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Research Article

# Effect of light curtailment on growth, biochemical response and essential oil content of rose scented geranium

**Vijay Kumar, Y[1]., Swamy, K.N[2]., Vardhini B.V[3]., and Rao, S.S.R*.[4]**

[1] Central Institute of Medicinal and Aromatic Plants (CIMAP), Resource Centre, Hyderabad, India.
[2,4] Plant Physiology Laboratories, Department of Botany, Osmania University, Hyderabad, India.
3. Department of Botany, Telangana University, Nizamabad
*Corresponding author: Prof. S. Seeta Ram Rao; Mobile: 919849652460

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***Abstract***

*The impact of various shades (sun light curtailment) on growth and yield parameters on geranium plant in the field were studied. Growth parameters like plant height, leaf area, biomass, biochemical parameters, herbage yield, oil percentage and oil quality were analyzed. Overall growth, biochemical parameters, herb yield and oil quantity were found increased at 75% level of solar radiation. The remaining solar radiation levels were less than 75% and some of these were more than control.*

***Keywords:*** *Geranium, growth, essential oil, solar radiation.*

## Introduction

Geranium [*Pelargonium graveolens* (L.) Herit] is one of the important aromatic plants, yielding the essential oil, geranium oil which belongs to geraniaceae family, highly valuable oil for its very profound and strong rose-like odour. Geranium is a native of the Cape Province in South Africa, Mozambique and Zimbabwe [1]. *Pelargonium* sps. belongs to the family Geraniaceae. Leaves are densely pubescent and highly aromatic in nature. The oil is slightly yellowish coloured liquid, with characteristic pleasant odour, insoluble in water and soluble in alcohol. It contains two types of constituents i.e., alcohols and esters. The chief constituents are citronellol and geraniol.

The performance of plants is influenced by many environmental factors. Plant growth and economic yield of plants can be suitably modified by fluctuating external influences. Light is one of the most important limiting factors for growth and biomass of the plant [2]. The most widely studied aspect of light plant relationship is photosynthesis, in which the energy of light is absorbed by the growing plant and used in combining carbon, hydrogen and oxygen into simple sugars. *Leucaena lucocephala* and *Gliricidia* grown in nursery in open and shaded conditions, shaded plants had a maximum plant height than sunlit plants [3]. Seedlings of *Rhizophora apiculata* and *R. muronata* grown in shade showed optimum growth, efficient nitrate utilization and photosynthetic characteristics [4]. The impact of curtailing solar radiation on the performance of geranium was studied in the present article.

## Materials and Methods

The field experiments were conducted in the experimental plots attached to the division of Agronomy and Soil Science, Central Institute of Medicinal and Aromatic Plants (CIMAP), Resource Centre, Boduppal, Hyderabad. The location provides an opportunity for the cultivation of various medicinal and aromatic crops ideal for the SAT area (semi arid tropics) and an average rainfall of 890 mm per year with moderate minimum (13 to 22 degree centigrade) and maximum temperatures (22 to 40 degree centigrade). Biochemical studies were carried out at Plant Physiology Laboratory, Department of Botany, Osmania University, Hyderabad.

### Curtailment of sunlight

The light intensity treatments were imposed by covering the crop with stretching shading net (Agro shade net) of varying mesh for achieving the desired level of light intensities which was determined with help of a Li Cor integrating quantum / radiometer / photometer. The plants which were exposed to normal sun light were used as control (100% solar radiation). The shading net covering was provided at a height of 275 cm above ground level (75%, 60% and 50%). Besides the top region, all the four sides were also covered with white colour Agro net.

**Raising nursery and planting**

Fresh terminal cuttings about 20 cm long and consisting of about 8 nodes, were taken from healthy and well grown geranium plants. All the leaves were removed except the 3 apical leaves. A slant cut was made with a sharp knife below the 6$^{th}$ node. The cuttings were dipped in 0.1% carbandazim solution and were transplanted in to nursery beds filled with sand, soil and organic manure (1:1:1) and maintained under adequate moisture level for 40 days for rooting under shade.

After 40 days, rooted cuttings were planted inter-row spacing of 60 cm and intra-row spacing of 45 cm. The field was irrigated immediately after transplanting and thereafter at 3 days intervals. The crop received successive weeding and hoeing.

**Growth parameters**

The growth of the plants was recorded in terms of plant height, leaf area (Model CI-203 CID Inc. Vancouver Washington – USA), number of leaves / plant, leaf fresh weight and fresh and dry weights of root and shoot.

**Chlorophylls**

The chlorophyll pigments were extracted and estimated according to the procedure of Arnon [5] by extracting of plant material in 80% (v/v) acetone.

**Carbohydrate fractions**

The alcohol homogenate was heated and centrifuged. The supernatant was used for the estimation of total sugars [6] and reducing sugars [7].

**Soluble proteins:**

Soluble proteins in the ethanol homogenate were precipitated by adding 20% (w/v) trichloroacetic acid. The precipitate was dissolved in 1% (w/v) sodium hydroxide. Lowry *et al*. [8] method was employed for estimation of proteins.

**Nucleic acids**

DNA and RNA fractions in the ethanol homogenate were separated by the method of Ogur and Rosen [9]. While DNA estimation was done with diphenylamine reagent [10], RNA was quantified with orcinol reagent [11].

**Oil content**

250 grams fresh geranium leaf samples were taken at each treatment for extraction and estimation of aromatic oil content. The essential oil was extracted by hydro-distillation using Clevenger's [12] apparatus for 3 hours. The volume of the essential oil collected in essential oil measuring tube was recorded. Anhydrous sodium sulphate (~3%) was added to remove moisture content. The oil collected in sample bottles and labeled and used for essential oil composition by gas chromatography.

**Quality of essential oil**

**Gas chromatography analysis**

The oils were analyzed using a Perkins Elmer gas chromatograph (Model 8500, Italy) equipped with flame ionization detector (FID), GP-100 printer-plotter and an electronic integrator using BP-1 (SGE, USE) (25 m x 0.5 mm id x 0.25 µm film thickness) capillary column coated with polydimethyl siloxane, nitrogen was used as carrier gas at 10 psi inlet pressure with a flow rate of 0.4 ml/min (Linear velocity 14 cm/sec). Temperature was programmed from 60° - 220°C at a ramp rate of 5°C/min. with a final hold time of 10 minutes. Injector and detector were maintained at 250°C and 300°C respectively. Samples (0.1 µL) were injected neat with a split ratio 1 : 80.

**Identification of essential oil constituents**

The compounds of the essential oils were identified by comparing the retention times of the chromatogram peaks with those of authentic compounds run under identical conditions, by comparison of relative indices [13]. Retention indices were computed from gas chromatograms by logarithmic interpolation between n-alkanes. The homologous series of n-alkanes C8-C22 Poly Science Inc., Niles, U.S.A. were used as standard with literature data [14], peak enrichment on co-injection with authentic compounds. Quantitative data obtained by electronic integration peak areas (FID) without the use of response correction factors.

**Statistical analysis**

The data represent the mean values of 3 replicates. The data were analyzed by one-way ANOVA, followed by Post Hoc Test (Multiple Comparisons). The differences were considered significant when P ≤ 0.05. The mean values were compared and lower case letters were used in the tables to show the significant differences between the treatments.

**Results and Discussion**

The effect of various levels of solar radiation on plant growth of rose scented geranium was observed in this study (Table-1). Plant height, plant spread and number of branches were amplified with increasing levels of curtailment of solar radiation. 50% and 65% Radiation

**Table-1** Effect of solar radiation levels on growth of geranium plant

| Solar radiation (%) | Plant Height (cm) | Plant spread (cm) | Number of branches/plant |
|---|---|---|---|
| 100 | 48.0±3.1b | 49.0±2.4 b | 10.7±0.4 d |
| 75 | 57.7±2.9 ab | 65.7±1.3 a | 19.0±0.7 a |
| 65 | 61.3±2.4 a | 69.3±1.7 a | 16.0±0.6 b |
| 50 | 61.3±3.2 a | 66.7±2.8 a | 12.7±0.9 c |

**Table-2** Effect of solar radiation levels on foliage growth of geranium plant

| Solar radiation (%) | Number of leaves/plant | Average leaf area ($cm^2$) |
|---|---|---|
| 100 | 147.3±15.4 d | 41.7±1.7 c |
| 75 | 188.0±14.2 a | 55.0±1.4 a |
| 65 | 169.3±16.7 b | 48.7±2.5 b |
| 50 | 154.3±18.2 c | 46.7±1.1 b |

**Table-3** Effect of solar radiation levels on biomass of geranium plant

| Solar radiation (%) | Stem (g) | | Root (g) | |
|---|---|---|---|---|
| | Fresh | dry | Fresh | dry |
| 100 | 364.3±22.3 d | 74.4±19.5 d | 26.8±1.1 a | 15.9±1.7 a |
| 75 | 528.3±24.8 a | 121.7±14.8 a | 23.3±0.9 ab | 12.5±1.2 b |
| 65 | 462.0±27.6 b | 104.5±20.7 b | 19.2±1.2b | 10.1±1.5 c |
| 50 | 410.7±21.4 c | 86.5±19.4 c | 17.9±0.6 bc | 9.3±0.9 cd |

**Table-4** Effect of solar radiation levels on chlorophyll content of rose scented geranium

| Solar radiation (%) | Chlorophyll-a (µg g-1 fr.wt) | Chlorophyll-b (µ g g-1 fr.wt) | Total chlorophylls |
|---|---|---|---|
| 100 | 10.4±0.7 d | 3.9±0.4 d | 14.3±1.1 bc |
| 75 | 14.6±0.9 a | 6.6±0.6 a | 21.2±1.5 a |
| 65 | 13.4±0.8 b | 5.5±0.2 b | 18.9±1.0 ab |
| 50 | 12.6±0.6 c | 5.0±0.1 c | 17.6±0.7 b |

**Table-5** Effect of solar radiation levels on nucleic acid content of rose scented geranium

| Solar radiation (%) | Reducing sugars (mg g-1 fr.wt) | Total sugars (mg g-1 fr.wt) | Soluble proteins (mg g-1 fr.wt) |
|---|---|---|---|
| 100 | 1.9±0.1 d | 4.8±0.5 d | 4.72±0.7 b |
| 75 | 4.0±0.3 a | 8.8±0.7 a | 5.74±0.5 a |
| 65 | 3.2±0.4 b | 7.0±0.9 b | 5.31±0.8 a |
| 50 | 2.4±0.2 c | 5.2±0.6 c | 4.92±0.4 ab |

**Table-6** Effect of solar radiation levels on nucleic acid content of rose scented geranium

| Solar radiation (%) | DNA (µ g-1 fr.wt) | RNA (µg g-1 fr.wt) |
|---|---|---|
| 100 | 366.0±12.7 c | 270.0±9.4 c |
| 75 | 591.7±11.4 a | 449.7±6.8 a |
| 65 | 539.0±16.9 ab | 318.7±7.5 b |
| 50 | 435.7±10.8 b | 322.7±8.6 b |

**Table-7** Effect of solar radiation levels on yield and oil content of rose scented geranium

| Solar radiation (%) | Herbage yield (t/ha) | Essential oil yield (kg/ha) |
|---|---|---|
| 100 | 5.6±0.6 c | 13.1±0.9 d |
| 75 | 8.9±0.9 a | 20.0±1.1 a |
| 65 | 7.9±0.7 b | 17.2±0.6 b |
| 50 | 7.4±0.5 b | 15.9±0.7 c |

**Table-8** Effect of solar radiation levels on nucleic acid content of rose scented geranium

| Solar radiation (%) | Citronellol (%) | Geraniol (%) |
|---|---|---|
| 100 | 23.3±1.2 | 28.9±1.4 |
| 75 | 24.7±0.9 | 28.7±1.1 |
| 65 | 23.1±0.6 | 29.2±1.3 |
| 50 | 22.1±0.8 | 29.9±1.7 |

was most effective followed by 75% level of solar radiation in plant height. Plant spread was found highest at 65%, but increased number of branches was found at 75% of solar radiation. Similarly, Scuderi *et al*. [14] reported that shading increased plant height in *Ficus benjamina*. Increased plant height and mean internodal length under shading conditions was also reported by Gong *et al*. [16] for tea and Vyas and Nein [17] for *Cassia aungustifolia*. Shading also increased canopy spread. The number of branches per plant and leaf number per plant were more in plants growing under 35% shading. Shivashankara *et al*. [18] reported that 10-60% light curtailment produced higher internodal length, increase in number of branches, leaf number in betel vine (*Piper betle*).

Reduction in solar radiation resulted in increase in number of leaves and average leaf area. Both the parameters were found highest at 75%, followed by 65% and 50% solar radiation levels (Table-2). Curtailment of solar radiation beyond 25% level was not advantageous in case of geranium as number of leaves and leaf area became limiting. The light intensities in treatments with curtailment of light beyond 25% might be limiting due to reduced foliage development and growth. Similarly, Naidu and Swamy [19] observed increase in number and area of leaves in *Pongamia pinnata* plant grown in shade. In *Aster scaber* and *Lingularia fischeri* plant height, leaf number, length and width were increased in 30-50% shading as against the open condition [20]. *Ailanthus tryphyta* performed better under shade, which was reflected by increased leaf area [21].

The enhanced stem and root weights were noticed under reduced solar radiation (Table-3). Plants under 75% solar radiation was recorded highest stem weight followed by 65%, 50% and 100% levels. Root fresh and dry weights were slightly decreased under light curtailment. Curtailment of illumination also favored increase in fresh weight of geranium plants. Bhatt *et al*. [22] studied the growth of 17 tropical range grasses and 3 legumes under varying light intensities (25% - 100%), and obtained higher forage yield (fresh biomass) under 75% light intensity. Patchouli (*Pogostemon cablin*), an aromatic plant grown in 50% and 70% shading had higher fresh weight than plants grown under open conditions [23]. In *Lawsonia inermis* decreasing light intensity upto 40% PAR caused increase in shoot growth, leaf yield and dry matter accumulation compared to open condition [24]. Paez *et al*. [25] observed increase in plant height, leaf area and biomass in tomato plants grown under shade as compared to the plants under full sun light.

Various levels of solar radiation on chlorophyll a, chlorophyll b and total chlorophyll were recorded in Table-4. Highest chlorophyll was found at 75% followed by 65%, 50% and 100% levels of solar radiation. Higher light intensities exhibit damaging effect on the chlorophylls in shade grown plants. Our results are also coincidence with those obtained by Mitchell [26] about chlorophyll concentration of shaded plants with larger and more efficient light harvesting systems than sun-grown plants. There is a sequential reduction in chlorophyll content as the intensity of light increases [19, 25]. In *Rumhora adiantiformis*, around 50 and 70% shading increased the contents of chlorophyll a, b and total chlorophyll [27]. Cavagnaro and Trione [28] obtained increased chlorophyll and biomass under shade conditions in *Trichloris crinite*.

Carbohydrate fractions and soluble protein content were found increased under reduced solar radiation (Table-5). Around 75% of solar radiation enhanced the reducing sugars, total sugars and proteins. Little decrease was observed at 65% and 50% levels of solar radiation over 75%. 25% light curtailment had proved to be optimum level of radiation for the photosynthetic process. It is a well-known fact that high intensities of light hamper the process of photosynthesis by photodamage to photosynthetic apparatus, solarization as well as inhibition to carbon dioxide fixation process. Joy *et al*. [29] reported that *Curculigo orchioides* grown under 25% to 50% shading had elevated levels of carbohydrate fractions in the rhizome than in open conditions. Protein content was improved by increasing shade levels in bangladhonia production by Moniruzzaman *et al*. [30] .

Geranium plants grown under reduced solar radiation conditions observed higher levels of DNA and RNA (Table-6). The increase was more at 75% level of solar radiation and followed by 65% and 50% level of solar radiation. The higher content of protein proved that the level of nucleic acids is high in plants, and this leads to herbage yield improvement.

Fresh yield per hectare was significantly influenced by different shade levels (Table-7). Among all the treatments 75% level of solar radiation proved to be highest herb yield. Nearly 58.6% herbage yield increase observed at 25% sunlight curtailment compared with open condition. The essential oil yield also found enhanced at 75% solar radiation level.

Essential oil is a secondary plant metabolite synthesized from the products of photosynthesis [31]. Restricted availability of photosynthates adversely affects crop growth and essential oil synthesis and accumulation. Thus, any factor that enhances photosynthesis seems to play an important role either directly or indirectly in essential oil biosynthesis and yield. Generally the low proportion of essential oil rich young and expanding leaves in the harvested biomass by Kothari *et al*. [32]. Similarly Jadhav *et al*. [23] reported that patchouli plants treated with 70% shade produced higher essential oil yield than plants treated with 50% shade and without shade.

The quality of the essential oil as determined by its chemical constituents (geraniol and citronellol) was slightly affected (Table-8). Curtailment of solar radiation has a little increase in citronellol at 75% and slight decrease at 65 and 50% of solar radiation compared to control. A gradual increase was found in geraniol from 75% to 50% levels of the solar radiation. But statically these are not significant.

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