Proceedings of the Tenth Symposium of the International Society for Tropical Root Crops, held in Salvador, Bahia, Brazil, October 23-29, 1994

NECTAR PRODUCTION IN CASSAVA

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Abstract

Cassava grown in Ibadan (Nigeria) produced an average of 19.9 million flowers/ha between September and December during the 1991 growing season. Over that period, the flowers secreted an average of 304 kg nectar/ha, which is equivalent to 127 kg of sugar. The main sugars present in the nectar were fructose, glucose, and sucrose in almost equal proportions. Although soluble sugars and cyanogenic glucosides are both synthesized in the leaves of cassava, no trace of cyanogenic glucosides was detected either in the floral or extrafloral nectar of cassava.

Introduction

Cassava is extensively grown, primarily as a food crop, in the tropical zones between 30^{o} north and 30^{o} south. Cassava is adapted to humid and subhumid environments and tolerates stresses such as drought and soil acidity. Agronomically, it is either an annual or biennial crop but, botanically, is regarded as a perennial. Cassava is normally propagated vegetatively and is monoecious, that is, with flowers of different sex on the same inflorescence of a plant.

Female flowers at the base of the inflorescence open first, while the apical male flowers, which are smaller, normally open a week later. Both female and male flowers usually remain open for 2 days, even though their nectar is exhausted by bees within several hours of opening. In the northern hemisphere, cassava normally flowers between July and January, with a peak during September-November; in the southern hemisphere, it flowers between January-July, with the peak occurring during March-May. This depends, however, on the cassava variety and its growing environment. In Africa, certain varieties do not flower at all; others are profusely flowering but rarely flower in dry savannas or highlands. During flowering, bees frequently forage the flowers between 10:00 and 14:00 h, particularly in the humid tropics.

Mutsaers (1991) reported honey production by bees (*Apis mellifera adansonia*) collecting nectar from cassava flowers in western Nigeria. Extrafloral nectar or exudate from petioles of cassava leaves has also been reported (Pereira and Splittstoesser 1987). But the literature otherwise makes no mention of floral nectar from cassava, for example, recent

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reports (Crane 1990; Crane et al. 1984) of the 450 most important nectar-producing plants does not include cassava.

Because cassava is known to synthesize the cyanogenic glucosides, linamarin and lotaustralin, which, when hydrolysed, may release cyanide, we studied the nectar production of cassava flowers and determined whether cyanogenic glucosides were present in floral or extrafloral nectar.

Materials and Methods

In our first experiment, we planted the cassava cultivars TMS 30572, TMS 4(2)1425, TMS 30001, and 58308 in April 1990 at the experiment farm of the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria (7°30'N, 4°3'E; average annual rainfall, 1,270 mm; mean temperature, 26.3 °C). Except for 58308, all are IITA-improved cultivars. The second experiment was also carried out at IITA with another set of five IITA-improved cassava cultivars: TMS 30001, TMS 30555, TMS 42025, TMS 63397, and TMS 71693. These were planted the following April (1991) to observe monthly flower production from September to December.

In the first experiment, female and male flowers, including flower buds, were counted from five plants per cultivar in October 1990. From 10:00 to 11:00 h nectar was collected (using syringes) at random from flowers of both sexes that were about to open. In the second experiment, flower counts were made monthly, from September to December 1991. The number of flowers from which 1.0 mL nectar was collected was used to estimate the volume of nectar per flower. Nectar production by flowers of cassava plants grown on 1 ha was calculated for each cultivar by multiplying the volume of nectar per flower by the number of flowers estimated from the average number of flowers per plant from 10,000 plants, a normal population in Nigeria.

This volume of nectar was converted into equivalent weight (mg) (Table 1). These data were used to estimate the monthly nectar production (kg/ha) for female flowers of each cultivar grown in 1991. The number of female flowers/ha (Table 2) was multiplied by 25.2 mg (mean nectar production by a female flower, Table 1), and the number of male flowers by 13.8 mg (mean nectar production by a male flower, Table 1). The monthly nectar production (kg/ha) for female and male flowers of each cultivar is presented in Table 3.

Extrafloral nectar was collected at 08:00 h from the petioles of cvs. TMS 30001 and TMS 4(2)1425.

Sugar content was determined by the phenol-sulphuric acid method (Dubois et al. 1956), using glucose as a standard. Aliquots of nectar containing about 100 μg of sugars were

subjected to ascending thin-layer chromatography on acetate silica gel (Polygram Ionex-25-SB-Ac, Machery-Nagel, Duren, Germany), using a solvent system consisting of chloroform, acetic acid, and water in the ratios of 6.0:3.5:0.5, with fructose, glucose, sucrose, maltose, and raffinose as standards. Separated sugars were detected by spraying the chromatograms with diphenylamine and heating at 130 ^{o}C for 10 min (Fort 1968). Yields (kg of sugar in nectar/ha of land) were estimated for female flowers by multiplying the respective total nectar production (kg/ha) for the 4 months by 35.8 (mean sugar content of nectar, Table 3) and for male flowers by 43.4 (% in Table 1). Cyanide was determined by using an automated enzymatic assay described by Rao and Hahn (1984).

Results and Discussion

The number of female and male flowers per hectare were estimated for the five cultivars in the second experiment on the basis of counts made monthly from September to December 1991 (Table 2). The highest peak of cassava flowering was in September with 1.5 million female and 8.4 million male flowers/ha for the month, followed by October, November, and December, in that order. The three cvs. TMS 30572, TMS 4(2)1425, and 58308 grown in 1990 produced an average of
0.8 million female and 6.6 million male flowers/ha, with male flowers representing about 90% of the total. As the dry season approached, flowering gradually decreased. Significantly, many cassava cultivars—particularly local unimproved ones—do not flower well in dry savannas or highlands.

The main sugars present in cassava nectar are fructose, glucose, and sucrose. Individually, female flowers secreted, on the average, about twice as much nectar as male flowers (22.3 versus 11.7 μL) (Table 1). However, the average sugar content (43.4%) of nectar from male flowers of the three cultivars in the first experiment was significantly greater than that from female flowers (35.8%) (Table 1). But the daily sugar production (9.1 mg) of a female flower was, on the average, greater than that of a male flower (5.8 mg), simply because it secretes more nectar (Table 2). Monthly nectar production (kg/ha) values are presented in Table 3.

The values are high, compared with sugar values ranging from 0.0005 to 8.0 mg reported for 66 plant species (Maurizio 1975). In the Crane et al. directory (1984), only five species of the 450 most important nectar sources exceeded this range. As a nectar producer, cassava therefore appears to rank with the highest of nectar-secreting species.

The pattern of nectar production was similar to that of flower production, for obvious reasons. The highest means (39.2 kg for female flowers and 115.7 kg for male flowers) was

observed in September, followed by October, November, and December in that order. Cv. TMS 42025 gave the highest total nectar yield/ha for the 4 months (448.9 kg), followed by TMS 63397 (281.7 kg) and TMS 71693 (279.8 kg). The average total nectar yields/ha for September-December was 64.3 kg for female flowers and 239.7 kg for male flowers (almost four times as much). The average total nectar yield/ha for this period for both female and male flowers was 303.9 kg.

Sugar yields (kg per hectare for the period) for the five cultivars are also shown in Table 3. For female flowers, they ranged from 11.1 to 45.3 kg/ha over the 4 months, with an average of 23.0 kg/ha; and, for male flowers, from 91.5 to 139.9 kg/ha, with an average of 104.0 kg/ha. Total sugar yield from both male and female flowers ranged from 105.1 to 185.2 kg/ha and was highest for cv. TMS 42025 (185.2 kg/ha). The mean total sugar yield/ha for the five cultivars for the 4 months was 127.0 kg/ha.

Table 4 shows that cyanogenic glucosides were present in cassava leaves but were not detected in floral nectar, extrafloral nectar from cassava petioles, or honey. The absence of cyanogenic glucosides in the extrafloral nectar from cassava petioles had previously been reported in plants grown in glasshouses (Pereira and Splittstoesser 1987). We confirmed this finding in our field-grown cassava plants. We therefore concluded that the bitterness of the cassava nectar is not caused by cyanogenic glucosides. The extrafloral nectar obtained from cvs. TMS 4(2)1425 and TMS 30001 had sugar contents of 28.4% and 21.1%, respectively. The main sugars identified in the extrafloral nectar were fructose and glucose.

Conclusions

Our findings lead us to believe that cassava is a major producer of nectar in the humid tropics, particularly in Africa, where few good sources of nectar are available during the rainy season. Because cassava floral and extrafloral nectar does not contain cyanogenic glucosides (even though these are synthesized in other plant parts), we suggest that this nectar be exploited to increase honey production in the tropics.

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Table 1. Daily nectar production (μL/flower) in male and female flowers, sugar content (%), and sugar value (mg/flower) for three cassava cultivars at Ibadan, Nigeria, October 1990.

Cultivar	Daily nectar production				Sugar content (%)		Sugar value (mg/flower per day)	
	Female		Male		Female	Male	Female	Male
	(μL)	(mg)	(μL)	(mg)[a]				
TMS 30572	25 ± 0.7	28.4	13	15.2	38.1 ± 0.3	42.1 ± 0.6	10.8	6.5
TMS 4(2)1425	23 ± 0.3	25.9	10	11.9	36.8 ± 0.2	43.1 ± 0.3	9.5	5.4
58308	19 ± 0.3	21.2	12	14.2	32.5 ± 0.3	39.9 ± 0.8	6.9	5.5
Mean	22.3	25.2	11.7	13.8	35.8	43.4	9.1	5.8
SE	1.8	21.0	0.9	1.0	1.7	2.5	1.1	0.6

a. Equivalent weight.

Table 2. Monthly average number[a] of female and male flowers (x 10^5 plants) per hectare in five cassava varieties at Ibadan, Nigeria, during the flowering season, September to December 1991.

Cultivar	September		October		November		December	
	Female	Male	Female	Male	Female	Male	Female	Male
TMS 30001	7.70	85.72	4.56	69.44	1.26	9.62	0.00	0.00
TMS 30555	5.96	88.52	4.00	45.10	2.44	23.36	0.00	0.00
TMS 71693	14.92	80.30	7.52	43.42	3.44	25.04	1.44	4.04
TMS 63397	14.22	70.76	7.74	68.24	1.56	18.78	0.58	2.38
TMS 42025	34.88	93.86	8.16	83.08	3.72	34.76	3.38	21.90
Mean	15.54	83.83	6.40	61.86	2.48	22.31	1.08	5.66
SE	5.14	3.93	0.87	0.65	0.49	4.11	0.63	4.13

a. The number of flowers/ha is estimated by multiplying the average number of flowers of each sex per plant by 10,000 (the average population density/ha in Nigeria).

Table 3. Per hectare nectar production (kg)[a] by female and male cassava flowers at Ibadan, Nigeria, September-December 1991.

Cultivar	Nectar (kg/ha)											Sugar yield[b] (kg sugar/ha/season)		
	September		October		November		December		Total					
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Total	Female	Male	Total
TMS 30001	19.4	118.3	11.5	95.8	3.2	13.3	0.0	0.0	34.1	227.4	261.5	12.2	98.7	110.9
TMS 30555	15.0	122.2	10.0	62.2	6.1	32.2	0.0	0.0	31.1	216.6	247.7	11.1	94.0	105.1
TMS 71693	37.6	110.8	19.0	59.9	8.7	34.6	3.6	5.6	68.9	210.9	279.8	24.7	91.5	116.2
TMS 63397	35.8	97.6	19.5	94.2	3.9	25.9	1.5	3.3	60.7	221.0	281.7	21.7	95.9	117.6
TMS 42025	88.0	129.5	20.6	114.7	9.4	48.0	8.5	30.2	126.5	322.4	448.9	45.3	139.9	185.2
Mean	39.2	115.7	16.1	85.4	6.2	30.8	2.7	7.8	64.3	239.7	303.9	23.0	104.0	127.0
SE	13.0	5.4	2.2	10.9	1.2	5.7	1.6	5.6						

a. Nectar production (kg/ha) estimated by multiplying the number of flowers/ha of each sex (see Table 1) by 25.2 mg of mean nectar production by a female flower and 13.8 mg by a male flower (see Table 1).

b. Sugar yield is estimated by multiplying the respective total nectar production (kg/ha) for the season in Table 3 by 35.8% mean sugar content of nectar for female and 43.4% for male flowers (see Table 1).

Table 4. Total soluble sugars (TSS) and cyanogenic glucoside content (CGC) of cassava leaves and floral and extrafloral nectar from cassava.

Entry	**TSS (g/100 g fresh wt)**	**CGC (mg HCN/ 100 g fresh wt)**
Cassava leaves		
TMS 30572	13.8 ± 0.03	64.8 ± 5.8
TMS 4(2)1425	13.4 ± 0.15	43.9 ± 2.2
58308	13.7 ± 0.10	77.4 ± 10.9
Floral nectar		
TMS 30573	40.1 ± 1.6	0.0
TMS 4(2)1425	42.5 ± 0.9	0.0
58308	36.2 ± 0.8	0.0
Extrafloral nectar		
TMS 3001	28.4 ± 1.6	0.0
TMS 4(2)1425	21.1 ± 2.5	0.0

The data relating to the nectaries and nectar secretion in invasive Brassicacean taxa are scarce. In the present paper, the nectar production and nectar carbohydrate composition as well as the morphology, anatomy and ultrastructure of the floral nectaries in Bunias orientalis were investigated. Nectary glands were examined using light, fluorescence, scanning electron and transmission electron microscopy. The quantities of nectar produced by flowers and total sugar mass in nectar were relatively low. Total nectar carbohydrate production per 10 flowers averaged 0.3 mg. Nectar contained exclusively glucose (G) and fructose (F) with overall G/F ratio greater than 1. The flowers of B. orientalis have four nectaries placed at the base of the ovary. These cassava starch production line are easy to operate and electric.Â A wide variety of cassava starch production line options are available to you, such as viet nam, brazil and none.You can also choose from machinery repair shops, retail and farms cassava starch production line,As well as from 1 year, {2}, and {3}. And whether cassava starch production line is vegetable processing plant, dairy products factory, or cooking oil factory. There are 3725 cassava starch production line suppliers, mainly located in Asia. , and. How cassava plants enhance the efficacy of their phytoseiid bodyguards. Proc. 8th Int.Â Is extrafloral nectar production an inducible defence? In Bock, J. and Linhart, Y. (eds.) Evolutionary Ecology of Plants.Â Induction of cotton extrafloral nectar production in response to herbivory does not require a herbivore-specific elicitor. Entomologia Experimentalis et Applicata 91: 149â€“154. WÃ¤ckers, F. L., BjÃ¶rnsen, A. and Dorn, S.. 1996.