MUARIK BULLETIN, Vol. 2. pp. 49-53, 1999
Printed in Uganda.

Pollination, fruit set and yield of hybrid passion fruits

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Abstract

Passion fruits are increasingly gaining importance as fruit crops in Uganda. But yield greatly depends on numbers of flowers produced, fruit set and final numbers that survive to maturity. The above characteristics were studied on *Passiflora edulis f. edulis* and *P. edulis f. flavicarpa* Kawanda hybrid. The close genetic composition of some of the hybrids to one parent or the other was observed. Receptivity of the stigma, plant compatibility, pollen wetting and the number of pollen grains deposited on the stigma affected pollination levels.

Key Words: Compatible cultivars, flower abortions, *Passiflora edulis f. edulis, P. edulis f. flavicarpa*

Introduction

Fruit production in Uganda has steadly increased since 1995 when the Uganda government made deliberate efforts to popularise non-traditional cash crops as an attempt to expand her export base. Passion fruits (*Passiflora Spp.*) are some of the fruit crops that can be economically grown throughout Uganda. Additionally, fruit consumption substantially contributes to balancing diets of the rural poor.

However, fruit yields are dependent on the number of flowers produced, the number that sets fruits and the final fruit number that survives to maturity. It is likely that the plant size, pest control and fertility levels influence the final yields. Flowers of some passion fruit are self-sterile while some are self-incompatible (Akamine and Girorami, 1957). Care must, therefore, be taken in the selection and distribution of compatible cultivars (clones or hybrids) in the field to ensure maximum production (Howell, 1976; Burgos and LedBetter, 1994).

Kawanda hybrid passion fruits are an improved cultivar gaining popularity through out the country but has not been studied for importance of pollination, fruit set and yield. Earlier studies indicated that yields of 2,400 kg to 8,500 kg $ha^{-1}yr^{-1}$ were obtained from experimental plots of *Passiflora edulis f. edulis*, one of the parents of Kawanda hybrid at Kabanyolo (Emechebe and Mukiibi, 1973). However, Kawanda hybrid, a cross between *P. edulis f. edulis* 1and *P. edulis f. flavicarpa*, yields about 6,121 to 58,965 kg $ha^{-1}yr^{-1}$ (Musaana, 1986).

During 1998 and 1999 it was found necessary to identify the former hybrids at Kawanda, assign them names and study the pollination, fruit set and yield of the new selections. This study was then initiated with the aim of determining the importance of pollination on fruit set and yield of the selected hybrids, and self-compatibility status of the selections.

Materials and Methods

Two parental lines, i.e., *Passiflora edulis f. edulis* and *P. edulis f. flavicarpa* were planted in the field at Kawanda Agricultural Research Institute (KARI) in central Uganda. Included in the trial were four other genetically different hybrids. At maturity, data were recorded on five tagged plants per cultivar. Data recorded were; the number of flowers produced over a four month period between April and August of 1998 and 1999, floral opening time, duration of flowers, and the movement of the stigmatic

lobes and their receptivity. Hand pollination was done at different stages of flower opening and fruit set was recorded. Artificial pollination was effected by bringing the exposed microsporangial surface covered with microspores in direct contact with the stigmatic surface, thus transferring pollen to the stigma. All the stigmatic lobes were pollinated. Self-pollination was done with pollen from the same flower or from another flower on the same plant. Fruit set or lack of it was then determined seven days after pollination using 50 flowers per cultivar. Mature fruit yields (number and weight) over two years i.e. 1998 and 1999 were then computed. The relationship of pollination to total fruit yields was also determined. The data obtained were then subjected to analysis of variance and means compared using Fisher's protected least significant difference test (LSD) at $P \leq 0.05$) using the MSTATC computer programme.

Results and Discussions

Four distinct hybrids were noted as having different gene markers for characters such a stem colour. The yellow passion fruit (*P. edulis. f. flavicarpa*) was the second parent (P_2) whose flowers opened from noon to about nine o'clock in the evening. Flowers of *P. edulis f. edulis,* the local purple type (P_1) opened mainly from early morning and closed by mid-day. Hybrid one (H_1) and two (H_2) opened between 10:000 a.m and 3:00 p.m. Hybrids 3 and 4 opened from 7:00 am to 1:00 p.m. In all cases the stigmas were found to be receptive on the day of floral opening. The most effective time of pollination was after the styles had completely curved after floral opening to touch the anthers (Table 1); with the resultant fruit set in all the hybrids and parents above 78%. This was therefore the optimum time for hand pollination when the stigmatic lobes were most receptive and offered the best condition for pollen germination and onward fertilisation.

Between 19 and 24 flowers, were either self or cross pollinated and their fruit set recorded (Table 2). The results indicate that H_3 was, for all practical purposes self incompatible and cross-compatible with all the other hybrids and P_1 though poorly compatible with P_2 .

The times at which flowers opened and closed for the two parents and hybrids plus the results of cross-compatibility tests indicate that H_3 was genetically closer to P_2 while H_4 was closer to P_1. Hybrids 1 and 2 were intermediate in behaviour. Backcrossing any of the hybrids, to P_1 would be easy while it would not be practical to backcross H_3 to P_2.

In the field, pollination and fruit set was also influenced by environmental factors. High temperatures in the morning encouraged anthesis and the pollen remained viable for 24 hours.

If there was rain and the pollen got wet, it bursted on contact with water, which resulted in fertilisation failure during rain. Pollen grains were, however, not destroyed by water after growth. Similar results were reported in yellow passion fruits (Kuhne, 1968; Purseglove, 1968).

Some fruits developed as many as 347 seeds. In cases where less than 100 seeds developed in the friuts, they were classified as hollow (Knight and Winters, 1962; 1964). Hollow fruit condition was observed when crosses were effected between H_1 and H_2, H_3 and P_2 and H_4 and P_1. Hollow fruit condition has been reported to be due to self-incompatibility, other genetic factors, and lack of pollination (Gilmartin, 1958; Ruberte-Torres and Martin, 1974; Howel, 1976). It should be noted that the hollow fruit condition was common in H_4 even for the flowers not artificially pollinated,. Selfing resulted in low fruit weight, fewer seeds and less juice per fruit. Similar results were reported by Knight and Winters (1964). A combination of the above factors that affected pollination, therefore, reduced fruit yields.

Results of mature fruit yields and weights per plant for the two years are shown and the figures 1 and 2 and reveal that H_3 had a large number of smaller sized fruits compared to H_1 and H_2. From visual observations H_4 had the biggest fruit size though it had a higher proportion of hollow fruits. Figure 1 also shows that continuous yields could be obtained throughout the year. This could also enhance higher production in H_3 which has compatibility problems.

Table 2. Fruit set by hand, self or cross pollination

Cross involved	No. of flowers pollinated	No. of fruits set	Percent fruit set
$P_1 \times P_1$	20	16	80.0
$P_1 \times P_2$	20	17	85.0
$P_1 \times H_1$	20	14	70.0
$P_1 \times H_2$	19	14	73.7
$P_1 \times H_3$	23	19	82.6
$P_1 \times H_4$	22	15	68.2
$P_2 \times P_2$*	20	15	75.0
$P_2 \times H_1$	24	12	50.0
$P_2 \times H_2$	23	14	60.9
$P_2 \times H_3$	24	1	4.2
$P_2 \times H_4$	22	28	81.8
$H_1 \times H_1$*	20	14	70.0
$H_1 \times H_2$	19	18	94.7
$H_1 \times H_3$	20	14	70.0
$H_1 \times H_4$	19	17	89.5
$H_2 \times H_2$*	24	19	79.2
$H_2 \times H_3$	24	10	41.6
$H_2 \times H_4$	24	18	75.0
$H_3 \times H_3$*	24	1	4.2
$H_3 \times H_4$	23	14	60.9
$H_4 \times H_4$*	20	15	75.0

* = Self pollinated flowers; P_1 and P_2 = Parents; H_1 - H_4 = hybrids.

There were significant differences in monthly yields (Table 4) because of differences in moisture availability during the different months. More flowers were produced during the wet season due to new growth; conversely fewer flowers were produced during the dry spells due to no growth hence low fruit yields. Similar results were reported by Kuhne (1968) for yellow passion fruit and granadilla. The yield differences between the hybrids (Table 4) were high with H_1 and H_3 out yielding H_2 and H_4 during the two years. The yields for the two years for P_1, P_2, H_2 and H_4 are within the range reported in literature of 2, 400 to 44, 836 kg $ha^{-1}yr^{-1}$.

Yields can be high or low depending on genetic differences, plant age, pest and disease pressure, amount of rainfall and levels of pollination. In this study, yields of H_1 and H_2 were not significantly different during 1998 but were significantly different during 1999. The yields of H_1 and H_2 were, however, higher than those of the two parents indicating the presence of transgressive segregation for yield for the two hybrids. Transgressive segregation has been reported in passion fruit for yield, aroma and flavour (Morton, 1967; Kuhne, 1968; Ruberte-Tores and Martin, 1974). None of the hybrids used in this study yielded less than both parents.

Conclusions

Pollination or lack of it influenced the yields of the hybrids by producing empty fruits if a few pollen grains were deposited on the stigma or if there was a total lack of pollination. Pollen wetting before

Table 3. Analysis of variance for yield of the passion fruit hybrids for the year 1998.

Source	df	ms	F
Months	11	30925.8	6.89**
Hybrids	3	30836.0	6.87**
Error	33	4488.5	

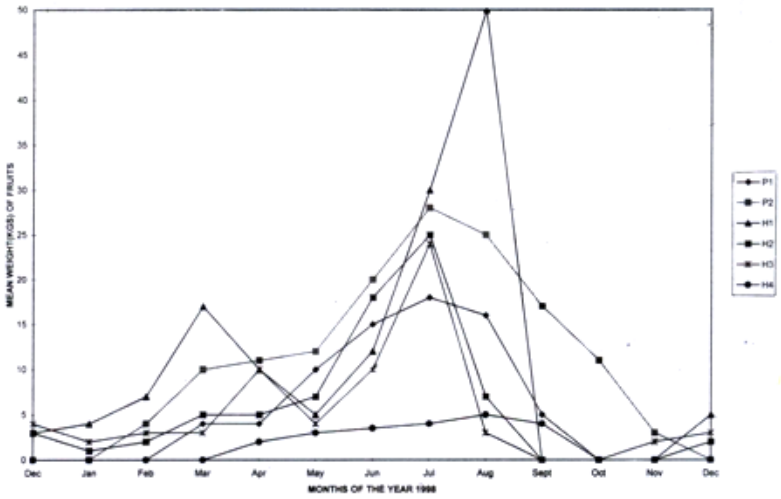

Figure 1. Yield of some selected passion fruit cultivars at Kawanda.

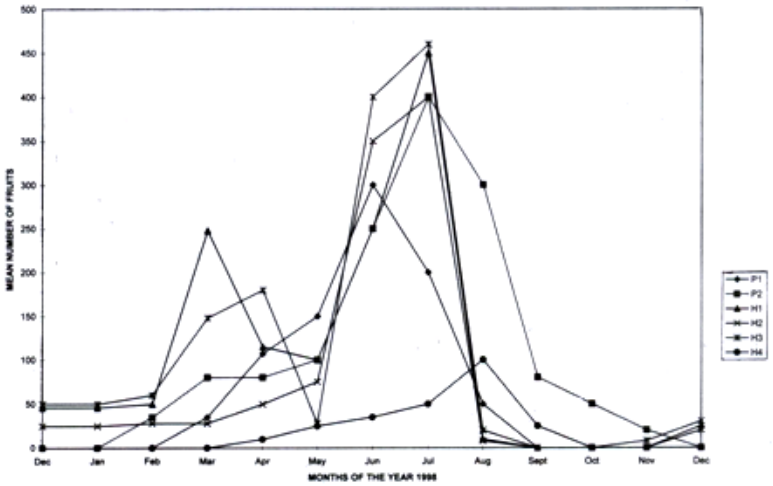

Figure 2. Mean number of fruits for selected passion fruit cultivars at Kawanda.

Table 4. Yields of the four passion fruit hybrids and their parents (kgha^{-1}yr^{-1}).

Cultivar	1998	1999
P1	6,488c	6,745c
P2	36,800b	42,858b
H1	46,851ab	54,899a
H2	40,494b	47,846ab
H3	53,299a	58,900a
H4	6,427c	9,920c

Means in a column bearing the same letter are not significantly different (LSD, 0.01)

tube growth resulting in busted pollen grains or incompatibility of the cultivars were the main causes of pollination failure. The stage of pollination with respect to floral opening and stigmatic receptivity also affected pollination levels.

Hybrids 1 and 2 were genetically midway between the parents while hybrid 3 was closer to P_2 and H_4 closer to P_1. Peak yields were obtained in March and July which are the peak rainfall periods but some fruits were harvested from February to August. The use of irrigation accompanied with selective pruning of old branches can result in all year round crop production.

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