

Flowering synchronisation between male and female West African cultivated yams (*Dioscorea cayenensis-rotundata* complex)

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Summary

It has long been admitted that male and female cultivars of *Dioscorea cayenensis-rotundata* complex do not flower at the same period and consequently natural outcrossing rarely occurs. Flowering in thirteen (7 males and 6 females) traditional cultivars were studied. Four main results were obtained: i) the first bud emergence occurred 25 days earlier in males; ii) the male and female first flower opening overlapped for 10 days (85 to 95 days after sprouting); iii) for both sexes, highest frequency of flower opening occurred at mid-day; and iv) the female cultivar 1800 could flower for 8 consecutive days, with a peak between day 4 and day 8. These results are discussed in relation to intercrossing success.

Introduction

Morphological and isozymic characterization of west African yams (*Dioscorea cayenensis-rotundata* complex) has shown that in Côte d'Ivoire this complex includes about twenty varietal groups (Hamon & Touré, 1990). Cultivated for their tubers and only vegetatively propagated, they often have a reduced flowering. Flowers are reduced in size and rapidly stop growing or are shed when handled. As a consequence, the only way forward in breeding seems to be open pollination in isolated plots. This approach gives the expected progenies showing that breeding programmes can be planned (Zoundjiekpon et al., 1994). But to optimize this approach, the flowering behaviour of parental cultivars must be known.

Yam species are dioecious (Miège, 1952), although a few monoecious plants are observed in cultivated yams. Floral biology including floral structure, flowering time, and flower opening, has already been investigated in *D. cayenensis-rotundata*. Akoroda (1983) reported global behaviour of females and males but for unidentified local cultivars or uncontrolled seedlings.

Thus, identification of possible behavioural differences among specific traditional cultivars was not possible.

In this paper, we report flowering patterns of seven male and six female well-identified traditional cultivars of *D. cayenensis-rotundata* complex as well as information on within-day flowering kinetics. Results are discussed in relation to yam breeding.

Materials and methods

Thirteen traditional cultivars from Côte d'Ivoire (8), Bénin (3), and Cameroon (2) were chosen from the yam collection of the Faculté des Sciences et Techniques, Abidjan, Côte d'Ivoire. They included seven males and six females. Except for cultivars Yaobadou (8x) and Baniakpa (6x), all were tetraploids (Table 1).

All experiments were conducted at the university station of Abobo-Adjamé (south Côte d'Ivoire). Tuber sets were planted in April on knolls in rows 1.5 meters apart, with a between-plant distance in each row of 1 meter. One stake was used per plant. For each cultivar,



Table 1. Sex, ploidy level and geographic origin of 13 yam cultivars belonging to *D. cayenensis-rotundata*

Cultivar	Sex	Ploidy level	Geographic origin
Yaobadou	male	8x	Côte d'Ivoire
Baniakpa	male	6x	Bénin
Frou	male	4x	Bénin
Gnan	male	4x	Côte d'Ivoire
Kroukroupa	male	4x	Côte d'Ivoire
Sopéré	male	4x	Côte d'Ivoire
Zrézrou	male	4x	Côte d'Ivoire
1800	female	4x ?	Cameroon
C20	female	4x	Cameroon
Krenglé	female	4x	Côte d'Ivoire
Lokpa	female	4x	Côte d'Ivoire
Sopéré	female	4x	Côte d'Ivoire
Dahomé	female	4x	Bénin

all three types of setts namely top, middle and tail were used in these experiments.

The sprouting date was considered as the initial date of reference (D0). Observations concerned the First Bud Emergence (FBE) date, First Flower Opening (FFO) date and pattern of flowering within a day. Emergence dates were observed for all flowered plants, whereas pattern of flowering was observed for six male and one female cultivars. This was achieved by counting the number of opened flowers on two secondary branches randomly chosen from two plants per cultivar. Data were recorded every hour from 8 a.m. to 6 p.m. Modes, first and third quartil values were chosen to compare flowering behaviour of the different cultivars.

Results

Male and female flowering patterns

FBE and FFO were recorded for seven male and six female cultivars. Corresponding modes, first and third quartil values are reported in Table 2.

In male cultivars, three clusters of mode values for FBE could be defined: cluster 1 comprised one precocious cultivar (cvs Zrézrou) characterized by an FBE of DO+30, cluster 2 included five cultivars (cvs Baniakpa, Frou, Kroukroupa, Gnan and Yaobadou) with an FBE around DO+49/60 and cluster 3 was defined by cv Sopéré and an FBE of DO+77. In most cultivars; three-quarters of plants had an FBE between

DO+38 and DO+66. Only cv Zrézrou was really earlier (DO+23/41) and cv Sopéré later (DO+71/89). Estimated on the basis of mode values, FFO mostly occurred at FBE+28/35, except for Frou (+46 days). These results showed that male flowering was a continuous process which started at DO+59 and continued up to DO+120 with a maximum around DO+90. On a given plant, when male anthesis started, all flowers opened in 15 to 20 days.

In female cultivars, FBE ranged from DO+31 (cv Sopéré) to DO+54 (cv 1800). Taking into account modes, FBE took place at DO+60/66, except for cv 1800 (DO+83). Considering mode values, FFO occurred at FBE+16/35 which corresponds to DO+80/118. Although FFO was essentially obtained at DO+80/97, no disruption in female flowering was observed between DO+72 and DO+125. On a given plant, when female anthesis started, all flowers opened in 3 to 5 days.

These results showed that in most cases, FBE started earlier in male than in female cultivars (DO+38/66 vs 46/77). The lag disappeared when their main FFO period was considered (DO+76/100 for males vs DO+72/105 for females). Interestingly, completion of flower opening took 2 to 3 weeks in a given male plant and 3 to 5 days in a female plant. Thus, flowering started earlier in males than in females, but the flowering period is shorter in females. However, the male and female flowering overlapped for about seven weeks at DO+72.

Male and female flowering kinetics

Yam flowers are spikes borne on leaf axils. They open acropetally. There are 2 female spikes per node with a flower density per centimeter of 1–2. There are 2–8 males spikes per node with a flower density of 3–8.

The number of opened flowers, for six male cultivars, was recorded from 8 a.m. to 6 p.m. (Figure 1). This greatly differed between cultivars and reached 160 to 180 for cvs Baniakpa, Cocoassié and Yaobadou, while they were only 70 to 90 for cvs Krenglé, Zrézrou and Gnan. Except for cv Krenglé, flowers did not open before 8 a.m. The number of opened flowers at 6 p.m. was very low (from 0 to 9.6%) for four cultivars but reached 21.2% and 41% for cvs Gnan and Krenglé, respectively. It seems that lower the total number of flowers that open longer the period of flowering during the day. Despite these varietal differences, flowering patterns were quite similar for all cultivars and exhibited maximum opening at mid-day.

Table 2. Male and female flowering patterns based on days needed for first buds emergence (FBE) and for first flower opening (FFO) counted from sprouting date. FBE_m and FFO_m indicate mode values

Cultivars	Number of days from sprouting (D0) to first buds emergence (FBE = a) and to first flowers opening (FFO = b)					$FFO_m - FBE_m$	Total number of observed plants
	Earlier plants	First quartil plants	Mode value	Third quartil plants	Later plants		
	a-b	a-b	a-b	a-b	a-b		
Males							
Zrézrou	19-40	23-59	30-65	41-62	85-115	35	28
Frou	23-81	38-88	49-95	60-98	85-123	46	33
Baniakpa	35-76	47-80	56-91	65-100	85-113	35	23
Kroukroupa	37-69	44-76	57-88	64-99	73-105	31	22
Yaobadou	36-66	44-78	58-86	66-93	83-95	28	20
Gnan	23-58	49-79	60-88	66-97	85-116	28	111
Sopéré	52-92	71-100	77-105	89-120	92-125	28	9
Females							
Dahomé	34-62	46-72	64-80	77-100	93-117	16	12
Sopéré	31-42	49-74	60-84	67-96	104-119	24	42
Krenglé	40-49	54-81	65-95	75-105	100-127	30	64
Lokpa	48-80	62-90	65-95	71-99	85-110	30	66
C 20	28-60	59-90	66-97	72-105	110-131	31	90
1800	54-86	68-100	83-118	92-125	103-131	35	16

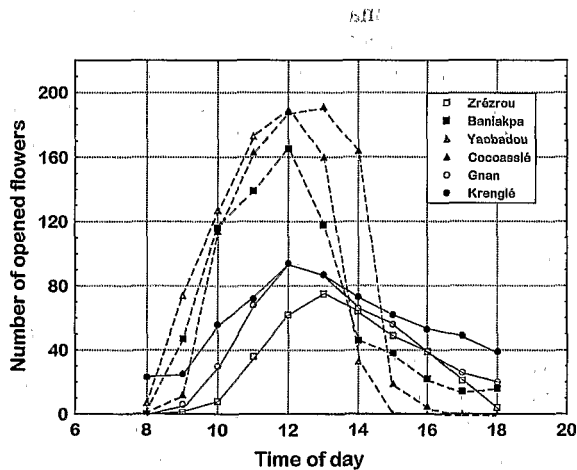


Figure 1. Number of new opened flowers per hour in one day, considering two secondary branchings on six male cultivars.

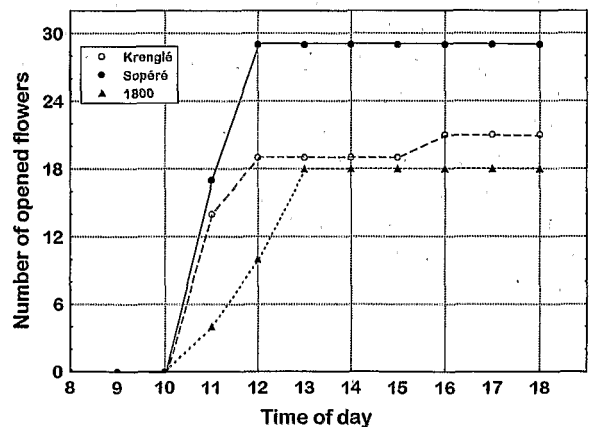


Figure 2. Number of new opened flowers in one day for three female cultivars, considering two secondary branchings per plant.

For three female cultivars, the plots of daily opened flowers versus time of day were similar (Figure 2). Flowers opened in the morning from 10 a.m. to 1 p.m. and remained open at 6 p.m. With cv 1800, the total number of opened flowers per hour between 8 a.m. and 6 p.m. was recorded on ten consecutive days (D1 to D10, Figure 3). On D1, no flower opened. Fifteen flowers opened on D2 and D3. On D4, this number

slightly increased and opening was continuous from 9 a.m. to 6 p.m. A total of 32 flowers opened during the first four days. This roughly doubled during D5 with continuous opening from 9 a.m. to 3 p.m. Maximum opening was observed between 9 a.m. and 12 noon on D6. During D7, flower opening decreased but occurred mainly between 10 a.m. and 1 p.m. During D8-9, flower opening was very limited and flowers

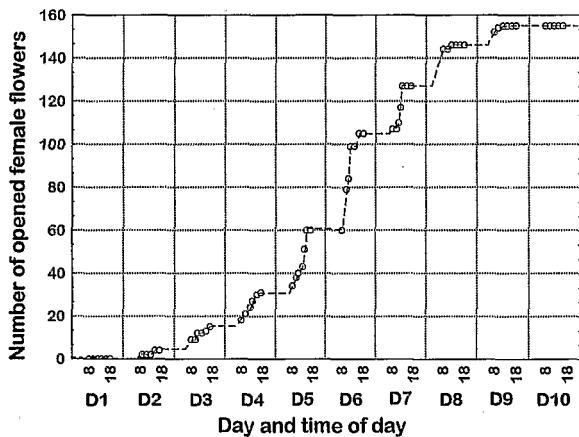


Figure 3. Number of new flowers opened per hour counted on two secondary branchings during ten consecutive days for the female cultivar cv 1800.

mainly opened before 8 a.m. On D10, no more flowers opened. Over a period of 8 days, cv 1800 had produced 155 flowers with a peak between D4 and D8. The numbers of opened flowers sometimes differed between one evening (6 p.m.) and the following morning (8 a.m.).

Overall, these results showed that pollination could occur for about one week after the first flower opening. Best conditions considering only flower opening were obtained between 9 a.m. and 12 noon especially at mid-flowering.

Discussion

The success of yam cultivar intercrossing is contingent on at least three conditions: i) simultaneous flowering period of males and females, ii) stigma receptivity of females and pollen viability of males; iii) genetic compatibility between cultivars.

It has long been admitted that males and females often do not flower at the same period and, consequently, natural outcrossing rarely occurs. Our study of the flowering behaviour of seven male and six female cultivars shows that buds appear about 3 weeks earlier in males (DO+23/89) than in females (DO+46/92). Touré & Ahoussou (1982) found a similar difference between male and female cultivars (DO+50/87 for males versus DO+70/96 for females). Akoroda (1983) also reported that female flowering began 1 to 3 weeks after male flowering. Our data clearly indicated that a lag in bud emergence is not necessarily followed by a lag in flower opening. An overlap between male and female culti-

vars exists even if all crosses will not have the same probability of success.

Not only synchronism in male and female flowering period is necessary. It is also required that flowers open at the same time during the day. Our results showed that male flowers started opening during the morning and peaked at midday as also observed by Akoroda (1983). In females, flower opening peaked on the fourth day between 9 a.m. and 12 a.m. and they remained open. Thus, there is an overlap of considerable flower opening between male and female cultivars.

Previous hybridisation programs have failed. Several interpretations were put forward. Akoroda (1983) invoked the inefficiency of insect pollinators and sub-optimal environmental conditions for flowering and fruit development. Doku (1973, 1982) attributed low fruiting in *D. rotundata* to pistil sterility. Ayensu & Coursey (1972) suggested poor pollen release or, poorly germinative pollen.

In Côte d'Ivoire, abundant yam seeds are often observed on wild plants and sometimes also on cultivated plants. In cultivated yams, the seed set is lower in the Guinean forest area (near Abidjan) than in the Sudanese savanna (north mid-part) in Côte d'Ivoire. Fargette (1985) showed in southern Côte d'Ivoire that the maximum activity and mobility of pollinators occurred between 10 a.m. and 1 p.m. Hamon & Koechlin (1991) in the same area, have shown that outcrossing due to insects was higher from 10 a.m. to 12 noon in okra. For yams, pollen availability is higher during the morning when natural pollinators (trips, *Larothrips dentipes*) are present and active. Conditions are thus effective for pollination.

The success of cross-pollination not only requires the presence of pollen on stigmas but also the absence of genetic incompatibility and sterility. The unclassical status of *D. cayenensis-rotundata* generates great confusion. This so-called species is in fact a complex which is related to several wild species (Hamon & Touré, 1991; Terauchi et al., 1992). Furthermore, Zoundjiekpon et al. (1990) and Hamon et al. (1992) show that three ploidy levels (4x, 6x and 8x) can be identified within the complex. Thus, not all crosses within this complex can succeed. Zoundjiekpon et al. (1994), used open pollination trials in isolated hybridization plots involving cv Zrèzrou as male and cv Sopéré as female to obtain small controlled progenies, checked by isozymic markers. These two cultivars are tetraploid and related to the same wild species (*D. praehensilis*). If we consider the size of their controlled progenies, according to our results obtained on flower

opening, it is clear that conditions for hybridization were not optimal in these trials.

To conclude, the results presented here define the flowering pattern of the *D. cayenensis-rotundata* complex. Combined with previous genetic characterization of West African cultivated yams and phylogenetic analyses, these results can be used to define a global hybridization strategy. Several crosses could be possible and should be tested if a real start is to be made in yam breeding.

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