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Research Article

Studies on floral display and mode of reproduction in jatropha (*Jatropha curcas* L.)

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Abstract :
Plant flowering and breeding characteristics are important for us to understand the reproduction of plant populations. In this paper, we studied the mode of reproduction of *Jatropha curcas*. in GKVK, UAS, Bengaluru. The plant produces flowers in dichasial inflorescences. Normally, the flowers are unisexual, and male and female flowers are produced in the same inflorescence. Only a few male flowers are produced in an inflorescence, and fruits are produced only through pollination between different flowers from the same or different plants. Pollination experiment clearly revealed the predominance of cross pollination in *Jatropha curcas* with the apomixis up to 28.5 per cent. The mean female to male flower ratio in the Jatropha was around 14.4 to 105.73. By the treatments of emasculation, bagging and artificial pollination, which showed that *Jatropha curcas* could facilitate sexual system geitonogamy up to 75.6% fruit set indicates self-compatibility and xenogamy up to 82.33 per cent fruit set. When the inflorescences were unbagged, unemasculated and with free pollination treatments, or unbagged, emasculated and with free pollination treatments, there were many fruits produced. It showed that out crossing up to 74.97 per cent fruit set, and demanding for pollinators. Normally, the male flowers open first and maximum number of male flowers open from fourth to ninth day. However, a large number of female flowers open from the fourth to the seventh day, with some female flowers opening first in a few raceme. This shows a tendency to promote xenogamy and minimize geitonogamy.

Keywords: Jatropha, reproduction, pollination

Introduction

A breeding system is the result of interaction between the internal genetic mechanism of plants and the external environment, and plays a critical role in deciding the route of plant evolution and phenotype mutation (Grant, 1981). There are three kinds of mechanisms in plant breeding systems: geitonogamy, xenogamy, and apomixis (Les, 1988). In spite of the common existence of geitonogamy in angiosperms, the tendency to promote xenogamy is still of universal significance in the evolution of angiosperms (Faegri, 1979; Guo, 1994). Plants have various adaptive ways to guarantee xenogamy, such as dioecism (separation between male and female sexual plants), dichogamy (timing separation of male and female sexual functions), opposite styles, styles of different lengths, incompatibility in incrossing, *etc*. (Wayatt, 1983; Fang, 1996). *Jatropha curcas* is monoecious, and produces male and female flowers in the same inflorenscence. Whether there is a mechanism on promoting xenogamy in *J. curcas* is beyond knowledge. Based on the tests of its floral display and breeding system, we intend to provide some data for the plant's pollination mechanism and breeding features

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Material and methods

In this study, ten germplasm accessions with two plants from each germplasm accessions were selected from the plants raised through cuttings in K-1 block, GKVK, UAS, Bengaluru. Five inflorescences were selected from each plant. All the plants and selected inflorescence were labeled before recording the observation. Observations were recorded on characters related to floral display and mode of reproduction.

Floral display

Female to male flower ratio was recorded by selecting five inflorescences randomly on each plant from the opening of the flowers to completion of flowering in each selected inflorescence by counting male and female flowers daily.

Mode of reproduction test

The experiments were performed respectively by bagging, emasculation of the inflorescences by removal of flower and conducting artificial pollination with female flowers. According to the method, treatments imposed on the target inflorescences were as follows. 1) Control: to check

pollination under the natural conditions unbagging, unemasculation, and free pollination; 2) Hand Geitonogamy: to check whether this measure would lead to fertilization and bearing fruits in the condition of emasculation and bagging the female flowers, and artificial pollination with male flowers from the same tree; 3) Hand Xenogamy: to detect whether outcrossing was compatible, in the condition of emasculation and bagging the female flowers, and artificial pollination with male flowers from different trees; 4) Outcrossing pollination: to compare with the results of both 1) and 3) and detect whether the fruit bearing was limited by pollinators, under the condition of emasculation without bagging and free pollination; 5) Emasculation: to check the effect wind pollination in the condition of bagging the female flowers with nets (use pesticide to kill small insects in the flower); 6) Emasculation: remaining female flowers bagged to check whether there is apomixes.

Except for the inflorescences of free pollination, all the male flowers were removed before petal opening Paper bags are removed after the experiment. Artificial pollination was carried out according to the pollination processes on the surface of the stigma of the un-bagged female flower in the same population. Similarly, parchment bags were removed and the experiment ended when petals wither and carpel enlarges evidently in accordance with the un-bagged female flowers in the population. During the experiment, flowers in the bags were checked and aired to prevent the decay of the flowers. Insects' activities were avoided while removing the bags. The observation were recorded were total male flower, total female flower, total floweres per inflorescence, days taken from initiation of flowering to fruiting, das taken frm fruiting to maturity, fruit set and per cent of fruit till maturity.

Result and discussion

Floral biology:

The study was carried in ten germplasm accessions with five inflorescence selected from each plant as a sample to observe the floral display and mode of reproduction in *Jatropha curcas*. Among which there were seven out of hundred inflorescence without any female flower. The average number of female and male flowers per inflorescence is 14.4 (9.6-17.82) and 105.73 (75-138.07) (Table 1, Fig. 1-3) respectively .Luo, *et al*. (2007), and Raju *et al* (2002), also reported near to this ratio.

Normally, the male flowers open first at the branch joined, followed by female ones. Female flowers at the top of inflorescence blume earlier than flowers at the other places. Some male flowers remain unopened even when all female flowers have opened. In few inflorescence, the female flower open before male ones.

In every inflorescence the flower duration last for 10-12 days this result was in accordance with report of Luo *et al.* (2007). A few female flowers open at the first one or two days followed by the quick opening of female flowers and about 60 per cent of the female flowers opened from fourth to seventh day. The flowering pattern showed that male flowers open slowly with a small peak between fourth to ninth days. Mean data of reproductive sysem are given in Table 1.

Open pollination showed maximum fruit set per cent compared to all other mode of reproduction and also showed negligible amount of aborted fruit set. However, out crossing recorded 75 per cent fruit set among which 8 per cent fruit set were aborted, which indicates role of insect and wind pollination in fruit set. Emasculation had little influence on fruit set in this population. It was further confirmed by controlled pollination through hand geitonogamy and hand xenogamy (Table 2). Among these hand xenogamy revealed 82.33 per cent fruit set while 76 per cent fruit set was observed through geitonogamy. Almost all xenogamous fruits once initiated developed to maturity, while 18 per cent of the developing geitonogamous fruits abort subsequently and the remaining fruits developed to maturity. Similar result was reported by Raju *et al*. (2002) which indicate that *Jatropha curcas* was more prone to cross pollination but it also exhibited self compatibility. Hence, there is more variability exist to exploit through suitable breeding programme.

The average days taken from flowering to fruiting was 6.81 days and the average number of days taken from fruiting to maturity was 48.19 days which is comparable with the result of Rao *et al*. (2008) and the fruits grow to full size in 2 month period with concentrated growth during third to fifth week. The fruits are green first, later turn yellow and finally to brown or black. The matured fruits dehisce passively and seeds fall off together with the capsule.

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Table I. Mean Data of reproductive system (open pollination) in *Jatropha curca* L

	X_1	X_2	Fruit set (%)	X_3	Fruit till maturity(%)	X_4	X_5	X_6	X_7	X_8
L1	13.85	13.11	94.65	12.33	89.02	7.50	50.30	141.94	128.09	1-9.24
L2	13.12	12.33	93.97	11.56	83.10	5.30	49.60	125.57	112.45	1-8.57
L3	16.42	15.78	96.10	14.40	87.69	6.00	48.70	101.78	85.36	1- 5.21
L4	14.22	13.56	95.35	13.15	92.47	7.40	47.70	104.02	89.8	1- 6.31
L5	15.73	15.40	97.90	14.78	93.96	6.00	41.80	112.09	96.36	1 -6.12
L6	17.82	17.20	96.52	16.58	93.04	5.60	54.20	155.91	138.09	1- 7.74
L7	9.64	8.38	86.92	8.30	86.09	5.80	42.20	121.46	111.82	1-11.59
L8	14.78	12.56	84.97	12.45	84.23	6.70	50.40	123.54	108.76	1- 7.35
L9	13.66	13.22	96.77	11.52	84.33	8.70	51.60	89.06	75.4	1- 5.51
L10	14.76	12.86	87.12	12.53	84.89	9.10	45.40	126.01	111.25	1- 7.53
Average	14.4	13.44	93.02	12.76	87.88	6.81	48.19	120.13	105.73	1-7.34
Range	9.6-17.82	8.38-17.20	84.97 – 97.90	8.30 –16.58	83.10 – 93.96	5.30-9.10	41.80-54.20	89.06-155.91	75.4 – 138.07	1-5.21 to 1-11.59
SD	2.18	2.393	4.77	2.221	4.04	1.322	4.001	19.60	19.27	
SEm±	0.691	0.757	1.50	0.705	1.27	0.418	1.266	6.20	6.10	

X_1= Number of female flower, X_5= Days for fruiting to till physiological maturity
X_2= Number of fruit set, X_6= Total flower
X_3= Number of fruit till maturity X_7 = Total male flower
X_4= Days for flowering to fruiting X_8= Female to Male flower ratio

Table 2. Mean data of reproductive systems (controlled pollination) in *Jatropha curcas* L.

	Hand Geitonogamy					Hand Xenogamy				
Lines	**X_1**	**X_2**	**fruit set (%)**	**X_3**	**fruit till maturity(%)**	**X_1**	**X_2**	**fruit set (%)**	**X_3**	**fruit till maturity (%)**
L1	9.8	8.4	85.7	5.7	58.16	8.3	7.2	86.75	6.8	81.93
L2	8	5.4	67.5	4	50.00	9.1	5	54.95	4.4	48.35
L3	5.5	4.6	83.6	3.5	63.64	7.5	6.2	82.67	5.7	76.00
L4	7.2	5.9	81.9	5	69.44	8.3	7.2	86.75	6.5	78.31
L5	7.6	6.1	80.3	5	65.79	5 .5	5.3	96.36	4.6	83.64
L6	9.7	6.9	71.1	5	51.55	8.7	7.6	87.36	6.9	79.31
L7	5.67	3.78	66.7	3.11	54.85	8.2	6.5	79.27	6.1	74.39
L8	10.33	6.67	64.6	4.56	44.14	7.3	6.5	89.04	5.7	78.08
L9	8.4	5.7	67.9	4.8	57.14	9.8	8.4	85.71	7.7	78.57
L10	7.4	6.7	90.5	5.1	68.92	8.8	7.2	81.82	6.7	76.14
Mean	7.96	6.015	75.6	4.577	57.50	8.15	6.71	82.33	6.11	74.97
Range	5.5-10.33	3.78-8.4	64.6-90.5	3.11-5.7	44.14-69.44	5.5-9.8	5-8.4	54.95-96.36	4.4-7.7	48.35-83.64
SD	1.651	1.2852	9.41	0.8	8.496	1.182	1.034	10.91	1.036	9.916
SEm±	0.523	0.4067	2.98	0.253	2.689	0.374	0.327	3.454	0.328	3.138

X_1= Number of female flower,
X_2= Number of fruit set,
X_3= Number of fruit till maturity

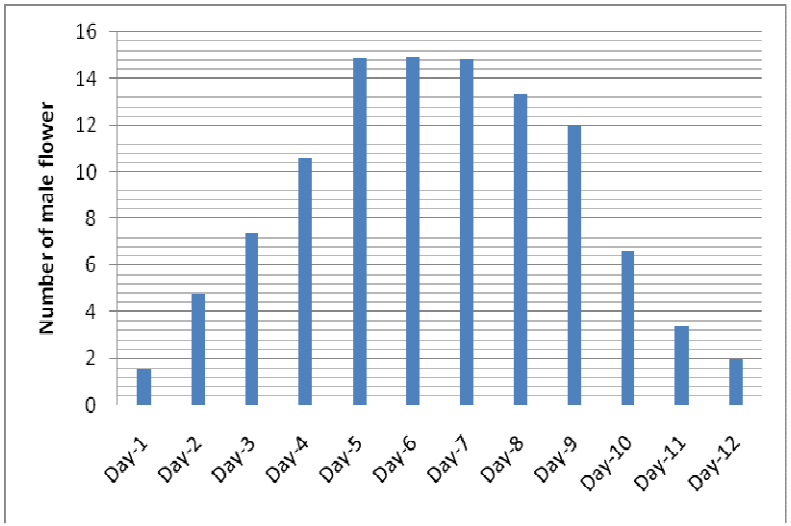

Fig 1. Mean of daily opened male flowers across ten germplasm accessions in Jatropha

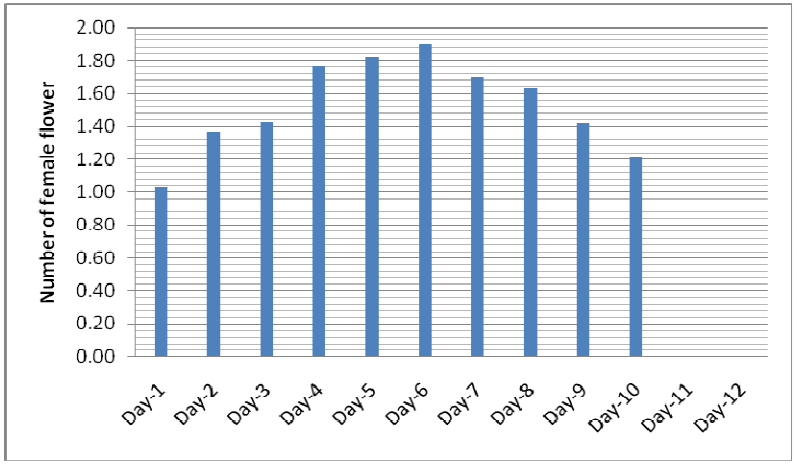

Fig 2. Mean of daily opened female flower across ten accessions in Jatropha

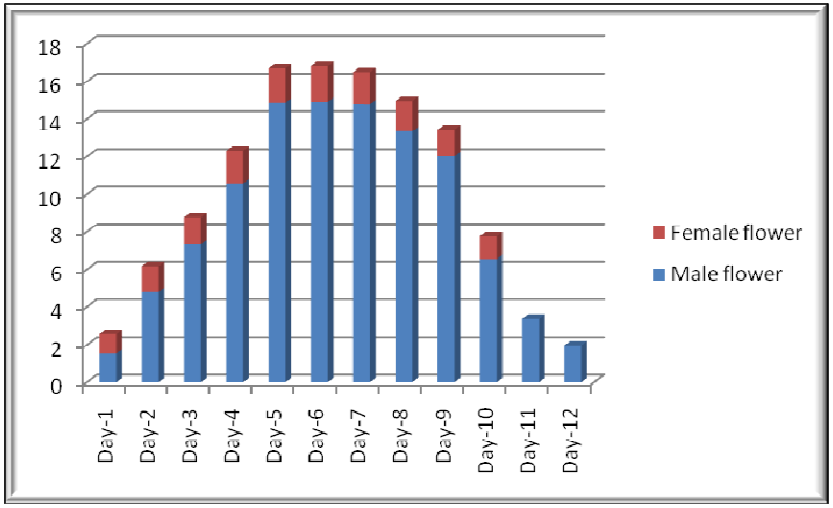

Fig 3. Mean of female to male ratio for daily opened flowers across ten accessions in Jatropha.