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# Crop productivity, aroma profile and antioxidant activity in *Pelargonium graveolens* L'Hér. under integrated supply of various organic and chemical fertilizers

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ABSTRACT

*Pelargonium graveolens* L'Hér. is an important commercial crop and source of industrially acclaimed geranium oil. Field experiments were conducted to study the response of integrated nutrient management on crop productivity, plant biochemical parameters, essential oil yield, oil quality, nutrient content and antioxidant property in *P. graveolens* during the years 2012–2013 and 2013–2014 in Lucknow, India. Different organic manures and chemical fertilizers in various combinations were applied to the crop. Plant height increased by 44%, leaf area by 40%, and essential oil yield increased to 106% in poultry manure (PM) + chemical fertilizer (CF) treatment. The N content was highest in CF followed by PM + CF, which were about 37% and 34% greater than the control, respectively. Antioxidant activity increased from 1.53% (control) to 5.94% in PM + CF treatment. Percentage of major aroma compounds increased in the combined application of organic manure and chemical fertilizer. Geraniol (26.08%–28.98%) was the major constituent of essential oil, followed by citronellol (22.86%–28.82%), 10-*epi*-$\gamma$-eudesmol (5.15%–5.31%), isomenthone (5.44%–6.83%) and linalool (3.01%–4.21%).

Study concludes that the combined application of fifty percent each of CF (75:30:30 N:P:K kg $ha^{-1}$) and PM (2.5 kg $ha^{-1}$) gave significantly higher herb and oil yield with improved aroma profile, enhanced antioxidant properties and improvement in soil characteristics.



## 1. Introduction

*Pelargonium graveolens* L'Hér. popularly known as rose-scented geranium, belongs to the family Geraniaceae. The crop is cultivated for its high value essential oil commercially known as geranium oil. The steam distillation of the fresh above ground parts of the plant (tender stem, leaves and flowers) yields geranium oil with characteristic rose-like odour. Cosmetics, perfumery and flavor industry, are the primary consumers of geranium oil (Rajeswara Rao, 2002). The oil possesses antibacterial and antifungal properties as well. The principal constituents of the oil are geraniol and citronellol, accounting for about 70% of the oil. Other major chemical components of the geranium oil are linalool, citronellol formate, geranyl formate, isomenthone and rose oxide. The world production of the oil is approximately 500–750 tonnes per annum with China being the leading producer followed by Egypt, Algeria, Morocco, Reunion Island and India. India produces around 5 tonnes of geranium oil against the industry demand of 50 tonnes (Maiti et al., 2006; Dasuki, 2002). The world trade in geranium oil is robust and stable (Demarne, 2002). The main importers of geranium oil are France and USA. Globally, the industrial demand of the oil far exceeds its production levels with FAO estimates of 10% per annum growth in world exports (Anon., 2006). Hence, there is a commercial opportunity to increase the production of geranium oil to meet the industrial demand. The cultivable land availability is always under pressure from food and competitive commercial crops. Therefore, the challenge is to increase the herb and oil productivity of such types of crops through improved agricultural practices without increasing their area under cultivation. The effect of organic and chemical fertilizers in increasing the crop yield is well documented. However, specific studies on the role of organic fertilizers and their combinations on *P. graveolens* are very few. Singh (2011) reported higher crop and oil yield with a combination of organic manure (vermicompost) and chemical fertilizer in *P. graveolens*. Similarly, Ram et al. (2003) observed that the application of paddy straw mulch gave higher essential oil yield in *P. graveolens*. None of the reported studies on *P. graveolens* have

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experimented with poultry manure (PM) as one of the organic fertilizers in their studies. Further, the effect of organic manures and their combinations on the antioxidant properties of *P. graveolens* have not been evaluated. This study reports the effects of PM and its combination on herbage yield, oil yield, and oil quality and antioxidant properties of the *P. graveolens*.

Practice of using chemical fertilizer alone has its flip side in terms of soil health and environment (Ahmadian et al., 2011). Plant nutrition is one of the most important factor affecting quantity and quality of secondary metabolites in plants. Further, the biological waste management is a serious challenge and its efficient utilization for increasing crop productivity, soil health and the environment is a viable proposition. In recent decades, growth of poultry production in developing countries has intensified to meet the demands of growing population. The poultry waste gives rise to potential environmental and human health concerns. Globally, poultry manure or litter has been applied to land to enhance crop production for centuries (Williams et al., 1999). Distillation and extraction process of medicinal and aromatic plants produces enormous amounts of distillation waste around the world and their safe disposal is a major problem. Converting them into high-quality vermicompost and using as an organic amendment for crops is commercially feasible and profitable. Recently, medicinal and aromatic plants have attracted attention for their potential as antioxidants in reducing free radical induced tissue injury. Therefore, efforts for searching natural antioxidants and increasing their activity have intensified in recent years.

Keeping the above facts in view, an experiment was conducted with the objectives to (1) determine the effect of different combinations of organic manure (vermicompost, farmyard manure, poultry manure) and chemical fertilizers (N, P, K); (2) arrive at the optimum fertilizer regime for higher herbage and essential oil yield with industrially acceptable quality of geranium oil; (3) study the effect of various amendments to the plant nutrients content and its effect on biochemical and antioxidant activity of plant; and (4) investigate the effect of organic manures and chemical fertilizer on soil fertility status.

## 2. Material and methods

### 2.1. Experimental detail

A field experiment was carried out for two consecutive years viz., 2012–2013 and 2013–2014 during December–April at the research farm of Central Institute of Medicinal and Aromatic Plants, Lucknow, India. The research farm is located at latitude 26.8940 °N and longitude 80.9816 °E, with an elevation of about 120 m above mean sea level. Mean maximum and minimum temperature fluctuated from 24.5 to 44.5 °C and 6.9 to 27.5 °C, respectively. The soil texture was clay-loam with pH of 8.2 and low in organic carbon (OC) 0.32%, available nitrogen (N) 135 kg $ha^{-1}$, available phosphorus 14.2 kg $ha^{-1}$ and available potassium ($K_2O$) 140 kg $ha^{-1}$.

The experiment was laid out in a randomized block design with eight treatments and three replications. The eight treatments were (1) FYM: farmyard manure at 20 t $ha^{-1}$ (2) VC: vermicompost at 10 t $ha^{-1}$ (3) PM: poultry manure at 5 t $ha^{-1}$ (4) CF: chemical fertilizer (N:P:K at 150:60:60 kg $ha^{-1}$) (5) FYM + CF: farmyard manure 10 t $ha^{-1}$ plus N:P:K (75:30:30 kg $ha^{-1}$) (6) VC + CF: vermicompost 10 t $ha^{-1}$ plus N:P:K (75:30:30 kg $ha^{-1}$) (7) PM + CF: poultry manure 2.5 t $ha^{-1}$ plus N:P:K (75:30:30 kg $ha^{-1}$) (8) Control: no fertilizer. The N, P and K were applied as urea, single superphosphate and muriate of potash, respectively. Poultry manure, vermicompost, farmyard manure and chemical fertilizer P and K were applied to the soil before planting in the plots ($3 \times 3\,m^2$). Nitrogen at 150 kg N $ha^{-1}$ was added in two split doses: 75 kg N $ha^{-1}$ as a basal dose and 75 kg N $ha^{-1}$ as a supplementary dose during the peak growth period. 45 days old seedlings of geranium variety "CIM-Pawan" were transplanted in the field with plant to plant and row to row spacing of 45 cm.

Plots were irrigated immediately after transplanting for the proper establishment of the crop in the field. All intercultural operations were carried out as per need. The crop was harvested after 90 days in mid of April during both the years of the field experiment. Plant height, leaf area and total plant biomass were recorded for the plants of each plot.

### 2.2. Organic matter and soil and plant nutrient analysis

The physicochemical properties of the three different organic amendments namely, vermicompost, farmyard manure and poultry manure was analyzed and recorded (Table 1). Organic C was determined by Walkley and Black (1934) method. For the determination of total N and total P, the organic material was digested in 1.2:1 $H_2SO_4/H_2O_2$ mixture at 360 °C. After digestion, total N and P were measured by flow injection analyzer. Available P was extracted with sodium bicarbonate and determined by the molybdo-phosphate blue color method by UV–vis spectrophotometer (Olsen et al., 1954). Potassium was extracted with ammonium acetate and analyzed by flame photometry. Zn, Mn, Cu, Fe in the soil were extracted with DTPA and analyzed with an ICP–OES. Plant N, P and K was estimated by acid digestion method and determined by flow injection analyzer.

### 2.3. Biochemical and antioxidant capacity determination of *P. graveolens* leaf extracts

Estimation of chlorophyll a and chlorophyll b was done by Arnon (1949). Carbohydrate content was measured according to the method of Yemm and Willis (1954) using anthrone reagent. Ascorbic acid was determined by Keller and Schwager (1977) method. In brief, 0.5 g of fresh leaf sample was homogenized with 20 mL of extracting solution (oxalic acid + EDTA in distilled water). It was centrifuged for 15 min at 6000 rpm and the supernatant collected. On an addition of the supernatant liquid (1 mL) to 2, 6-dichlorophenol indophenol (DCPIP), the solution turned pink. The optical density (OD) of the mixture was taken at 520 nm (*Es*). After taking the OD of the mixture, one drop of ascorbic acid was added to bleach the pink color and again the OD was taken at the same wavelength (*Et*). The OD of DCPIP solution was also taken at 520 nm (*Eo*). A standard curve was prepared by using different concentration of ascorbic acid following the same method. Concentration of ascorbic acid was calculated as under:

**Table 1**
Chemical properties of organic manures.

| Parameters | OC (%) | TC (%) | N (%) | Available P mg $kg^{-1}$ | Available K mg $kg^{-1}$ |
|---|---|---|---|---|---|
| Poultry Manure (PM) | 30.0 ± 3.10 | 33 ± 3.30 | 3.2 ± 0.20 | 57.91 ± 4.72 | 192 ± 17.2 |
| Vermicompost (VC) | 16.12 ± 1.20 | 19.2 ± 1.30 | 1.30 ± .012 | 14.01 ± 1.26 | 99.1 ± 8.50 |
| Farmyard manure (FYM) | 12.7 ± 0.910 | 17.2 ± 0.91 | 0.82 ± 0.021 | 28.01 ± 2.1 | 115 ± 10.3 |

OC – organic carbon; TC – total carbon; N – nitrogen; P – phosphorous; K – potassium. All values are the mean of three replications ± standard error of mean.