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BREEDING FIELD CROPS FOR ORNAMENTAL PURPOSE: A CASE IN *Jatropha* spp.

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ABSTRACT

Populations of F_1, F_2 and BC_1F_1 were formed from an interspecific cross between green-flowered *Jatropha curcas* and red-flowered *J. integerrima* (dwarf type) to observe for segregation in flower colors and to select for ornamental segregants. The crossing to produce F_1 and BC_1F_1 was successful only when *J. curcas* was used as the female parent. The suitable time for crossing was between 08:00 – 13:00 o'clock with fruit setting rate of 65-78%. The F_1 segregated into white- and pink-flowered plants. While flowers of the F_2 population segregated into nine different colors, viz. light green, green, white, very light pink, light pink, pink, deep pink, very deep pink, and red. When *J. curcas* was backcrossed by a pink-flowered F_1, its BC_1F_1 progenies segregated into green, light green, white, very light pink and light pink flowers. While another set of BC_1F_1 progenies obtained from a white-flowered F_1 parent segregated into green, light green, and white. The segregating progenies in both sets showed smaller plants than jatropha and bore colorful flowers suitable for ornamental purpose. Six plants were chosen and registered at Kasetsart University and the Thai Department of Agriculture as commercial cultivars, 'Kamphaeng Saen 1' to 'Kamphaeng Saen 6'.

Keywords: crossing durations flower color, ornamental jatropha, interspecific cross

INTRODUCTION

Ornamental plants are plants grown for decoration in vase, hanging, and garden landscape for pleasure and to improve the environment. The demand for ornamental plants follows the country's economic growth and the quality of life. The market of ornamental plants depends on satisfaction of the buyers, thus kinds and varieties of plants have to be novel in response to the market demand.

Breeding field crops for ornamental purpose is a new idea to develop unique ornamental plants such as red castor bean (Arslan, 2012), multi-colored and spineless safflower (Bradley *et al.,* 1999 and Golkar *et al.,* 2010). In pineapple, ornamental characters include brightly-colored flower head on a long stalk, small decorative fruit and long stalk, deep red leaf and a small clumping habit (Sanewski, 2009 and de Souza *et al.,* 2009). In sunflower, the objective in improvement for commercial cut flowers are medium flower size and long shelf-life, while for pot plant is dwarf plant type.

Jatropha (*Jatropha curcas* L.) is a shrub from which its seed oil is normally used for biodiesel production (Kumar *et al.,* 2008). Jatropha also has a potential for ornamental purpose through interspecific cross with related species; especially with *J. integerrima*, an ornamental shrub, hard wood, frost tolerance and resistant to root rot diseases and leaf eating caterpillars (Lakshminarayana and Sujatha, 2001). Crossing among the two species is usually successful but the F_1 plants set only few seeds (Sujatha and Prabakaran, 2003; Parthiban *et al.,* 2009 and Dhillon *et al.,* 2009) and thus it is difficult to advance the selection process to the next generation. In this study, we produced populations of F_1, F_2 and BC_1F_1 from a cross of *J. curcas* and *J. integerrima* and selected individual plants based on flower color and plant type for ornamental purpose.

MATERIALS AND METHODS

Jatropha or physic nut (*J. curcas*) and dwarf peregrina (*J. integerrima*) were propagated by cuttings and sown in plastic bags filled with

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commercial soil during the rainy season of 2009. At 3 months old, the seedlings were transplanted to a crossing block in the field of Agronomy Department, Kasetsart University, Kamphaeng Saen, Nakhon Pathom, Thailand; using a spacing of 1m × 1.5m. Six months after transplanting, the plants were flowering and thus pollinated at various time durations in both direct (*J. curcas* as female) and reciprocal crosses.

J. curcas has green corollas in both male and female flowers setting on the same florescence of raceme type, while *J. integerrima* has deep red corollas in both male and female flowers. The male flowers of each species were emasculated before anthesis and covered with pollinator-proof bag. Pollination was attempted in five time durations, viz. 06:00 – 07:00, 08:00 – 09:00, 10:00 – 11:00, 12:00 – 13:00, 14:00 – 15:00, and 16:00 – 17:00 o'clock. The pollen grain of each species was collected at the time of anthesis and dusted on female flowers of the opposite species. In each time duration, pollination was performed on 4 inflorescences, each treated as a replicate. Each inflorescence was trimmed leaving only 5 female flowers. The same practice was done for both direct and reciprocal crosses. Fruit setting rate and mature seed number per fruit were recorded. The parental and hybrid seeds were sown in plastic bags filled with commercial soil and kept in a nursery at 50% sun light intensity for 2 months, then transplanted to the field. At flowering, plants showing prolific flowers with distinct colors were chosen and grafted onto jatropha stocks grown in pots of 30 cm in diameter. The pots were filled with commercial soil and kept under the same nursery during December 2011 to August 2012. Horticultural characters were observed on the F_1 and parental plants at the age of around 8 months old, which was the common blooming time of both species. Each plant was recorded for sizes of canopy and leaf, as well as characters of raceme and flower. Once the *F*-test indicated a difference among the genotypes, their means were compared using Least Significant Difference (LSD). The number of F_2 and BC_1F_1 plants segregating in different flower colors were also recorded.

RESULTS AND DISCUSSION

The suitable duration for interspecific pollination between *J. curcas* and *J. integerrima* was 08:00–13:00 o'clock (Table 1). Crossing was successful only when *J. curcas* was used as the female parent, while the reciprocal cross failed to set fruit. This can be explained based on the flower behaviors of both species. Their female flowers are fully blooming in the morning around 7:30-8:00 AM, while pollen from the male flowers is shedding around 8:00-8:30 AM and gradually wilting in afternoon of the same day. Thus pollinations are more successful in the morning.

Table 1. Mean and percentage of fruits set from interspecific hybridization between *J. curcas* and *J. integerrima* at different time durations. Crossing was successful only when *J. curcas* was used as the female parent

Duration (o'clock)	Mean fruits set ±SD (%) [a]
06.00 - 07.00	5.50 ± 1.36 (27.50)
08.00 - 09.00	14.50 ± 1.16 (72.50)
10.00 - 11.00	15.75 ± 1.28 (78.75)
12.00 - 13.00	13.00 ± 1.16 (65.00)
14.00 - 15.00	8.50 ± 1.32 (42.50)
16.00 - 17.00	4.50 ± 1.92 (22.50)
F-test	**
LSD	2.97
CV (%)	27.15

Remarks: ** Significant at P ≤ 0.01, [a] average form four replications

Interspecific hybrid seeds were obtained only when *J. curcas* was used as the receiver. Our result corresponds with the earlier report of Sujatha and Prabakaran (2003). They observed that when *J. integerima* was the female parent, although the pollen tube of *J. curcas* germinated entering into the ovule, there was no fertilization, however. At 8 months after transplanting, the F_1 plants were different from their parents in all morphological characters (Table 2).

The F_1 plants showed exceptionally high heterosis in number of inflorescences per plant, giving the average number of more than 27 inflorescences per plant. Although the number of flowers per inflorescence of the F_1 hybrid fell between both plants, the total number of flowers were many more than the high parent (*J. integerrima*). Flower colors in the F_1 segregated into five white-flowered plants and four pink-flowered plants.

Table 2. Mean ± SD of horticultural characters of F_1 hybrid and their parents at 8 months old

Genotypes	**Canopy height (cm)**	**Canopy width (cm)**	**Leaf length (cm)**	**Leaf width (cm)**	**Length of flower stalk (cm)**	**No. inflorescences /plant**	**No. female flowers/inflorescence**	**No. male flowers/ inflorescence**
J. curcas	189.44 ± 19.03	80.67 ± 9.49	13.69 ± 0.66	12.38 ± 0.27	12.86 ± 0.36	6.67 ± 2.22	11.12 ± 2.12	114.51 ± 12.93
J. integerrima	48.78 ± 7.69	31.00 ± 3.45	4.83 ± 0.33	4.54 ± 0.13	16.08 ± 0.46	14.44 ± 1.99	4.87 ± 0.53	30.09 ± 6.24
F_1 hybrid	127.78 ± 8.36	45.56 ±7.53	11.62 ± 0.16	11.34 ± 0.23	13.92 ± 0.70	27.56 ± 5.64	7.70 ± 0.76	69.92 ± 14.53
F-test	**	**	**	**	**	**	**	**
LSD	15.26	8.99	0.45	0.25	0.62	4.57	1.59	14.05
CV (%)	9.49	12.63	3.92	2.06	3.28	21.37	15.32	14.91

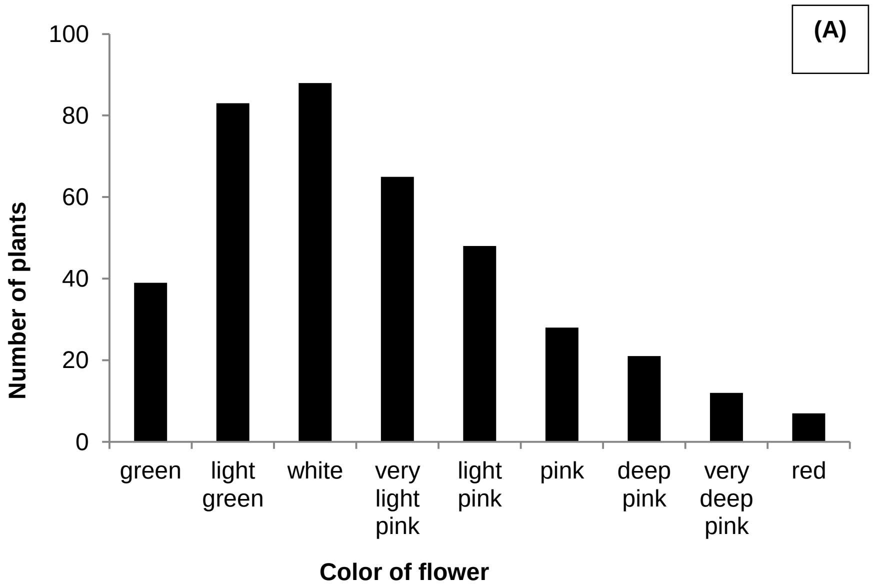
Remarks: ** Significantly different between genotypes at $P \leq 0.01$

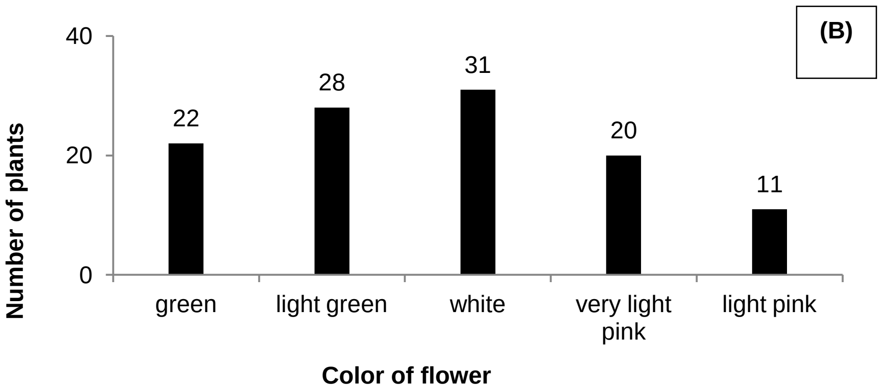
Figure 1. Variation of flower colors in an F2 population derived from selfing of a pink F1 plant: A) green, B) light green, C) white, D) very light pink, E) light pink , F) pink, G) deep pink, H) very deep pink, and I) red

The F_2 plants obtained from selfing of an F_1 plant with pink flowers segregated into nine color patterns (Figure 1), viz. 39 green : 83 light green : 88 white : 65 very light pink : 48 light pink : 28 pink : 21 deep pink : 12 very deep pink : 7 red-flowered plants. The backcross progenies of *J. curcas* and a pink-flowered F_1 segregated into 22 green : 28 light green : 31 white : 20 very light pink : 11 light pink. While backcross between *J. curcas* and a white-flowered F_1 plant segregated into 27 green : 22 light green : 19 white (Figure 2).

The number of plants segregated for flower colors in this study was similar to those reported by Sujatha and Prabakaran (2003). They observed flower colors in a BC_1F_1 population derived from interspecific cross between *J. curcas* and *J. integerrima* and postulated that the colors were controlled by three loci of genes; *G*, *R* and *r* for green and red patterns, and white flowers, respectively. They explained that gene at locus *G* was inherited from *J. curcas*, while *R* and *r* were from *J. integerrima*. There were 2 or more alleles with both additive and dominance effects. Unfortunately, our segregating populations did not show any possible Mendelian segregation ratios. Thus we assumed that flower colors in jatropha is quantitatively inherited (see also Fig. 2), and the darker colors are resulted from accumulation of more alleles controlling read pigmentation. Yet, there are also other important characters to be considered in selection for ornamental jatropha such as plant type, number of flowers per inflorescence, number of inflorescences per plant, leaf shape, propagation potential and disease resistance.

We finally selected 6 ornamental jatropha plants from the F_2 population based on their unique flower colors and high number of flowers per plant. They were registered at Kasetsart University and the Thai Department of Agriculture under the names ‘Kamphaeng Saen 1’ to ‘Kamphaeng Saen 6’. The cultivars were made available to the public since early 2013. All varieties can be easily propagated by cutting or grafting (Muakrong *et al.,* 2014).





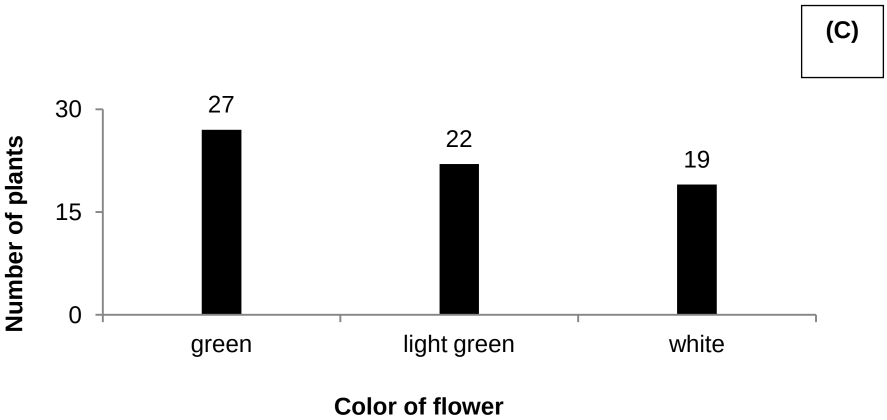


Figure 2. Histograms of F_2 and BC_1F_1 plants segregated in different flower colors. (A) F_2 derived from pink-flowered F_1 plant, (B) BC_1F_1 from *J. curcas* and pink-flowered F_1 and (C) BC_1F_1 from *J. curcas* and white-flowered F_1

CONCLUSIONS AND SUGGESTIONS

Interspecific hybridization between *J. curcas* and *J. integerrima* was successful only when *J. curcas* was used as female parent, with the suitable crossing duration spans from late morning to early afternoon. Their progenies showed high variation in flower colors, particularly in the F_2 population which could be classified into nine color groups. To maximize this genetic variation, jatropha breeding for ornamental purpose should be conducted the in F_2 population as in improvement of most other plants. The selected plants can be vegetatively propagated as clones for further tests as well as for commercial purpose.

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