International Journal of Horticultural Science 2008, 14 (3): 51–55
Agroinform Publishing House, Budapest, Printed in Hungary
ISSN 1585-0404

Reproductive biology of *Duranta repens* L. (Verbenaceae) in relation to its environment

Sharma, D., Rana A., Chauhan, S. & Chauhan, S. V. S.

Department of Botany, School of Life Sciences, Dr. B.R. Ambedkar University, Agra-282002, India

Summary: Impact of environmental changes (temperature and RH) on reproductive biology in *Duranta repens* (Verbenaceae) growing at ten different sites of Agra was studied. It flowers throughout the year, with optimum flowering in September. The flowers are arranged in loose clusters on terminal or axillary racemes. They are either blue or lavender in colour, hermaphrodite, actinomorphic and complete. The plants exhibit floral polymorphism (increase and decrease in number of petals and stamens) and considerable variation in extent of pollen fertility, floral density, insect pollinators and fruit-set percentage. The changes in temperature and relative humidity during the entire flowering period, was found associated with the variation in floral structure, pollen fertility and fruit-set percentage. Based on the percentage of fruit-set during different seasons of a year, there were three distinct periods, namely maximum, moderate and minimum periods. The present paper deals with the comparative view of reproductive biology of this ornamental plant in these periods. During the months of August–November when temperature ranges between 13.7–36.6 °C and RH between 79–89% the plant exhibits maximum fruit-set percentage (68–85%). This was associated with maximum flowering, increase in floral size, and increase in visitation rates of pollinators and higher degree of pollen fertility. On the other hand, with temperature reaching to the maximum (15.1–41.5 °C) and reduction in RH (14.1–41.3%), the percentage of fruit-set was reduced to the minimum (21–30%). During this period, number of flowers/plant, floral size, pollen fertility, visitation rates of pollinators were reduced to the minimum. During this period floral polymorphism was also recorded.

Key words: *Duranta repens*, fruit-set, relative humidity, temperature, floral polymorphism, pollinators, pollen fertility

Introduction

The environment in which an organism lives affects its reproductive success (Sedgley & *Griffin*, 1989). The process by which the interaction of individual organism with its environment is translated into changes in the underlying genetic structure of the population is called natural selection (*Raghvan*, 2000). Individuals that are relatively well adapted to their current environmental conditions are likely to pass on relatively more of their genes to the next generation than those in the population that are not so well adapted (*Shivanna*, 2003). The physiology of reproduction in most of the flowering plants is closely under the control of environmental factors (*Taiz & Zeiger*, 2003). Environment exerts considerable influence on flowering, pollen fertility, *in vitro* pollen germination and fruiting in plants (*Shivanna*, 2003). The factors like soil nutrients, atmospheric conditions e.g., light, relative humidity and temperature affects formation of fruits to a great extent (*Shivanna & Johri*, 1985). Flowering and fruiting of tree crops is a highly complex process involving many developmental stages. Perennial trees must interact with the environmental conditions at all times of the year, and flowering and fruiting is closely related to seasonal climatic changes (*Sedgley & Griffin*, 1989). Extensive studies have been made on the effect of various environmental factors on floral development, pollen fertility, female sterility, flower and fruit abscission including diseases on the development of fruit in the plants (*Shivanna*, 2003).

Duranta repens L. (Verbenaceae) is a native of Mexico, Central America, South America to Argentina, Southern Florida (Possibly naturalized), Bermuda, the Bahamas and the West Indies (*Howard*, 1989; *Liogier*, 1995). It is an upright to drooping shrub or rarely a small tree (*Liogier*, 1995). It is cultivated in the gardens for its ornamental as well as medicinal value. It flowers throughout the year, but exhibits some interesting changes in flowering phenology and fruiting during different parts of a year. An attempt has been made to understand the impact of environment on the reproductive biology in *Duranta repens* L. growing at Agra.

Materials and methods

Present investigation was carried on *Duranta repens* L. plants growing at ten different places of Agra. Flowering phenology was observed at plant and inflorescence level with reference to day- to-day flowering pattern in fifty marked plants (5 at each site). For the latter, 200 inflorescence, selected at random from different individuals were tagged before the initiation of flowering. These inflorescence were followed daily and the number of open flowers was recorded. The open inflorescence was then removed to avoid recounting the next day. The tagged inflorescence was followed until flowering ceased. One hundred flowers/plant were sampled to record the floral density, floral morphology, pollen fertility, insect-pollinator

interaction and fruit-set percentage. Anthesis, anther dehiscence and stigma receptivity were studied using various methods as described by *Shivanna & Rangaswamy* (1992). The number of pollen grains/anther/ flower was determined from 100 flowers/plant following the method of *Kearns & Inouye* (1993). Pollen size was measured with an ocular micrometer under light microscope following the procedure of Shivanna and Rangaswamy (1992). The number of pollen grains and the number of ovules per flower was recorded to get the pollen-ovule ratio. Pollen fertility of these plants was tested at regular intervals by using TTC (1% solution (w/v) of 2,3,5- triphenyl Tetrazolium chloride in 0.15 M tris buffer at 7pH). Breeding behaviour (autogamy, geitonogamy and xenogamy) was tested using controlled pollination studies in emasculated and bagged flowers. Self- and cross-pollination experiment was performed by dusting pollen obtained from freshly dehisced anthers on the receptive stigma. The pollinated flowers were re-bagged and observed periodically for fruit formation (*Shivanna & Rangaswamy*, 1992). Foraging behaviour of insects was recorded. Pollination efficiency of different insects was checked by observing pollen load on their body parts under a microscope according to the procedure given by *Kearns & Inouye* (1993). Data on daily maximum and minimum temperature and relative humidity during the entire flowering period was collected from Meteorological Department, Indian Air Force Station, and Agra.

Results and discussion

Duranta repens L. is an evergreen shrub or small tree showing simultaneous vegetative and reproductive growth. The leaf fall and leaf renewal occurs throughout the year. Maximum leaf fall was observed during October–November and leaf renewal was maximum during December–March. The maximum fruiting was recorded during September to December and minimum during the month of January to March. The fruits started maturating in October and dispersal of seeds took place in November. The flowers are blue during July– November but lavender in December-June. They are five lobed and are borne in loose clusters on terminal or axillary racemes. Flowers are small, complete, slightly zygomorphic, hermaphrodite, hypogynous, tubular in shape (*Table 1*). There are 5 sepals each of which is 0.77 ± 0.299 cm long, gamosepalous, valvate, green, with the same number of petals (0.99 ± 0.62 cm) which are gamopetalous, quincunical aestivation and hypocrateriform in shape. Stamens are 4, epipetalous and didynamous. Gynoecium is tetracarpellary with a long style and capitate stigma. Ovary is superior, syncarpous, tetralocular, placentation is parietal but due to inward growth of the placentae, it appears to be axile. Pollen grains are spherical, tricolpate with reticulate exine. There are 10–25 floral buds/inflorescence. A visibly differentiated floral bud took approximately 15 days to develop into a flower. One or two flowers/ inflorescence open every day. Fruiting started after 15–20 days of flowering and continues throughout the year. Fruit-set/inflorescence ranged between 5–12.

Table 1 Floral characters of *Duranta repens* L.

Parameters	Observations
Inflorescence	Terminal or Axillary racemes
No. of floral buds/ Inflorescence	10–25
Calyx	5, gamosepalous, green in colour
Corolla	5, gamopetalous, petal in defined by a light lavender boarder, marked by a white eye and shape is hypocrateriform
No. of Stamens	4, creamish, epipetalous
Pollen Size	23.5 µm
Stigma	Capitate
Style	Short & Simple
Ovary	Superior, Tetracarpellary
No. of ovules/flower	4
No. of seeds/fruit	4

The reproductive success of this plant species is directly under the influence of environmental factors, temperature and RH in particular. Based on the percentage of fruit-set during different parts of a year, three distinct periods, namely maximum, moderate and minimum fruiting period have been recorded. The extent of pollen fertility, floral density, floral size, floral polymorphism, number of flowers/plant, pollen/flower, insect pollinators, fruit-set percentage and temperature and RH has been described in different periods in the following paragraphs and summarized in *Table 2*.

Table 2 Floral biology of Duranta repens during different fruiting periods

S. No.	Parameters	Periods		
		Maximum	Moderate	Minimum
1	Months	August-November	December-March	April-July
2	Temperature (°C)	13.7–36.6	6.2–31.5	15.1–41.5
3	Relative Humidity (%)	79–89	29.2–88	14.1–41.3
4	Floral Density (%)	71–85	54–62	21–50
5	Flower Opening (h)	1530–1600	1630–1700	1330–1400
6	Anther dehiscence (h)	1600–1630	1700–1730	1400–1430
7	Pollen/flower	3612	2679	1720
8	Pollen fertility (%)	80	48–76	11.9
9	Stigma receptivity (h)	1630–1700	1730–1800	1430–1500
10	Insect visitation rates	High	Medium	Low
11	Fruit-Set (%)	68–85	50–82	21–30

Maximum fruiting period (August–November)

During this period, floral density was highest (71–85%) and maximum being in September (85%) (*Figure 1*).

The flowers open between 1530–1600 h, followed by anther dehiscence through longitudinal slit around 1600–1630 h. During the month of November, the number of pollen/flower was 3612 showing maximum pollen fertility (80%) (*Figure 3*). The stigma became receptive after anther dehiscence between 1630–1700 h. During this period, the insect visitation rate was also high as compared to other months. The effective pollinators are butterflies and honey bees (*Figures 7 & 8*). Other pollinators like carpenter bee, wasps were also observed (*Figures 9 & 10*). The plants exhibited maximum fruit-set (68–85%) (*Figure 5*). The temperature ranged between 13.7–36.6 °C and RH 79–89%.

Moderate fruiting period (December-March)

During this period, floral density was moderate which ranged between 54–62%. The flowers open between 1630–1700 h, followed by anther dehiscence between 1700–1730 h. However, during the month of December, the floral density was lowest, but the flowers were largest in size (1.92 ± 0.57 cm), as compared to those in normal period (1.79 ± 0.11 cm). The number of pollen/flower was 2679 with 48–76% pollen fertility (*Table 2*). The stigma became receptive after anther dehiscence between 1730–1800 h. The visitation rates of effective pollinators also declined. The fruit-set was slightly lower than that of maximum period (50–82%). The temperature ranged between 6.2–31.5 °C with 29.2–88% RH. According to *Smith* (1970) and *Thorp* (1979), the insect activity is reduced below 10 °C. On the

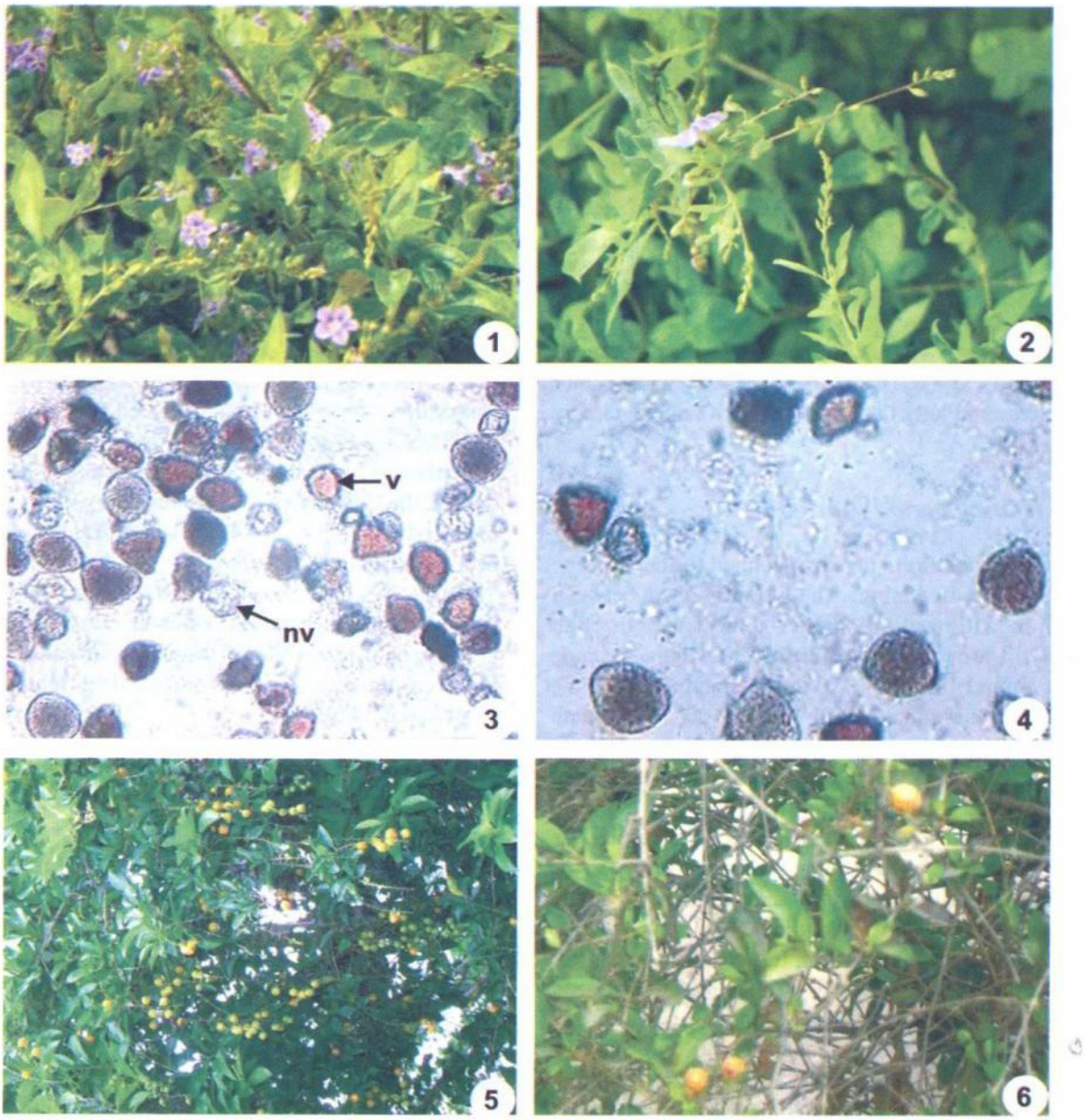

Figure 1–6 1) Plant of *Duranta repens* L. showing maximum floral density. 2) Plant showing minimum floral density. 3) Maximum pollen viability showing various viable (v) and non-viable (nv) pollen grains as checked by 1% TTC. 4) Minimum pollen viability as checked by 1% TTC. 5) Plant with maximum fruit-set. 6) Plant with minimum fruit-set.

Figure 7–10 7–8) Butterfly and Honeybee as an efficient pollinators. 9) Flower of *D. repens* L. with carpenter bee. 10) Wasp as a pollinator

other hand, foraging flights of honeybee may occur at 12–14 °C in early spring (February) with somewhat higher temperature required later in the year (March) and on cloudy days (*Free*, 1970).

Minimum fruiting period (April-July)

During this period floral density declined further as there was only 21–50% flowering. The flowers open between 1330–1400 h, followed by anther dehiscence through longitudinal slit around 1400–1430 h. The stigma became receptive at around 1430–1500 h. In the month of May, the plant exhibited minimum pollen fertility (11.9%), much reduced floral density, and number of pollen/flower is 1720 (*Figures 2 & 4*). There was a reduction in the number of petals and in nearly 40% flowers and there were only 4 petals/flower. In June, the number of stamens increased and in 72.7% flowers there were 5 stamens/flower. However, the fifth stamen was represented by a staminode. Nearly, 60.1% flowers showed maximum reduction in their corolla size (0.032 ± 0.041cm). It is interesting to note that during this period, butterflies and honeybees were remarkably absent. At the end of April, the plants under observation exhibited a gradual decrease in fruit-set percentage (21–30%) (*Figure 6*). The activity of pollinators is related to the ambient temperature. Their activities were limited by low temperatures in temperate climates and high temperature in tropical climates (*Sedgley & Griffin*, 1989). It seems probably that on account of the absence of the effective pollinators, the plants exhibited lowest fruit-set. The temperature during this period ranged between 15.1–41.5 °C and RH 14.1–41.3%. Similar observations have also been recorded by *Singh & Chauhan* (1993), *Singh & Chauhan* (1994), and *Singh* et al. (2008) in several other ornamental plants. According to these workers, during the months of May and June, when temperature reaches to its peak (40–45 °C) at Agra, the pollen grains become more or less sterile.

Thus, the changes in various reproductive parameters, fruit-set percentage in particular in *Duranta repens* plants growing at different sites of Agra city are caused by changes in environmental factors particularly temperature and relative humidity.

References

Free, J.B. (1970): "Insect pollination of crops". Academic press, London.

Howard, R.A. (1989): Flora of the lesser Antilles Vol.6. Arnold Arboretum, Harvard University, Jamaica Plain, MA. 658 P.

Kearns, C.A. & Inouye, D.W. (1993): Techniques for pollination Biologist, University Press of Colorado, Niwot. Colorado, USA.

Liogier, H.A. (1995): Descriptive flora of Puerto Rico and Adjacent Islands. Vol.4. Editorial de la Universidal de Puerto Rico, San Juan, PR. 617.

Raghvan, V. (2000): Developmental biology of flowering plants, Springer-Verlag, New York.

Sedgley M. & Griffin, A.R. (1989): Sexual reproduction of tree crops. Academic Press, London.

Shivanna, K.R. (2003): Pollen Biology and Biotechnology. Oxford and ISH publishing Co. Pvt. Ltd., NewDelhi.

Shivanna, K.R. & Johri, B.M. (1985): The angiosperm Pollen Structure and function. Wiley Eastern Ltd. Publisher, New Delhi.

Shivanna, K.R. & Rangaswamy, N.S. (1992): N.S., *Pollen Biology: A* laboratory *Manual*, Narosa Publishing House, New Delhi.

Singh, J. & Chauhan, S.V.S. (1993): Floral biology and Pollination in *Tecoma stans* in relation to fruit formation. In: International Symposium on Pollination in tropics Veeresh, G.K., Shankar, R.U. Ganeshiah, K.N. (Eds). pp. 54–59.

Singh, J. & Chauhan, S.V.S. (1994): Floral polymorphism and establishment of self-incompatibility in *Tecoma stans* L. J. Tree Sciences. 13: 57–60.

Singh, S., Rana, A. & Chauhan, S.V.S. (2008) Impact of Environmental changes on the reproductive biology in *Pyrostegia venusta* Presl. J. Environ. Biol. (In Press)

Smith, B.D. (1970): Natural pollen transfer. In: "Towards Regulated cropping" (R.R. Williams and D.Wilson, eds.), Grower Books London, pp. 29–40.

Taiz, L. & Zeiger, E. (2003): Plant Physiology. 3rd Edition, Panima Publishing Corporation, New Delhi.

Thorp, R.W. (1979): Honeybee foraging behaviour in California almond orchards. In Proceedings of the 4th international symposium on Pollination 385–392, Maryland Experimental Agricultural station. Miscsellaneous Publication 1, Maryland.