Pollination Efficiency of *P. juliflora* (Sw) DC in Petrolina, Pernambuco

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Introduction

In recent years, *P. juliflora* (Sw) DC has been planted in large scale for production of wood for different end uses, as well as for fruit production for fodder, on account of the pods' high protein content, as Alves (1972) points out. Fruit production ranges from 0.00 to 120 kg per tree, observing, however, that at inflorescence level fruit yield is low compared to the high number of flowers contained in each inflorescence.

On the other hand, wide spacings are needed, generally 10 × 10 m, for the trees to show satisfactory fruit output. This reduces considerably the number of trees per hectare and, consequently, production volumes.

In view of the above, it becomes necessary to study factors related to the *P. juliflora* reproductive system, in search of alternatives capable of increasing fruit output. This research study aims, therefore, at defining the reproductive system and the possible causes for the low fruit output per inflorescence, i.e. the low pollination efficiency.

Review of Literature

The characteristics of drought hardiness and the good performance of *P. juliflora* in the different ecological regions of the Brazilian Northeast (Pires and Ferreira, 1983) make this species a prime candidate for use in afforestation programs aimed at timber and/or fodder production, as well as for use in programs targeted to small farmers, such as provision of windbreaks, shading, firewood, construction timber, etc. Most of the plantations existing at present have the purpose of producing fodder.

The number of fruits per inflorescence observed normally in *P. juliflora* populations in the Northeast ranges from 1 to 3, for a high number of flowers. Solbrig and Cantino (1975) found an average of 220 to 240 flowers per inflorescence in *Prosopis flexuosa* and *Prosopis chilensis*, respectively, also with a low number of fruits per inflorescence.

These same authors point out that the high number of flowers per inflorescence can be a strategy for attracting pollinating insects. Meanwhile, low pollination efficiency (Solbrig and Cantino, 1975) and other factors such as protogyny (Habit, 1981) cannot be ruled out as the reason for the low fruit yield. A question arises in this regard: Are all flowers in an inflorescence hermaphrodite and viable?

Augspurger (1980), working with *Hybanthus prunifolius,* concluded that the low percentage of fruit produced by that species is not due solely to the phenologic pattern of floral production, but also to factors such as compatibility of reproductive systems, forms of development and temporal and spatial density of the populations.

Another aspect is the presence of pollinating agents at the moment of greater pollination viability. Within this context, Haber and Frankie (1982) carried out controlled pollinations in daytime and nighttime periods with *Luehea candida,* and found 92% fruit yield for nighttime pollination and 47% for daytime pollination. This difference is due, probably, to the absence of pollinators during the night, when the flowers are more receptive, or even to the effect of protogyny.

According to Koptur (1984), an inflorescence of the genus *Inga* contains around 40 flowers and produces 4 to 5 fruits, a fact which may be related to physical, chemical or spatial factors.

Bawa and Webb (1983) found a correlation in *Mutingia calabura* between the amount of fruits produced and ovary size. This leads to the conclusion that, possibly, in the case of the genus *Prosopis,* a physical restriction may exist; i.e. the size of the ovary or of the pollinical tube varies from flower to flower, being fertilized only those flowers with size above a certain minimum.

Material and Methods

The experiment was carried out in Petrolina, Pernambuco, at the Bebedouro experimental station of the Agriculture and Livestock Research Center for the Semi-Arid Tropic (CPATSA), in a 16-year-old *P. juliflora* (Sw) DC population.

Twenty trees were selected at random and identified, collecting 20 ripe inflorescences from each tree identified in order to determine number of flowers per inflorescence (NFI) and to measure inflorescence length. The purpose was to devise a regression equation to estimate the number of flowers. The inflorescences collected were stored in a freezer, both for conservation purposes and to facilitate flower counting in subsequent days.

Inflorescence length was measured with a cm ruler. Then, 10 of the 20 trees identified initially were selected, identifying 15 inflorescences at random from each of them, leaving ten free and storing in bags the remaining five. The length of each inflorescence (IL) was measured with a common ruler.

For each inflorescence stored in bags, another free one was identified from the same bunch with the purpose of assessing the occurrence of effective pollination with external pollen. The bags were made of kraft paper, 35 cm in height and 16 cm in length, with a string to tie them up and spiral wire and cotton padding to protect the bunch. Those inflorescences were controlled until the end of the pollination phase.

In the other 10 trees, ten inflorescences were identified and measured with 2 controls per week, to estimate free pollination efficiency and fruit persistence, until their physiological ripening occurred.

Results and Discussion

Number of flowers per inflorescence and inflorescence length

Table 1 shows the average number of flowers per inflorescence, with the corresponding standard deviation per tree, resulting from direct counting in the first stage.

The number of flowers per inflorescence ranged from 269 to 456, while inflorescence length varied from 7.09 to 14.08 cm.

The average number of flowers per inflorescence was 344, with inflorescence length of 11.45 $\pm$ 1.77 cm, by direct counting.

Based on these data, a linear regression equation was arrived at: $N\hat{F}I = 117.80919 + 19.79285$ IL, with a correlation coefficient (r) of 0.77985, which makes it possible to estimate the number of flowers per inflorescence ($N\hat{F}I$) according to inflorescence length (IL). Figure 1 shows shows the data distribution observed and the line resulting from the regression equation.

Table 2 shows mean number of flowers per inflorescence for the 20 trees used in this trial, estimated as per the above regression equation. As shown therein, the estimated number of flowers per inflorescence ranged from 304 to 393, with a mean of 344 for inflorescence length varying from 9.4 to 13.9 cm; average value for the latter was 11.47 $\pm$ 1.3 cm.

The analysis of Tables 1 and 2 shows that inflorescence length and number of flowers per inflorescence varied both within and between trees, with the wider variations occurring between trees.

TABLA 1
Average Inflorescence Length (IL) and Average Number of Flowers per Inflorescence (NFI)

Tree No.	IL (cm) + standard deviation	NFI
01	11.94 ± 1.20	342
02	13.31 ± 1.42	438
03	14.08 ± 1.54	456
04	13.67 ± 1.27	364
05	9.78 ± 1.19	319
06	11.24 ± 1.59	342
07	13.36 ± 1.81	358
08	10.16 ± 1.33	319
09	11.56 ± 1.49	326
10	12.23 ± 1.95	362
11	9.87 ± 1.33	299
12	13.91 ± 1.72	366
13	12.67 ± 1.75	353
14	9.60 ± 1.55	335
15	10.26 ± 1.29	337
16	11.53 ± 1.39	324
17	11.22 ± 1.37	371
18	10.40 ± 1.34	274
19	11.01 ± 1.53	334
20	7.09 ± 1.69	269
Mean	**11.45 ± 1.77**	**344**

IL: Average inflorescence length.

NFI: Number of flowers per inflorescence.

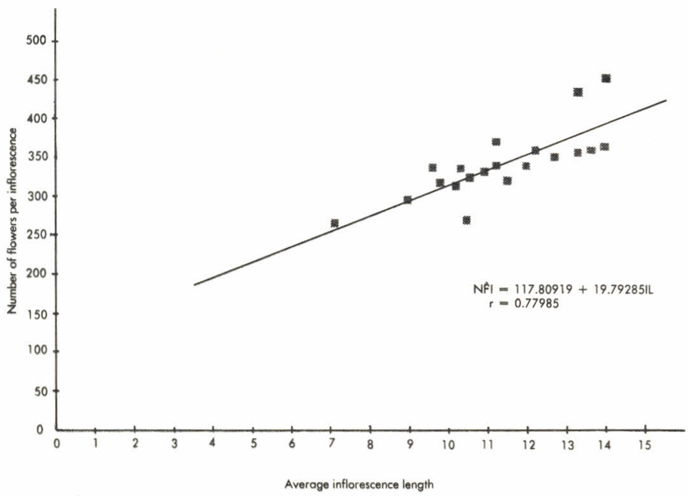

Figure 1. Distribution of the number of flowers/inflorescence as related to average inflorescence length.

No fruits were produced by the inflorescences stored in bags, confirming the expected predominance of allogamy.

Pollination efficiency and fruit production

Pollination efficiency, defined as the amount of flowers pollinated per inflorescence, and fruit production and characteristics per tree are shown in Table 2.

Taking as base 10 inflorescences per tree, it was found that the number of inflorescences pollinated varied from 0.00 to 10.0, i.e. pollination efficiency basing on the amount of pollinated inflorescences ranged from 0.00% to 100%, with a mean of 29% (Table 2). This shows high phenotypic variation among trees in terms of the amount of flowers pollinated, which may be due to pollinators, level of incompatibility, flower abortion or degree of kinship between trees, bearing in mind that Pires and Kageyama (1985) questioned the genetic base of those populations. Figure 2 illustrates the pollination efficiency at tree level, basing on the inflorescences pollinated and inflorescences producing ripe fruits.

It must be stressed that out of the pollinations taking place, on the average, only 42.3% formed fruit that held on until it reaching maturation, (Table 2). Taking as base the total number of flowers per inflorescence and the amount of fruits produced, a 1.48% pollination efficiency was found. Solbrig and Cantino (1975), working with *Prosopis flexuosa* and *Prosopis chilensis,* also found low fruit production for a high number of flowers per inflorescence. The authors suggest that the high number of flowers may have the sole function of attracting pollinator insects.

The definition of pollinating agents, as well as of the pollen release period and stigma receptivity, are fundamental to explain such low pollination efficiency. The lack of synchronization between pollen release and pollen reception period, added to the absence of pollinating agents at the moment of anthesis, may affect dramatically pollination efficiency (Haber and Frankie, 1982).

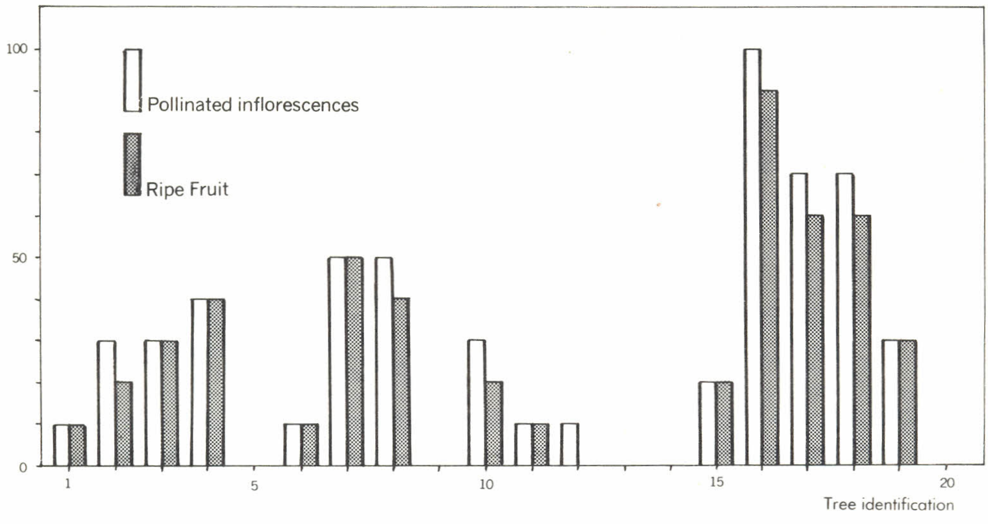

Figure 2. Percentage of pollinated inflorescences and inflorescences with ripe fruits per tree.

TABLE 2

Pollination Efficiency, Inflorescence and Fruit Characteristics Taking 10 Inflorescences per Tree as Base

Tree (No.)	Pollinated Inflorescences No.	(%)	Av. No. of flowers per inflorescence	Total No. of pollinations	Ripe Fruits No.	(%)	Average fruit length (cm)	Av. Inflorescence length + standard deviation (cm)
01	01	10	327	01	01	100.	17.5	10.6 ± 0.54
02	03	30	355	09	04	44.44	16.0	12.0 ± 1.57
03	03	30	376	20	13	65.00	16.9	13.1 ± 1.94
04	04	40	371	13	07	54.00	20.4	12.8 ± 1.41
05	00	00	343	00	—	—	—	11.4 ± 1.07
06	01	10	304	01	01	100	20.1	9.40 ± 0.98
07	05	50	314	08	07	87,5	13.6	9.90 ± 1.07
08	05	50	351	22	12	54,5	17.7	11.8 ± 1.31
09	00	00	369	00	—	—	—	12.7 ± 1.51
10	03	30	317	09	05	55.50	18.4	10.1 ± 0.98
11	02	20	322	04	02	50.00	15.30	10.3 ± 1.61
12	01	10	319	01	00	0.	—	10.2 ± 2.25
13	00	00	322	00	00	0.	—	10.3 ± 0.97
14	00	00	319	00	00	0.	—	10.6 ± 1.48
15	02	20	332	05	03	60.0	17.7	10.8 ± 0.58
16	10	100	354	111	26	23.4	20.7	11.9 ± 1.40
17	07	70	373	24	11	46.0	17.9	12.9 ± 1.58
18	07	70	378	08	06	75.0	13.0	13.2 ± 1.72
19	04	40	348	05	04	80.0	21.4	11.6 ± 1.37
20	00	00	393	00	00	0.	—	13.9 ± 2.35
Mean	**2.90**	**29**	**344**	**12**	**05**	**42.3**	**17.1 ± 2.54**	**11.47 ± 1.30**

Fruit average length, presented in Table 2, varied between 13 and 21.4 cm, evidencing the great phenotypic variation among trees.

As seen in Table 2, pollination efficiency varies greatly from individual to individual, which leads to hypotheses involving environmental influence, including pollinating insects, as well as genetic factors. The need for further and more detailed research is thus evident, at clone level, to verify the reasons for the low pollination efficiency in *P. juliflora* populations in the Brazilian Northeast.

Conclusions

1. Average length of *P. juliflora* inflorescences was 11.47 cm;
2. Average number of flowers per inflorescence was 344;
3. Pollination efficiency based on the number of inflorescences per tree was 29%; however, in relation with the number of flowers, efficiency dropped to a mere 1.48%;
4. High phenotypic variation exists among trees as regards pollination efficiency;
5. Further in-depth studies on floral biology are needed to identify the factors responsible for the low efficiency of pollination in *P. juliflora* populations in the Northeast.

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