On Characteristics and Some Problems In Cultivation of *Palargonium* species

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Breeding a new type of *Pelargonium*

Pelargonium denticulatum had been the most popular of all the *Pelargonium* species in Japan, but in 1954 three types of *P. roseum*, viz., varieties "Italy", "France" and "America", were introduced into Japan in the hope of obtaining better and more oil. *P. roseum* plants are more spreading and shrubby with vigorous growth than *P. denticulatum*, but the former is lower in yearly yield of oil per hectare. However, the oil of *P. denticulatum* is inferior to *P. roseum* in quality.

Both *P. denticulatum* (2n=88) and *P. roseum* (2n=77) are completely sterile owing to the absence of functional pollen. Induced tetraploids (2n=176 and 154, respectively) of both species, however, produce good pollen and bear germinative seeds by selfing. Interspecific hybridization was succeeded from reciprocal crosses between the teraploids of both species.

Interspecific hybrids were intermediate between the parental species in every character. A new promising type occurred from backcrossing F_1 hybrid with tetraploid *P. roseum*. The new type (B_1 No. 10) is characterized by the high yield of oil (about 20~50% higher than *P. roseum*), the good quality of oil (as goods as *P. roseum*), and the slightly low yield of crop (about 15~17% lower than *P. roseum*). The new type is now being planned to be spread.

Principal *Pelargonium* producing lands and suitable lands in view of small climatic condition in Japan

In the investigation of the principal *Pelargonium* producing lands of the world it was found that the characteristics of such lands were of yearly average atmospheric temperature ranging from 16 to 18°C with an annual average rainfall of approximately 1,000 mm and no frost during winter.

The Seto Inland Sea district of Japan which is the prinicpal *Pelargonium* producing land fairly satisfies the conditions of yearly average atmospheric temperature as well as the amount of annual rainfall, but its monthly average temperature drops to 6°C with frequent frost during the coldest days of winter. Investigations were conducted on the topography and the wintering of the plants in a small island of the Seto Inland Sea, and it was found that frost damages on the *Pelargonium* had been much influenced by cold air currents.

Consequently it was discovered that prospective farms should be chosen with the greatest possible care so as to avoid the cold air current passages for the plants. The result of the investigation on the relation between the topography of the farms and the number of the plants withered by frost showed that for the successful wintering of the plant the frequency of frost should not exceed 16 to 20 days during the winter season.

On distribution of oil gland

The oil gland differentiates from the epidermis of the plant, and consists of three parts, i.e., basal cells, stalk cells and a secretory cell. Essential oil is accumulated in the form of oil globules between the cuticle and the cell wall of the secretory cell, and oil globules enlarge their volume to form a large spherical mass. The oil globules are easily detectable by staining sudan III (Fig. 1). The number

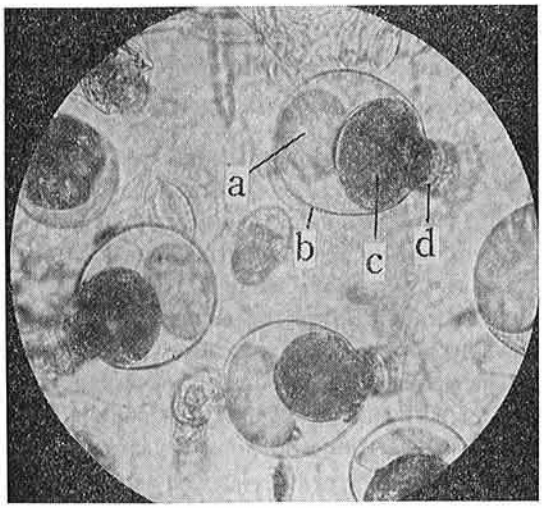

Fig. 1. Distribution of oil gland on the surface of leaf blades.

Note: a—Oil globules
b—Cuticular membrane
c—Secretory cell
d—Stalk cell
(magnification 600 ×)

of oil glands per unit area is found to be significantly different with respect to the position of the leaves on the stem. The number of oil glands is the greatest in the uppermost leaves, and it decreases remarkably at the 2nd or 3rd leaves and gradually diminishes with the lower position of leaves. The percentage of yielding essential oil per fresh plant material is discovered to be considerably different as regards the position of leaves on the stem (Fig. 2). This trend is very similar to that of the distribution of oil glands.

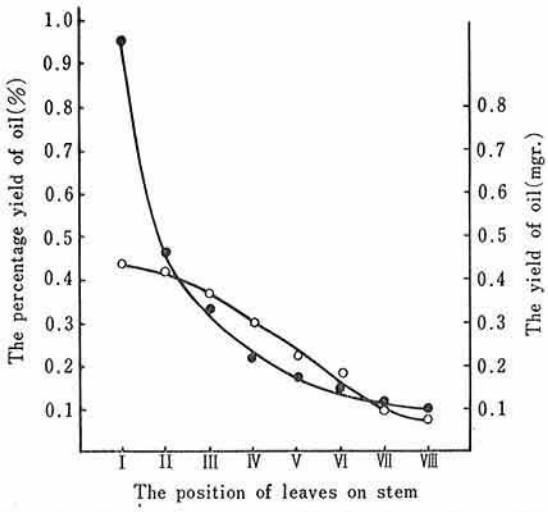

Fig. 2. The percentage yield of oil and the yield of oil per one leaf in different positions of leaves on stem.

Note: ●—● the percentage yield of oil in main stem leaves.
○—○ the yield of oil per one leaf on main stems.
Measured in Aug. P. roseum.

Seasonal and daily variations of percentage of the essential oil yield

The percentage of oil increases gradually from June (spring harvest), reaches a maximum in August (summer harvest) and then decreases somewhat in October (autumn harvest), and thereafter decreases remarkably (Table 1).

The percentage of essential oil is highest

Table 1. Seasonal variations in the percentage yield of oil

Date	Leaf-blades* (microstill)	Leaves and stalks (10 kilo type still)	Mean air temp.
May	0.100%	0.062%	16.5°C
June	0.138	0.080	21.8
July	0.179	0.092	25.5
Aug.	0.273	0.160	27.7
Sept.	0.225	0.107	24.4
Oct.	0.238	0.110	19.1
Nov.	0.156	0.070	14.6

* Materials are upper five leaf-blades.
P. roseum.

towards evening and lowest in early morning. The essential oil content of the leaves depends mainly upon weather condition,—the high temperature or the intensive sunshine greatly influences the yield of essential oil. When the temperature rises, the percentage of oil yield increases remarkably. But, on cloudy or rainy days, no marked daily fluctuation in oil content can be noticed. Moist condition lowers the percentage of the oil yield. The amount of water contained in the plant tissue is almost constant during the day time. It is concluded that daily fluctuation of the percentage of essential oil yield must be caused by the change in the secretory activity of oil glands, because the distribution of oil glands in the leaves is not changed.

Proper method of harvest

The more remote end of green leaves of the plant, the richer is the oil and more oil extractable per leaf. In as much as the high percentage of oil is extractable during the hottest season of summer, it is important to arrange to have rich harvest of green leaves during the summer season. Moreover as the percentage of oil yield fluctuates daily significantly, it is also essential to harvest the leaves in the afternoon of clear days.

Two-year plants will provide more leaves than one-year ones and naturally the former will yield more oil per unit area of the farm. The highest yield of oil can be expected from

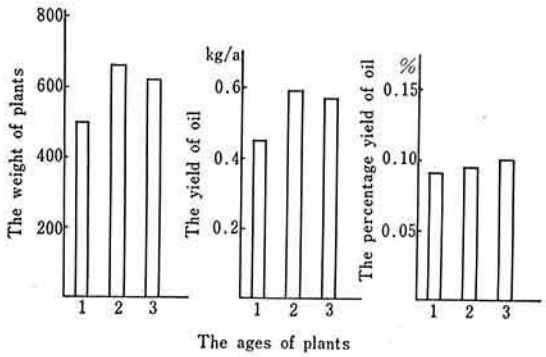

Fig. 3. The difference in the weight of plant, the yield of oil and the percentage yield of oil by the ages of plants.

Note: The manurial elements N: 2.0–2.5 kg/a, P: 1.0–1.4 kg/a, K: 1.5–2.0 kg/a. 2,500 plants/a. P. roseum.

Table 2. Seasonal variations of the chemical composition of essential oil (by gaschromatography)

Chemical composition	B_1 No. 10							P. roseum	
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Sept.	Dec.
	%	%	%	%	%	%	%	%	%
isomenthone	13.9	19.8	15.7	11.9	16.1	16.5	14.9	12.6	11.5
citronellyl-formate	5.9	8.5	9.3	13.1	14.2	11.4	9.0	13.8	12.0
geranyl-formote	13.3	7.5	6.0	5.7	6.7	7.6	7.5	5.6	9.6
citronellol	20.2	19.8	32.3	38.9	27.8	27.8	22.5	33.8	28.1
geraniol	30.0	24.0	11.7	8.9	12.6	15.2	21.8	6.9	15.8
the others	16.7	20.4	25.0	21.5	22.6	21.5	24.3	27.3	23.0

Experimental conditions: Column: Polyethylene glycol-6000 (Support: Celite 545), 3mm×3m, 160°C, 45ml/min He, Range 2mV, 160mA Bridge Current, Chart speed 5mm/min.

two or three-year plants. The proper frequency of harvesting would be 2 or 3 per year for one-year plants and 3 or 4 for two-year plants. (Fig. 3).

Seasonal variation of the chemical composition in *Pelargonium* species

Concerning the quality of extracted oil, B_1 No. 10 was not inferior to *P. roseum*. The main components of the oil being citronellol and geraniol, the components existed generally in a free state. As a result of examining in the variation of citronellol and geraniol by gaschromatography, it was found that there was seasonal variation (Table 2). That is, when the oil contents of them both in early period of growth were compared, the percentage of geraniol showed a higher value, but as the temperature got higher in summer the percentage of geraniol decreased, and the other hand, the percentage of citronellol significantly increased.

However, as the temperature dropped lower in November and December the percentage of citronellol decreased and that of geraniol again increased. The optical rotation of essential oil was also high in the season of high temperature and low in the low temperature season. This is probably due to the increase and decrease in percentage of l-citronellol.

We can conclude that the seasonal variation of the percentage of citronellol and geraniol is due to a biochemical oxidation-reduction reaction. It is considered that geraniol is changed into citronellol mainly by phytochemical reduction during the summer season, and that the percentage of geraniol is increased by dehydrogeneration in the late autumn season.

The quality of geranium oil greatly depends upon the proportion of content of geraniol and citronellol. It has been reported that the above mentioned proportion is different according to the producing land and species, but as described above, the phenomenon that the oil content percentage greatly varies in different seasons of oil extraction can not be overlooked.

References

1) Guenther, E.: Essential Oils. Vols. 1-IV, New York, 1950.
2) Tamai, T. and Tokumasu, S.: Studies on Breeding of *Pelargonium* Species Used for Essential Oil production. IV. Jap. J. Breeding, Vol. 14, No. 4, 263–269, 1964.
3) Yoshida, T.: Physiological and Ecological Studies on Secretory Function of Essential Oil in *Pelargonium* Species. Special Bulletin No. 2, College of Agriculture, Ehime University, 1–82, 1961.
4) Yoshida, T. *et al.*: Seasonal Variation of Both the Percentage Yield of Essential Oil and Chemical Composition in *Pelargonium* Species. Proc. Crop Sec. Soc. Japan, Vol. XXX VII, No. 4, 565–569, 1968.