SHORT COMMUNICATION:

POLLINATION AND FRUIT SET IN TWO SPECIES OF PUMPKIN IN LOWLAND PAPUA NEW GUINEA

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ABSTRACT

Two species of pumpkin were grown under lowland conditions in Papua New Guinea (PNG). These were Cucurbita moschata *Duchesne, the most widely used species in lowland PNG and* Cucurbita maxima *Duchesne for which there is an unsatisfied market demand. The numbers of pollinators visiting open female flowers of* C. moschata *was significantly higher for flowers which developed into fruits. Although planted in adjacent plots and available to the same populations of pollinators, very few* C. maxima *flowers developed into fruits; female flower bud loss was the cause of low yields in this species. Hand pollination caused an apparent slight increase in yield for* C. maxima. *It was concluded that the failure of* C. maxima *to fruit satisfactorily in lowland PNG was due to physiological factors and not a lack of insect pollinators.*

INTRODUCTION

In Papua New Guinea, pumpkin is a popular vegetable grown for leafy tips as well as fruit. It will grow from sea level to an altitude of 2400 m (R.M. Bourke, pers. comm.). The traditional species found in village gardens is *Cucurbita moschata* Duchesne, but more recently other pumpkin species have been introduced. Most markets are well supplied with local types, but there is an unsatisfied demand for fruit of the variety Queensland Blue (*Cucurbita maxima* Duchesne) (Bourke 1984). This variety fruits poorly in the lowlands (below 600 m a.s.l.) but well at higher altitudes (P.B. Bull, unpublished data). In the lowlands the poor fruit set has been attributed to inadequate pollination and provision of bee hives near commercial crops has been recommended (G. Gorogo, pers. comm.). The family Cucurbitaceae is generally considered dependant on insect pollination although published data on the genus *Cucurbita* is scarce (McGregor 1976). Two trials were conducted with the two species, at separate lowland sites; one to quantify and identify insect pollinators and the other to determine whether regular hand pollination would increase fruit set.

MATERIALS AND METHODS

Two species were used in each trial; a selection 'Rabaul' (*C. moschata*) originating from East New Britain, and 'Queensland Blue' (*C. maxima*) an Australian seed line. Trial I was conducted at Bubia Agricultural Research Centre (30 m a.s.l.), 15 km north west of Lae. Seeds were sown in Jiffy-7 peat pots and transplanted 12 days later on 18th November 1981. Plots consisted of two rows 8 m long. The plant population was equivalent to 2500 plants ha^{-1}. There were two replications of each species. Trial II was grown at Laloki Research Station (30 m a.s.l.), Port Moresby. Seed was sown in single row, 6 m long plots on

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24th September 1982. After emergence, plants were thinned to give a population equivalent to 350 plants ha^{-1}. There were six replications of each species. In three of the blocks, plots were visited at about 0800 h, three times weekly from 10th November to 22nd December. Any open female flowers were hand pollinated with male flowers from the same plot. Hand pollinated flowers were not screened from natural pollination.

No fertilisers, herbicides or insecticides were used in either trial. Plots were hand-weeded as necessary. Irrigation was applied when necessary in Trial II. Rainfall and temperature (maximum and minimum) recordings were made daily.

To establish the proportion of potentially pistillate flowers in Trial I, the sex of 15 flower buds at the distal end of 21 main vines, was determined for each species (29th January 1982).

Recordings of insect pollinators in Trial I, were started once production of both male and female flowers was established. Numbered aluminium tags were loosely attached to the pedicels of newly opened flowers. As each flower was labelled the pollinators inside the flower, and the cloud cover (in octas) were recorded. Two species of hymenopteran pollinators were present, *Apis mellifera* Linnaeus (Apidae) and *Lasioglossum* sp. (Halictidae). Observations on the first flower were made at 0715 h on each occasion and subsequent recordings taken at ten minute intervals for ninety minutes. A total of ten observations were made for each flower, and 115 flowers were observed between 26th January 1982 and 26th February 1982 (29 staminate and 53 pistillate *C. moschata* and 30 staminate and 3 pistillate *C. maxima*). To identify the date of any fruit loss, daily inspections were subsequently made of the numbered fruits.

All surviving numbered fruits in Trial I were harvested on 25th February 1982. The weight of each fruit and the numbers of mature seeds were counted. In Trial II, all the mature fruits were harvested on 21st January 1983. Two fruits were selected at random from each plot and the number of seeds in each was counted.

RESULTS

In each trial both species grew well although the vine of *C. moschata* was the more vigourous, developing faster and giving better ground cover. Mosaic symptoms, identified as cucumber mosaic virus (M. Pearson, pers. comm.) were apparent on the leaves of both species. In Trial II, *Aphis gossypii* (Glover) was present.

The conditions during the five sampling days for insect pollinators in Trial I, were very similar with fine weather and hazy cloud cover. Analysis of variance indicated no significant differences in the number of bees in flowers at the various sampling times. The mean numbers of pollinators visiting the different flower types, the mean fruit weight and the mean number of mature seeds at harvest are shown in *Table 1*. The numbers of bees visiting flowers varied with the species, sex and ultimate fate of the flower; differences were highly significant. None of the harvest and pollinator data for *C. moschata* showed any significant correlations, ($p < 0.05$), *Table 2*.

The ratio of staminate to pistillate flower buds for the 15 distal buds was 5:1 for *C. moschata* and 7:1 for *C. maxima*. Despite the similar number of pistillate flower buds on both species, only three *C. maxima* flowers opened during the recording period. Of these only one developed into a harvestable fruit. A total of 53 female *C. moschata* flowers were studied, of which 19 (35.8%) developed into fruits.

The yield, mean fruit weight and mean seed number per fruit for Trial II, are

Table 1.—**The mean numbers of pollinators visiting different flower types and the mean fruit weight and seed number at harvest Trial I, Bubia**

Species and flower type	*A. mellifera* mean No./ flower	*Lasioglossum* sp. mean No./flower	Both spp. mean No./ flower	Mean fruit weight (kg)	Mean seed numbers
C. moschata					
Successful female	1.85	0.14	1.99	2.39	273
Unsuccessful female	1.21	0.15	1.36	—	—
Male	0.28	0.17	0.44	—	—
C. maxima					
Successful female	0.10	0.80	0.90	2.65	1374
Unsuccessful female	0.05	0.55	0.60	—	—
Male	0.18	0.41	0.58	—	—

Table 2.—**Correlation coefficients (17 df) for parameters measured on *Cucurbita moschata* flowers and fruits. Trial I, Bubia**

	Number of *A. mellifera*	Number of all pollinators	Fruit weight
Fruit weight	0.042 (n.s.)	0.016 n.s.	n.a.
Number of mature seeds	0.252 (n.s.)	−0.250 n.s.	−0.020 (n.s.)

Table 3.—**The effect of hand pollination on the yield, mean fruit weight and mean seed number of *C. maxima* (Queensland Blue) and *C. moschata* (Rabaul) pumpkins. Trail II, Laloki**

	Yield t/ha			Mean fruit weight (kg)			Mean seed No./fruit		
	Natural pollination	Hand pollination	Mean	Natural pollination	Hand pollination	Mean	Natural pollination	Hand pollination	Mean
Variety									
C. maxima	7.1	20.9	14.0	2.54	2.76	2.65	518	440	479
C. moschata	57.2	46.4	51.8	2.43	2.77	2.60	306	376	341
Mean	32.1	33.6	32.9	2.48	2.76	2.62	412	408	410
Significant effects									
pollination × variety			n.s.			n.s.			n.s.
pollination			n.s.			n.s.			n.s.
variety			*			n.s.			n.s.
L.S.D. (Variety $p<0.05$)			25.50						

shown in *Table 3*. Hand pollination had no significant effect ($p < 0.05$) on yield, fruit weight or seed number, although there was a trend to higher yields from hand pollination of *C. maxima*. *C. moschata* with 51.8 t ha^{-1} had over three times the yield of *C. maxima*.

Mean maximum and minimum temperatures were 32/25.5°C and 33.6/21.7°C for Trial I and Trial II, respectively.

DISCUSSION

Total yields for Trial I were not measured, but an adjacent block of *C. moschata* yielded over 60 t ha^{-1} (Sutherland, in preparation), which is similar to the yield obtained in Trial II and in other trials at Laloki (P.B. Bull, unpublished data). Fruit weights and seed number for *C. moschata* were similar in each trial.

The ratio of staminate to pistillate flower buds, for both species, was comparable with the only other data for *Cucurbita* spp., a ratio of 10:1 for *C. pepo* (Battaglini 1969). This suggests that potential fruit production was good in both species. In the case of *C. maxima* the potential was never realised with most pistillate buds failing to develop to flowers, whilst the few that opened usually aborted. There was no evidence that this was due to insect attack. Staminate flowers on *C. maxima* opened normally, as did both staminate and pistillate on *C. moschata*.

The female flowers on *C. moschata* can be divided into two categories, those which were successful and developed into fruit and those which did not. A significantly ($p < 0.001$) larger number of *A. mellifera* visited the former (*Table 1*), and presumably provided adequate pollination. There were no correlations approaching significance between the numbers of *A. mellifera* visiting the flowers and the fruit weight or seed number at harvest (*Table 2*), neither did hand pollination affect these parameters. This is a little surprising since it has been shown with some *Cucurbita* spp. that increased amounts of pollen on the stigma increases the fruit weight and seed number (Hayase 1953). It does not appear from our results that pollination is limiting seed number or fruit weight for *C. moschata*. Flowers which failed to develop into fruits (*C. moschata*) were visited by a lower number of bees, this may have been the cause of the failure to fruit or it may have been some intrinsic property of the flowers which made them both less acceptable to bees and more likely to abort. Without more detailed study of individual flowers it is not possible to know which. Very few *Lasioglossum* sp. were found in flowers of *C. moschata*, and it is unlikely that this small halictid, although undoubtedly a pollinator, plays a significant role in the pollination of pumpkin when *A. mellifera* is present. Staminate flowers of *C. moschata* were less attractive to *A. mellifera* than the pistillate, and from observations made during the trial, visits by bees to staminate flowers were of much shorter duration than those to the female. The nectaries on the female flowers are much larger than those on the male, and this is the likely reason.

Since hand pollination had no significant effect on fruit set, fruit weight or seed production of *C. moschata*, insect pollination would appear to be adequate. Although the data for pollinators visiting the female flowers of *C. maxima* are very limited (3 flowers) it is not unreasonable to assume that again pollinators are not limiting since sufficiently large numbers of both *A. mellifera* and *Lasioglossum* sp. were in the trial area and the morphology of the flowers is very similar. *C. moschata* is recognised as being better adpated to the lowland tropical climate than other *Cucurbita* spp. (Cobley and Steele 1976). The fact that very few female flowers of *C. maxima* developed, suggests that this species is not as well adapted.

This supports our contention that *C. maxima* ('Queensland Blue') is adversely

affected by the climate in lowland Papua New Guinea and not limited in its productivity by a lack of pollinators. Further trials to study pistillate flower abortion in *C. maxima* would be worthwhile.

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