referred to above, is the fact that eight new varieties (final selections), which have been raised from seed and selected for their desirable characters, are now showing signs of having little resistance to virus attack. In a variety trial of the eight selections, plus the control variety Bitambi, the plots were scored just before harvest for the number of plants showing conventional virus attack symptoms. The best variety was the control Bitambi, with over 75% clean plants. The nearest 'raised from seed variety' had only just over 50% clean plants and the worst 10% clean plants. The differences between the control variety Bitambi and the 'raised from seed varieties were significant at the 1% level. No explanation is offered for the fact that the virus attack in the Bitambi plots was very much higher than normally observed on the farm fields.

The over-riding importance of virus resistance was not initially appreciated and the selected varieties were not originally screened for virus resistance; this is an aspect requiring more attention in any future breeding scheme.

From the writer's observations, it would seem that there is considerable variation in virus resistance, both between 'mother' groups and individuals; for example seedlings with Bitambi as the mother plant appear to have more resistance than those from Caroline Lea mother plants. and Early Port mother plant seedlings appear to be very susceptible to virus diseases. Presumably the varieties

in local cultivation have been unconsciously selected by the cultivators themselves for virus resistance.

A PROPOSED BREEDING PROGRAMME FOR SWEET POTATOES IN UGANDA

The writer's experience to date is the basis of the following proposed breeding programme for sweet potatoes in Uganda.

It is possible that there are as many sweet potato varieties in Uganda as banana varieties. This fact tends to question the need for breeding work on sweet potatoes, straightforward variety trials being more appropriate and cheaper. However, there has been concern expressed at the rate of deterioration of existing varieties; it is not known whether varieties are deteriorating at a quicker rate these days, but as the virus is of relatively recent introduction it is possible that its effects are becoming more evident. If this is correct then a breeding programme is the only way of producing resistant or immune varieties, although screening of existing varieties should also be done. Further argument in favour of a breeding programme is that the full genetic potential of the sweet potato species cannot be obtained by casual and unconscious selection by peasant cultivators; a considered breeding programme should be a means of considerable improvement. Observations of the sweet potatoes for sale in local markets e.g. Kigezi in the S.E. of Uganda, where many of the varieties for sale were deeply ridged and misshapen also indicates a need for a controlled breeding programme.

Genetically the sweet potato plant is not a very convenient plant to work with, being a hexaploid (2n – 90), but it has the advantage that it has not been exposed to very much selection pressure due to its method of propagation.

Although seed can be obtained by controlled selfing or crossing it is not a very prolific means of producing seed and under such circumstances, it is recommended that the major source of seed should be from open pollinated mother plants. However, as shown by the writer in a paper (5), certain characteristics of the mother plants do appear to be dominant and a controlled crossing programme should be carried out and the parents tested for good combining characteristics.

It is suggested that a breeding programme should be based on a population of 3-5000 seedlings per year. This number is based on the availability of seed and is not overlarge.

Large populations will be required in order to allow all the desired characteristics to be combined:—

1. Virus resistance
2. Disease resistance
3. Cylas resistance
4. Palatability
5. Total yield
6. Tuber shape and size
7. Skin colour
8. Depth at which tuber is produced

9. Maturation period
10. Vine production (for propagation purposes)
11. Rooting at the node capacity (for propagation purposes).

All seedlings would be raised in the 'egg container' type of fibrous pots until the five to seven leaf stage when the roots begin to penetrate the sides of the pots (3 to 5 weeks approximately). Then the seedlings and the fibrous pots are to be planted out on ridges at a spacing of 3' x 2'. As soon as the seedlings are large enough three cuttings are to be obtained from each seedling and these are to be planted on three mounds at a spacing of 3' x 3'. Previous work at Kabanyolo has shown that there is little correlation between the seedling's tuber characteristics and those of its vegetative progeny and thus selection at the seedling stage is unwise.

At this stage the individual plants will have to be exposed to virus carrying vectors.

On maturation of the sweet potatoes at five to five and a half months all plants showing virus symptoms will be discarded, plus all plants that have other undesirable characteristics e.g. lack of tubers, mis-shaped tubers, lack of vine vigour, other disease susceptibility etc.

The survivors (less than 20%) will be replanted on a further three or more mounds and observed for virus symptoms. (There appears to be a difference between plants with a primary or a secondary infection and consequently one has to go through two generations before the plant's resistance can be determined). Surviving plants will then be bulked up and put into variety trials.

Virus resistant or immune plants (if produced) would be kept even though their other characteristics were not favourable, and used in a crossing and selfing programme.

SUMMARY

Although the sweet potato crop is relatively important as a food crop in Uganda (586,000 acres in 1963) it has had little research attention. Recent observations of significance have been (1) the recording of the presence of sweet potato virus diseases in Uganda by Hansford in 1944 and (2) the observation (by the author) of reasonably prolific sweet potato seed production in 1961. That deterioration of sweet potato varieties occurs is generally accepted, but no field surveys have been carried out to assess the importance or rate of the deterioration; the position is complicated by the peasant cultivator assigning existing variety names to new varieties, which may conceal a greater deterioration rate than is apparent.

From preliminary observations on the variation exhibited by sweet potato seedlings (5), the breeding potential of the Buganda seed is good. However, an error in breeding procedure was made by the author, in that there was no screening for virus resistance at an early stage in the programme. Consequently the Kabanyolo sweet potato seedling selections, which appeared to have combinations of the desired characteristics, have had to be discarded due to their virus disease susceptibility. The writer has proposed a breeding programme, based on the

Kabanyolo experience, which should correct this basic error in procedure. Visual observation on the existing cultivated varieties, individual seedlings and seedling 'mother' groups indicate that there is a range of virus resistance which can be exploited, quite apart from other improvements.

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Table 1.

	Variety (Female)	No of sets of pollinations (1)		No of sets producing seed (2)		Varieties (male) with which cross fertilization occurred
1.	Caroline Lea	11	(78)	7	(36)	Namujuna, Bitambi, Kawungezi, Kanena, Early Port, Magabali.
2.	Namujuna	4	(70)	Nil		
3.	Kalebe	4	(100)	1	(1)	Bitambi.
4.	Bitambi	11	(104)	6	(33)	Caroline Lea, Kawungezi, Kiwoko, Mulalama, Early Port, Magabali.
5.	Kawungezi	5	(52)	1	(5)	Caroline Lea.
6.	Mulalama	4	(64)	1	(1)	Early Port.
7.	No. 46	1	(20)	Nil		
8.	Early Port	7	(70)	3	(19)	Caroline Lea, Kawungezi, Kiwoko.
9.	Magabali	8	(89)	8	(41)	Caroline Lea, Namujuna, Bitambi, Kawungezi, Mulalama, Kanena, Early Port, Kiwoko.
10.	Chai	5	(50)	5	(25)	Caroline Lea, Namujuna, Bitambi, Malalama, Early Port.
11.	Secolya	5	(48)	Nil		
12.	Kiwoko	8	(80)	Nil		

(1) The figure in brackets is the total number of flowers pollinated.

(2) The figure in brackets is the total number of seeds produced.

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