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Towards improving highland bananas

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Abstract

Banana is an important food crop in Uganda. Its production per unit land area has declined due to pests and diseases and soil fertility depletion. Host plant resistance is a recommended intervention. However, banana breeding is technically difficult because of low female fertility. The landraces in the field gene bank at Kawanda were pollinated with pollen from the wild banana 'Calcutta 4' to evaluate them for seed fertility. Out of the 62 clones screened, 33 were seed-fertile. The most fertile landraces belonged to 'Nakabululu' and 'Nfuuka' clone sets. Viable seeds were obtained from several landraces indicating that genetic improvement of these highland bananas through cross breeding is possible. The fertile landraces should be cross-pollinated with improved diploids to produce resistant hybrids.

Key words: Production decline, seed fertility, resistant hybrids, female fertility.

Introduction

Banana (*Musa* spp.) is an important food crop in Uganda. Annual production is estimated at 8.44 million tons accounting for 15 % of total world production output (Karamura, 1993). More than 85% of the bananas grown in Uganda are East African highland banana (EAHB) landraces (*Musa* spp., AAA group, 'matooke' and 'mbidde') (Karamura *et al.*, 1996). The crop is grown on 1.5 million hectares equivalent to 38% of land under crops and is a staple for 7 million people. It is also an important source of income and has a high industrial potential through juice, wine and assorted post-harvest food stuffs.

During the past twenty years, banana production per unit land area has steadily declined due to increasing pest and disease pressure (Gold *et al.*, 1993). Banana weevil and a complex of parasitic nematodes are the major pests, while fungal leaf spots (mainly black sigatoka) and viruses are the most important diseases. Decline in soil fertility also contributes to decreasing yields (Zake *et al.*, 1994, Bwamiki and Ssali, 1998). Breeding for host plant resistance is an economically sustainable intervention (Stover and Simmonds, 1991). Successful cross breeding requires the production of true seed through sexual hybridization. However, the majority of the edible *Musa* spp. are female-sterile and, therefore, do not set seed on pollination (Shepherd *et al.*, 1987).

There are more than 80 distinct clones (landraces) of highland bananas in Uganda, belonging to 5 clone sets (Karamura, 1998) and it was not known which of these were female-fertile. The objective of this research therefore was to identify female-fertile EAHB that can be used in a cross breeding program.

Materials and methods

Plant material

The EAHB landraces maintained in the field gene bank at Kawanda Agricultural Research Institute were screened for female fertility. Sixty-two clones representing the major variability of the landraces grown in Uganda were selected, belonging to different clone sets; namely 'Musakala', 'Nfuuka', 'Nakitembe', 'Nakabululu' and 'Mbidde' (Karamura, 1998). A total of 10, 29, 6, 7 and 10 clones were pollinated for 'Musakala', 'Nfuuka', 'Nakitembe', 'Nakabululu' and 'Mbidde', respectively. These landraces were pollinated with pollen from 'Calcutta 4', a highly male-fertile wild diploid banana (Simmonds, 1953).

Pollination

Pollen from 'Calcutta 4' was always collected around 7.00 a.m from male flowers at anthesis. Male buds were covered with cotton bags to prevent pollen contamination from other sources. Likewise, emerging inflorescences of the landraces were bagged with transparent plastic bags, to avoid potential natural crossing with alien pollen, until the last flower was pollinated.

Hand pollinations were performed daily between 7.00 a.m and 10.00 a.m (Shepherd, 1954) in freshly exposed female

flowers of the landraces by rubbing a cluster of male flowers (from 'Calcutta 4') on to the female flowers. At full maturity, pollinated bunches were harvested and placed in a ripening room. Seeds were extracted subsequently from fruits with yellow peel.

Seed germination

Embryos were extracted from seeds and germinated *in vitro* (Talengera *et al.*, 1996).

Data recorded

Data were recorded for number of bunches pollinated, number of bunches with seeds, total number of seeds, number of embryos obtained, and number of embryos germinated. Seed set per bunch was computed as the total number of bunches pollinated, divided by the total seeds obtained. Pollination success was computed as number of bunches with seed, divided by total number of bunches pollinated, multiplied by 100. Likewise, embryo success was computed as number of embryos germinated, divided by total number of embryos obtained, multiplied by 100.

Results and discussion

Seed set rates in the different clone sets of EAHB

Out of the 62 clones screened, 33 were seed-fertile (Table 1). More than 80% and 70% of the clones in 'Nfuuka' and 'Nakabululu' clone sets, respectively, were seed-fertile, while only 10% and 30% of 'Musakala' and 'Mbidde', respectively, were fertile; none of the clones in 'Nakitembe' was female-fertile.

Pollination success for 'Nakabululu' and 'Nfuuka' was about 60% and 48%, respectively, and either very low or zero for the other clone sets. Similarly, seed set per bunch for 'Nakabululu' and 'Nfuuka' was 6.1 and 5.8, respectively, but either very low or zero for the other clone sets.

Table 1. Seed set by clone set of East African highland bananas (December 1994 – November 1997)

Clone set	Number of clones	No. of seed fertile clones	Pollination success (%)	Seed set bunch^{-1}
Musakala	10	1	1.5	0.2^{b}
Nfuuka	29	24	47.9	5.8^{a}
Nakitembe	6	0	0.0	0.0^{b}
Nakabululu	7	5	60.9	6.1^{a}
Mbidde	10	3	4.0	0.1^{b}

Means followed by the same letter are not significantly different according to the Lsmeans method of separating means.

Table 2. Seed set in the ten most fertile landraces (December 1994 – November 1997)

Clone	Pollination success (%)	Seed set bunch^{-1}	Seeds with embryos (%)	Embryo success (%)
Entukura	93.9	25.6	52.1	3.2
Enzirabahima	85.4	19.0	55.2	2.7
Nante	50.0	14.0	63.5	7.8
Kabucuragye	75.8	12.5	44.3	6.5
Kazirakwe	69.2	10.6	42.0	0.0
Tereza	61.0	9.3	31.5	0.0
Nakasabira	83.3	8.1	47.0	1.6
Nakayonga	96.6	7.6	42.1	1.7
Nakitengwa	76.9	7.2	39.0	0.0
Enyeru	50.0	7.2	34.3	1.7

Seed set rates in the different clones of EAHB

Seed set rates varied greatly among clones, even within the same clone set, with means ranging from 0 to more than 25 seeds per bunch, and pollination success of up to 90% in some clones (Table 2). Within the 'Nfuuka' clone set, the most seed-fertile landraces are 'Entukura', 'Enzirabahima', 'Nante', 'Kabucuragye', 'Tereza', 'Enyeru' and 'Nakitengwa', while in the 'Nakabululu' clone set, 'Kazirakwe', 'Nakasabira', and 'Nakayonga' are the most fertile. The results of this study indicated that 33 out of 62 clones were female-fertile, most of them belonging to the 'Nakabululu' and 'Nfuuka' clone sets (Table 1). Likewise, Vuylsteke *et al.* (1997) screened 111 plantain landraces belonging to French, French Horn, False Horn and True Horn types and identified 28 and 8 female-fertile cultivars belonging to the French and False Horn, respectively. This

stresses the importance of screening for female fertility in any *Musa* breeding program.

There was also great variation in seed set within the same clone, e.g., seed set range in individual bunches of 'Entukura' was 0 to 227. Similar variations were made in plantains (Vuylsteke *et al.*, 1993) and in 'Gros Michel' (Simmonds, 1966). Studies by Ortiz and Vuylsteke (1995) revealed that seasonal changes accounted for the large fluctuation in seed set within the same cultivar. Thus, climatic factors might be the cause of the great variation observed in seed set within the same clone in this study.

Seed germination

Clones Nante, Enzirabahima and Entukura had more than 50% of their 'seeds' containing embryos, while Nakasabira, Kabucuragye, Nakayonga and Kazirakwe had embryos in at least 40% of their seeds. Nante had the highest embryo success (7.8%), followed by Kabucuragye (6.5%), Entukura (3.2%) and Enzirabahima (2.7%). Although seed germination is a general problem in banana breeding (Vuylsteke *et al.*, 1990; Bakry and Horry, 1992), viable seeds were obtained from several landraces in the present study (Table 2).

Conclusion

Genetic improvement of the highland bananas through cross breeding is possible, because viable seeds were obtained from several landraces.

Recommendation

The female-fertile highland bananas identified in this study should be cross pollinated with improved diploid bananas (Rowe, 1984, 1990; Vuylsteke *et al.*, 1997) to develop EAHB hybrids that express disease/pest resistance, with acceptable quality and improved agronomic traits.

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