Journal of Scientific & Industrial Research
Vol. 76, March 2017, pp. 179-183

# Effect of Foliar Application of Femi Grow on Female Flowers, Fruit Set and Seed Yield of *Jatropha Curcas* L

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*Received 29 February 2016; revised 11 September 2016; accepted 16 January 2017*

*Jatropha curcas* L. is a perennial shrub with proven potential as a biofuel source in addition to its immense medicinal utility. The seed and oil yield of plant is low due to high male to female flowers ratio. This study was undertaken to determine the effect of exogenous application of a herbal formulation named "Femi-grow" on flower development, sex determination, fruit set, seed and oil yield of *J. curcas*. The effect of exogenous application of Femi-grow significantly increased the total number of flowers per inflorescence and decreased the male to female flowers ratio. It also enhanced the percentage fruit set, fruit weight, fruit length and seed as well oil yield.

**Keywords:** *Jatropha Curcas*, Femi-Grow, Female Flowers, Fruit Set, Seed Yield, Oil Yield

## Introduction

*Jatropha curcas* L. has potential as a source of biofuel in addition to its medicinal uses. Jatropha seed contains about 30-40% oil which is an ideal feedstock for producing biodiesel that partially replace fossil fuel[1-7]. The flower characteristics of a plant are one of the important traits that directly affect its productivity. In Jatropha, seed yield and oil production is highly associated with the number of female flowers. Since the ratio of male to female flowers is high, therefore, increasing the number of female flowers is needful for higher oil production[8-9]. Another setback in this plant is low percentage of fruit set with frequent occurrence of small sized fruits and seeds[10-11]. This is mainly caused by the improper development of pistillate flowers. According to many researchers, a large number of factors are accountable for sex expression and determination in plants[12-13]. The present study was initiated to assess the effect of foliar application of Femi grow containing the extract of plants of *Asparagus racemosus* and *Phyllanthus emblica* on female flowers, fruit set, fruit weight, fruit length and seed as well as oil yield in *J. curcas.*

## Materials and methods

### Experimental details

Experiment was laid down on 3-years old *Jatropha curcas* plants from a single accession IC-565735 in a randomized complete block design (RCBD) during July-2014 at experimental site of CSIR-Central Salt and Marine Chemical Research Institute, Nesvad (21° 30'29.71" N;72° 02'11.54" E; 92 m), located in Bhavnagar district of Gujarat state in India. The soil was calcareous and sandy loam in texture. The initial physico-chemical properties of soil were: 7.3 pH (soil/water, 1:2.5), 0.12 dS $m^{-1}$ electrical conductivity (EC), 0.3% organic carbon, 80 kg $ha^{-1}$ available N, 2.9 kg $ha^{-1}$ available P, and 176 kg $ha^{-1}$ available K. Twenty plants with appropriate growth and reproductive stage were selected from Jatropha experimental plot to give four different treatments viz. 2 ml $L^{-1}$, 3 ml $L^{-1}$and 4 ml $L^{-1}$ along with control (water) in this experiment. Thus each treatment was replicated five times, each plant representative of one replication. Five inflorescences were tagged in each of the treatments in all the replications for taking observations on floral characteristics. All the plants were taken into account for taking observations on yield attributes, yield and oil content. The Femi-grow spray product was supplied by Swaroop Agro Chemical Industries, Goregaon (W), Mumbai, and Maharashtra, India. This liquid consists of extracts from *Asparagus racemosus* (1%) and *Phyllanthus emblica* (0.06%). The remaining parts are wetting agent (12%) and aqua solution (Q.S.).

The first foliar spray application of Femi grow (FG) was applied as foliar spray on all the inflorescences of selected plants before the initiation of anthesis. After the flower anthesis the second foliar application was

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given with the same concentrations. The 17 morphological and biochemical characters were studied in the present study. The oil from seeds was extracted in hexane solvent using a soxhlet apparatus[14]. The treatment effects were assessed by analysis of variance (ANOVA) followed by Duncan's multiple range test using MSTAT-C statistical software (MSTAT-C 1991, Michigan State University, East Lansing, MI).

## Results and Discussion

### Femi grow enhanced female flowers and fruit set percentage

The flowering characteristic is an important trait which has a significant correlation to productivity. Mendez and Traveset[15] reported that the plant can modify its gender through number of male and female flowers, stamens and carpels per flower or pollen grains and ovules per floral organ. Exogenous applications of plant growth regulators (PGRs) like benzyl adenine (BA), gibberellic acid ($GA_3$), ethereal and cytokinin helped in enhancing number of total flowersinflorescence$^{-1}$, female-to-male flower ratio and the percentage of fruit set in *J. curcas* and other oil yielding plant[9,16-17]. The flower and fruit behaviour in control and FG treatment is presented in Fig. 1 (a-d). Higher number of female flowers and fruits were observed in FG treated inflorescence as compared to control. Data on the tagged inflorescences revealed that the maximum number of female flowers (39) was observed in $T_2$ followed by that in $T_1$ (32). This concentration level showed 1.8 folds increase in female flowers as compared to control, whereas $T_1$ exhibited 1.5 folds increase for this trait. $T_2$ (3ml $L^{-1}$) showed maximum number of flowers (395.85±22.30) as compared to control (337.07±47.73). All the FG treatments significantly increased the number of female flowers and reduced the male to female flower ratio when compared to control (Table1). From the present investigation, we observed that the male to female flowers ratio decreased significantly in 2 ml $L^{-1}$ and 3 ml $L^{-1}$ concentration, whereas control and 4 ml $L^{-1}$ concentration of this herbal formulation were at par with each other. Applications of FG at concentration of 2 and 3 ml $L^{-1}$ also significantly increased the fruit set percentage in *J. curcas.* There was an increase of 18.13% in seed yield plant$^{-1}$ of *J. curcas* at 2 ml $L^{-1}$ of FG application. The higher dose of FG ($T_3$) also enhanced the female flower number compared to control although the enhancement was significantly lower than that in the other two treatments (Table 1). Evidently, even though all the FG treatments were equivalent to each other with respect to their effect on total number of flowers, they had differential response with respect to different concentrations in case of effect on female flower production. The FG treatments were at par at


Fig. 1—Flower and fruiting behaviour in control and femi grow treatments (a) Control inflorescence (b) Control Fruiting (c) FG treated inflorescence (d) FG treated fruiting

Table 1—Effect of FG treatment on flower number and M/F ratio in *J. curcas*

| Treatments | Total flowers | Total male flowers | Total female flowers | Male to female flowers ratio | % fruit set |
|---|---|---|---|---|---|
| Control | 337.07$^{b}$±47.73 | 315.67$^{b}$±45.64 | 21.40$^{d}$±2.15 | 14.69$^{a}$±0.81 | 73.44$^{b}$±2.88 |
| T1 (2 ml $L^{-1}$) | 388.12$^{a}$±22.45 | 356.12$^{a}$±22.09 | 32.00$^{b}$±0.89 | 11.13$^{b}$±0.64 | 95.00$^{a}$±1.68 |
| T2 ( 3 ml $L^{-1}$) | 395.85$^{a}$±22.30 | 356.85$^{a}$±21.61 | 39.00$^{a}$±1.26 | 9.15$^{c}$±0.47 | 99.44$^{a}$±1.04 |
| T3 ( 4 ml $L^{-1}$) | 389.22$^{a}$±17.34 | 362.82$^{a}$±17.58 | 26.40$^{c}$±1.02 | 13.77$^{a}$±0.94 | 74.42$^{b}$±4.28 |
| CV% | 7.22 | 7.63 | 4.42 | 6.50 | 3.93 |
| Probability | 0.0179 | ns | 0.0000 | 0.0000 | 0.0000 |

*Data shown for 5 inflorescences per replication; Mean ± standard deviation; Values followed by the same letters within each column are not different using DMRT at 95%.

Table 2—Effect of FG on fruit and seed characteristics in *J. Curcas*

| Treatments | Seed yield plant$^{-1}$ (g) | Seed oil content (%) | Kernel oil content (%) | Oil yield plant$^{-1}$(g) |
|---|---|---|---|---|
| Control | 110.71$^{b}$±6.66 | 27.92$^{a}$±2.47 | 50.74$^{a}$±2.98 | 30.83$^{b}$ ±2.28 |
| T1 (2 ml $L^{-1}$) | 113.64$^{b}$±4.35 | 27.16$^{a}$±3.57 | 48.11$^{a}$±3.17 | 30.77$^{b}$ ±3.49 |
| T2 (3 ml $L^{-1}$) | 130.79$^{a}$±3.16 | 27.63$^{a}$±3.30 | 50.03$^{a}$±3.33 | 36.21$^{a}$ ±4.82 |
| T3 (4 ml $L^{-1}$) | 114.37$^{b}$±3.54 | 30.34$^{a}$±2.90 | 51.42$^{a}$±2.31 | 34.69$^{ab}$ ±3.37 |
| CV% | 4.86 | 10.49 | 7.84 | 9.97 |
| Probability | 0.0005 | ns | ns | 0.0500 |

Mean ± standard deviation; Values followed by the same letters within each column are not different using DMRT at 95%.

all the levels and significantly higher over control with respect to number of male flowers however, the increase was not commensurate with the extent of increase in the number of female flowers. Eventually, there was marked reduction in male to female flower ratio which was significant over control in $T_1$ and $T_2$, recording 11.1 and 9.2, respectively in contrast to the highest (14.7) obtained in control. The highest dose of FG was at par for this trait, when compared to control. The reduction in male to female flower ratio due to FG treatments ranged from 6.26 to 37.77%. Moreover, the application of FG at concentration of 2 and 3 ml $L^{-1}$ markedly increased the fruit set percentage, while the highest dose failed to influence it significantly.

**Femi-grow enhanced the fruit and seed characters**

Data on length and width of fruits, single fruit weight, number of seeds fruit$^{-1}$, length and width of seed and single seed weight under different treatments are given in Table 2. Among these characters, only single fruit weight and fruit length were significantly increased in treatment $T_2$ and $T_3$, whereas $T_1$ was at par with control. The maximum single fruit weight (2.05 g) was obtained in treatment of $T_2$ (3ml $L^{-1}$), which was statistically equivalent to $T_3$, while the minimum (1.82 g) was observed in control which was at par with $T_1$. The character fruit length followed similar pattern of change by the application of different concentrations of FG as single fruit weight. Evidently, 3 ml $L^{-1}$ FG was more effective than 2 ml $L^{-1}$ for enhancement of these characters. Roussos *et al*.[18] reported that the exogenous application of seaweed extract plus other plant growth stimulators such as mixture of nitrophenolates, an auxin (phenothiol), gibberellic acid increase marketable yield and fruit size in Strawberry. Makwana *et al*.[19] showed that low dose of $GA_3$ decreased the male to female flowers ratio but higher dose of $GA_3$ increased the male to female flower ratio.

**Femi grow increased the seed and oil yield**

The seed and oil yield characters are presented in Table 3. The seed yield plant$^{-1}$ increased by application of FG only in treatment T2 (3 ml $L^{-1}$), whereas other treatments were statistically at par with control. The maximum seed yield plant$^{-1}$ (130.79 g) was obtained in treatment T2, which was 18.1% higher than control. The mean range of seed oil content was from 27.16% to 30.34% and all the FG treatments were statistically at par with control for this trait. The kernel oil content also behaved likewise. The oil yield plant$^{-1}$ was increased significantly in treatment in T2 and recorded the maximum value (36.21 g plant$^{-1}$), which was 17.45 % higher over control. All other concentrations were at par with control with respect to oil yield plant$^{-1}$. The observations may be due to the fact that Femi grow contains the extract of *Phyllanthus emblicaw* which contain high amounts of ascorbic acid (vitamin C),

Table 3—Effect of FG on seed yield, oil content and oil yield in *J. curcas*

| Treatments | Single fruit weight (g) | Fruit length (mm) | Fruit width (mm) | Number of seeds fruit$^{-1}$ | Single seed weight (g) | Seed length (mm) | Seed width (mm) |
|---|---|---|---|---|---|---|---|
| Control | 1.82$^{b}$±0.06 | 23.71$^{b}$±0.30 | 19.82$^{a}$±0.59 | 2.28$^{a}$±0.09 | 0.515$^{a}$±0.027 | 16.76$^{a}$±0.42 | 8.37$^{a}$±0.14 |
| T1 (2 ml L$^{-1}$) | 1.82$^{b}$±0.09 | 23.78$^{b}$±0.48 | 19.87$^{a}$±0.49 | 2.31$^{a}$±0.35 | 0.517$^{a}$±0.010 | 16.83$^{a}$±0.24 | 8.38$^{a}$±0.02 |
| T2 ( 3 ml L$^{-1}$) | 2.05$^{a}$±0.10 | 24.88$^{a}$±0.37 | 20.33$^{a}$±0.47 | 2.51$^{a}$±0.05 | 0.519$^{a}$±0.022 | 17.11$^{a}$±0.29 | 8.49$^{a}$±0.12 |
| T3 ( 4 ml L$^{-1}$) | 2.03$^{a}$±0.15 | 24.83$^{a}$±0.75 | 19.79$^{a}$±1.02 | 2.48$^{a}$±0.12 | 0.516$^{a}$±0.028 | 16.95$^{a}$±0.72 | 8.38$^{a}$±0.05 |
| CV% | 5.81 | 2.50 | 3.57 | 8.26 | 5.44 | 2.22 | 1.12 |
| Probability | 0.0075 | 0.0124 | ns | ns | ns | ns | ns |

Mean ± standard deviation; Values followed by the same letters within each column are not different using DMRT at 95%.

polyphenols, flavonoids, gallic acid, tannins and lignins[20-21]. A similar commercial product named NEOO–FF that reboost female flowers, contains Lignin sulphonate that helps in reducing female flower dropping and improving fruit size, fruit setting and abortiveness of fruits thus enhancing female flowers. Therefore it may be postulated that lignin present in the extract of Amla might be helping in the enhancement of female flowers resulting a considerable increase in yield in Femi grow treated plants. This herbal formulation has the extract of different plant parts of *Asparagus racemosus* (Shatavari) containing proteins, polysaccharide, phenolic compounds (ferulic acid, rutin, quercetin and flavonoids), tannins, saponins and phytominerals[22-25]. ShatavarinsI-VI are considered to be the source of a plant driven estrogen that may be responsible for hormonal like effect of Shatavari and explain the traditional use of this plant as a female reproductive tonic since ancient time[26]. It may be mentioned here that the plant extracts are complex mixtures that contain multiple components; therefore it would be very difficult to point out which particular active constituent is responsible for a specific action in plants. A systematic fractionation, purification and characterization of the possible active ingredients followed by confirmation of their role on plants by selective elimination of active ingredients should be further taken up as a future course of study.

## Conclusions

The application of a phytochemical namely Femi grow increased the total number of flowers, female flowers, fruit set, fruit weight, fruit length and finally seed and oil yield in *J. curcas*. It was observed that the higher dose of Femi grow should not be used for this plant as that may cause adverse effect. Since Femi grow used in this experiment is in the form of a herbal formulation consisting two plants extracts namely *Phyllanthus emblica* (Amla) and *Asparagus racemosus* (Shatavari), it is difficult to attribute a particular active constituent responsible for enhancement of female flowers, fruit set and a source of phytoestrogens. Therefore, further research is needed to define the actual mode of action responsible for the observed effect of this herbal formulation. In addition, developing an understanding of the effects of phytoestrogens from *Asparagus racemosus* as opposed to human oestrogens also holds great promise for further research. However, this study did not seek to identify any specific constituent responsible for the observed effect on Jatropha plants, but the encouraging results connotes the need of such natural extracts to be investigated further not only in Jatropha but in other crop plants as well.

## Acknowledgement

The authors gratefully acknowledge CSIR, New Delhi for financial support. We are thankful to Mr. DR Parmar, Prakash Ambaliya, Mr. Bhavesh Baraiya, Mr. Harpalsinh Chauhan and Mr. Ramji Chauhan for their assistance in maintenance of Jatropha plantation and data collection work and Mr PJ Dodia for oil extraction work of seed samples.

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