INCREASING SEED YIELD IN GLORY LILY (*Gloriosa superba*) - EXPERIMENTAL APPROACHES

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**Abstract**

*Gloriosa superba* L. (locally known as Kalihari, Langli, Agnishikha) belonging to family Liliaceae, is highly valued in both traditional and modern therapies. Its seed and tubers (active content colchicine) are used mainly for treating gout and rheumatism and the colchicine is also used for inducing polyplody in plants. The widespread use of its tubers only for medicinal purposes has led to its threatened state, and being placed on negative list of exports by Ministry of Commerce, Govt. of India. Use of its seed, which have the same medicinal use as that of tubers ensures that its plants are not destroyed in nature, being a non-destructive harvesting. However, seed yield in nature is very low and variable. So, to understand the reasons for low and variable seed yield, different pollination methods were studied including natural, controlled selfing and crossing. No genetic self or cross incompatibility was observed. Although flower colour and shape favour cross-pollination, self-pollination has given better results. Controlled selfing between flowers on the same plant (idiogamy) has given significantly higher seed yield (9.20 g per plant and 681.73 kg per hectare), as compared to natural pollinated ones (4.31 g per plant and 319.26 kg per hectare). The controlled pollination can be attempted when the perianth lobes are crimson coloured at the top, and middle portion yellow with greenish base, when the stigma is most receptive for pollen germination.

1. Introduction

Due to expanding human population, increasing agriculture, rapid urbanization, pressure on land due to industrial and other uses, unchecked extraction of plants or plant parts for various uses from their natural habitats, have led to many species, especially medicinal plants, either becoming extinct or are under various stages leading to extinction (Nayar & Sastry, 1987; Chadha & Gupta, 1995). This situation is causing concern not only for loss of species diversity but also because the availability of raw material for uses in various medicines are becoming scarce day by day.

*Gloriosa superba*, belonging to family Liliaceae is one of such species, which is extensively used for treatments in gout, rheumatism, cholera, typhus, gonorrhoea etc. The active content colchicine present in it is also capable of inducing polyplody in plants, and for cancer control (Amoroso, 1935; Satyavati et al., 1976).

Earlier, the medicinal properties were thought to be present only in its tubers (Anonymous, 1956) and these were/are ruthlessly extracted without any concerted attempt to regrow these plants. However, the seeds also possess the same medicinal properties and contain colchicine (Bhakuni & Jain, 1995), but the seed yield in nature is quite low and variable. Hence, the species has been grouped as a threatened plant. Due to its scarce availability and increasing demand for its parts, especially for export, this species was placed on the negative list of exports by Ministry of Commerce, Govt. of
India (Vide Public Notification No. 47 (PN)/92-97 dated 30.03.1994). Again the seeds contain up to 0.75 per cent colchicine as compared to only 0.30 per cent in its tubers (Gupta, 1997).

Keeping in mind its higher demand and threatened status, this species needs conservation and also strategies for increasing the yield of its official parts, to sustain its use. To save this species from further extinction, seed use has to be encouraged, which apart from ensuring annual harvest, will also be eco-friendly while the use of tuber involves destructive harvesting.

However, there should be adequate seed yield per plant, to make the seed use feasible/to discourage tuber use. With a view to understand the reasons of its low and variable seed yield in nature, the present investigation was conducted.

2. Material and methods

The tubers collected from its natural habitats in Himachal Pradesh (with latitude - 30°22'44"N to 33°12'40"N and longitude - 75°45'55"E to 79°04'20"E), India, were used for raising its population in the field. The experiment was conducted under Randomized Block Design with three replications and seven pollination treatments with spacing of 0.45x0.30 m between rows and plants. Planting of tubers was done in March. At the time of land preparation, 10-15 tonnes of farm yard manure was mixed in the soil, followed by application of 40 kg N, 50 kg P₂O₅ and 75 kg K₂O per hectare at the time of planting and 80 kg N per hectare, 8 weeks after planting.

Seven pollination treatments studied were:

1) Natural pollination.
2) Bagging.
3) Autogamy (controlled selfing within the same flower).
4) Idiogamy (controlled selfing between different flowers on the same plant).
5) Open cross (after emasculation in the bud condition).
6) Allogamy (controlled crossing between flowers on different plants).
7) Honey bee pollination (for this purpose a population of one hundred plants was enclosed by a nylon net inside which honey bees (Apis mellifera) in a nucleus hive were kept).

The extent of fruit setting, fruit size, number of seeds per fruit and plant, and seed yield per fruit and plant was recorded.

3. Results and discussion

The flowers of Gloriosa superba are large, showy and change colour from green (at the bud opening stage) to yellow-crimson and finally deep red. The perianth, consisting of six free tepals with wavy margins, is greenish at first, upon opening becoming yellow, and bend backwards to form a bowl shaped structure exposing the essential parts (stamens and carpels) of the flower on the opposite side. The six stamens radiate around the tricarpellary, syncarpous ovary with the trifid stigma far away from the anthers.

Results obtained in seven pollination methods/treatments studied have been presented in Table 1. As it is clear from ANOVA table (Table 2), all the characters are significant at one per cent level of significance. Although the flower of Gloriosa superba exhibited strong tendencies towards cross-pollination (attractively coloured, provide reward to the insect pollinator like nectar and pollen, can withstand mechanical stresses of insect visitation and the pollen adhering to the body of the pollinator) but bagging and
controlled selfing of its flower also yielded seed. The results of various pollination
methods studied reveal an interesting pattern. As is clear from Table 1, the selfed
flowers (autogamy, idiogamy and bagging) performed better as compared to cross
pollinated flowers in terms of number of fruits per plant, number of mature seeds per
fruit, and seed yield per fruit and plant.

The performance of controlled cross-pollination and natural pollination was better
than open cross and bee pollinated flowers. Again among the selfed flowers, the
performance of flowers pollinated by pollen from another flower on the same plant
(idiogamy) was best. Honey bee pollinated flowers were the least successful as
deprecated to all other methods tried. The bagged flowers produced more number of seed
per fruit (21.47) as compared to open cross pollinated flowers (11.33) but produced less
number of fruits per plant. On the basis of these findings, following assumptions can be
made:

i) *Gloriosa superba* is both self as well as cross-pollinated species.

ii) Although shape and colour of its flowers favour cross-pollination, self-pollination,
especially idiogamy, gives best results.

iii) There is no genetic self-incompatibility and the seed set is purely dependent on
pollinator behaviour and availability of pollen.

This adaptation towards both self and cross-pollination may not be without any
evolutionary significance. *Gloriosa superba* occurs throughout tropical India and
ascending up to 2100 m above mean sea level (Hooker, 1894; Anonymous, 1956 and
Chopra *et al.*, 1956). For its populations to survive changing environments and
geographical conditions and to colonize newer habitats, the species has developed
mechanisms to preserve its genetic makeup suitable for a particular niche by vegetative
and selfed seeds. The seed produced as a result of cross-pollination enables it to colonize
newer niches, by providing newer gene combinations. Both these mechanisms coupled
with its vegetative propagation have bestowed diverse advantages to this species.

Taking these considerations in to account, there should have been no significant
differences in seed yield per plant, between autogamous and idiogamous flowers. But
the seed yield depends not only on the availability of the pollen, but also on the timing
when the stigma receives the pollen. As has been found in this study, and also reported
by earlier workers (Narain, 1976 and Mamatha *et al.*, 1992) in *G. superba*, the stigma
becomes receptive by a duration of 24 to 36 hours after anther dehiscence. Accordingly,
within the same flower when pollination is attempted, the stigma may not be receptive or
if the stigma is receptive, then the pollen might have lost its viability. Since flowering in
this species is staggered i.e. different flowers open in a sequential order on the same
plant, pollination of earlier opened flowers by later opened flowers ensures increased
fertilization rates. There was a strong correlation between stigma receptivity and flower
colour. The perianth at the time of stigma receptivity is crimson coloured at the upper
tonwards its tips, the middle portion being yellow and the basal portion greenish.
Stigma receptivity has been noted to decrease with the gradual crimson colour spreading
towards the middle portion, with the disappearance of greenish colour at its base.

Again in the bagged flowers, both stigma and pollen mature at different periods, but
since the pollen remains viable for two days (although with a reduced percentage) some
fertilization is possible. However, as is clear from Table-1, although bagged flowers
produced 21.47 seeds per fruit, the number of fruits per plant was quite low (2.83) being
only higher than bee pollinated flowers (2.08). The pollination in bagged flower seems
to be affected by either shaking of the bagged flower or the stigma brushing against any
of its anthers in the bag. The situation is different with regard to open cross and bee
pollinated flowers. While in case of open cross pollinated flowers, the low seed set
might be due to limited availability of pollen at the stigma receptive stage, because of
reduced pollinator activity, in the case of bee pollinated flowers it seems that the honey bees did not find its flowers favourable for their attention.

It seems that the seed setting in this species depends on pollen availability/viability, stigma receptivity and pollinator behaviour. In this backdrop, the staggered flowering ensures that the different flowers do not compete with each other for pollen and pollinator, and every flower has equal chances of receiving adequate amount of pollen.

In the present studies the highest estimated seed yield of 681.73 kg/ha was recorded in controlled selfing (idiogamy), which is significantly higher than 319.26 kg/ha in naturally pollinated plants. The higher yield recorded in the controlled selfing (idiogamy) is due to assured pollination which is not the case with naturally pollinated flowers.

4. Acknowledgements

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5. References

Table 1 - Mean performance of yield parameters vis-a-vis pollination methods in *Gloriosa superba* L.

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Characters Treatment</th>
<th>Fruit size (cm²)</th>
<th>Number of fruits per plant</th>
<th>Number of mature seeds per fruit</th>
<th>Seed yield per fruit (g)</th>
<th>Seed yield per plant (g)</th>
<th>Estimated seed yield (kg/ha) (0.3 x 0.45 m spacing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>Natural pollination</td>
<td>6.02</td>
<td>4.43</td>
<td>18.35</td>
<td>1.03</td>
<td>4.31</td>
<td>319.26</td>
</tr>
<tr>
<td>02.</td>
<td>Bagging</td>
<td>7.54</td>
<td>2.83</td>
<td>21.47</td>
<td>1.55</td>
<td>4.96</td>
<td>367.65</td>
</tr>
<tr>
<td>03.</td>
<td>Controlled selfing (within the same flower)</td>
<td>10.17</td>
<td>4.54</td>
<td>26.00</td>
<td>1.46</td>
<td>6.82</td>
<td>505.43</td>
</tr>
<tr>
<td>04.</td>
<td>Controlled selfing (between different flowers on the same plant)</td>
<td>11.50</td>
<td>5.13</td>
<td>31.16</td>
<td>1.75</td>
<td>9.20</td>
<td>681.73</td>
</tr>
<tr>
<td>05.</td>
<td>Open cross (after emasculation of unopened buds)</td>
<td>7.00</td>
<td>5.31</td>
<td>11.33</td>
<td>0.69</td>
<td>3.45</td>
<td>255.31</td>
</tr>
<tr>
<td>06.</td>
<td>Controlled cross pollination (between flowers from different plants)</td>
<td>10.08</td>
<td>3.28</td>
<td>25.55</td>
<td>1.24</td>
<td>4.42</td>
<td>327.41</td>
</tr>
<tr>
<td>07.</td>
<td>Honey bee pollination</td>
<td>7.79</td>
<td>2.08</td>
<td>20.87</td>
<td>1.32</td>
<td>2.90</td>
<td>214.81</td>
</tr>
</tbody>
</table>

| CD<sub>(0.05%)</sub> | 1.022   | 0.431   | 6.831   | 0.048   | 0.743   | 54.98   |
| C.V.         | 21.490  | 6.140   | 17.373  | 2.088   | 8.097   | 8.097   |

Table 2 - Analysis of variance table for yield parameters in *Gloriosa superba* L.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degree of freedom</th>
<th>Fruit size (cm²)</th>
<th>Number of fruits per plant</th>
<th>Number of mature seeds per fruit</th>
<th>Seed yield per fruit (g)</th>
<th>Seed yield per plant (g)</th>
<th>Estimated seed yield (kg/ha) (0.30 x 0.45 m spacing)</th>
<th>Estimated seed yield (kg/ha) (0.45 x 0.60 m spacing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>6</td>
<td>12.0300</td>
<td>4.4936&lt;sup&gt;*&lt;/sup&gt;</td>
<td>120.6006&lt;sup&gt;*&lt;/sup&gt;</td>
<td>0.3689&lt;sup&gt;*&lt;/sup&gt;</td>
<td>14.2333&lt;sup&gt;*&lt;/sup&gt;</td>
<td>78098.211&lt;sup&gt;*&lt;/sup&gt;</td>
<td>19524.521&lt;sup&gt;*&lt;/sup&gt;</td>
</tr>
<tr>
<td>Error</td>
<td>12</td>
<td>0.3299</td>
<td>0.0586</td>
<td>14.7492</td>
<td>0.0007</td>
<td>0.1741</td>
<td>955.0566</td>
<td>238.8080</td>
</tr>
</tbody>
</table>

<sup>*</sup> Significant at 1 per cent level of significance