Research on the Introduction and Transplanting of Aromatic Plants from the Mediterranean Region to Heshuo Xinjiang and Shanghai China

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Keywords: Herb, latitude, climate, essential oil content

Abstract

This research was designed to solve problems related to introducing and transplanting aromatic plants from the Mediterranean region to Heshuo and Shanghai in China. The investigated species included lavender (*Lavandula angustifolia*), thyme (*Thymus vulgaris*), sage (*Salvia officinalis*), clary sage (*Salvia sclarea*), German chamomile (*Matricaria chamomilla* L.), Roman chamomile *Chamaemelum nobile* L., hyssop (*Hyssopus officinalis*), sweet basil (*Ocimum basilicum*), oregano (*Origanum vulgare*), marjoram (*Origanum majorana*). After investigating and analyzing the climate condition of the native regions for these plants, we tried to plant the same varieties on the Shanghai and Heshuo, of Xinjiang. Shanghai's latitude (31°10') is lower than Heshuo's (43°) and Heshuo's latitude approached that of Provence (44°) France. The growing performances of these plants in the different places were recorded and the content of essential oil was determined. Our results showed that lavender, hyssop and Roman chamomile grow very well in Heshuo, but not in Shanghai. The growth of German chamomile thyme, sage, oregano, and marjorams is better in Heshuo than in Shanghai. The content of essential oil of sweet basil in Xinjiang is higher than in Shanghai, although the height of plants in Xinjiang was shorter than in Shanghai. The following climate factors are very important for the aromatic plants to be introduced and transplanted successfully from Mediterranean region: same latitude and hours of sunshine of growing period, ≥ 0 ºC accumulative temperature, ≥ 10 ºC accumulative temperature and days, ≥ 5 ºC precipitation and humidity, ≥ 10 ºC amount of solar radiation.

INTRODUCTION

Many herbaceous aromatic plants grow along shore of the Mediterranean, France, England, Morocco have become well known for the production of aromatic species. Lavender (*Lavandula angustifolia)*, thyme(*Thymus vulgaris*), sage (*Salvia officinalis*), clary sage (*Salvia sclarea*), hyssop (*Hyssopus officinalis*), sweet basil (*Ocimum basilicum*), oregano (*Origanum vulgare*), and marjoram (*Origanum majorana*) originate from the Mediterranean shore of Europe and from the India. Now, these plants which are widely used in perfumes and cosmetics; which effected the historic culture of Europe and the world. In China, no other species have been successfully introduced to a large area of cultivation. The research of introduced cultivation should consider many factors, such as soil, water, and human factors. This paper focus on climate factors, the other factors will be studied in the future. Introducing these aromatic plants successfully is an important research subject in China. Cultivation of these plants in China has been rare and only minimal research in this field has been completed in recent years.

MATERIALS AND METHODS

At first, we analyzed the climate factor differences between the original region and the introduced region. Then we introduced the plants to Shanghai and Xingjiang respectively, according to climate. The growth and the rate of the essential oil were monitored.

Main Quantity of Heat Index in Every Area

The weather indexes of Provence was a criterion for transplanting. Lavender was transplanted in the late of 1970s in Sapporo, and was used as a reference index. There are

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34 weather indexes in the table 1, they refer to 0 °C, 5 °C, 10 °C, 15 °C, 20 °C. The critical growing temperature was 0 °C, 5 °C was the starting temperature of bourgeoning, 10 °C is growing temperature, 15 °C is flower bud differentiation temperature, 20 °C is the optimum flower temperature. All the weather indexes are located in Table 1.

The transplanted herbs were seeded or bourgeoned in early April, and harvested before October. The time of growth and bearing of every herb was different. Growth of lavender, sage, thyme, hyssop, oregano, marjoram, sweet basil and clary sage was 180 days, German chamomile was 120 days, and Roman chamomile was 150 days. In other words, the length of growth and bearing period were not over 180 days.

In the 34-weather index, a comparison of Provence and referencing Sapporo, the weather in Heshuo was nearly the same in the two areas. Accumulated temperature, base temperature ≥ 10 °C, accumulated temperature, base temperature ≥ 15 °C, annual sunshine hours and annual global solar radiation(kcal/cm^2) slightly exceed that of Provence. These indexes, however do not check plant growth in nature.

In the weather index of Shanghai, the average number of days per annum with t ≥ 0 °C, accumulated temperature and base temperature ≥ 0 °C, accumulated temperature and base temperature ≥ 5 °C, accumulated temperature and base temperature ≥ 10 ºC, accumulated temperature and base temperature ≥ 15 °C, accumulated temperature and base temperature ≥ 20 °C exceed that of Provence, but annual sunshine hours, total sunshine hours of the period with t ≥ 0 °C. Total sunshine hours of the period with t ≥ 5 °C, total sunshine hours of the period with t ≥ 10 °C , total sunshine hours of the period with t ≥ 15 °C, total sunshine hours of the period with t ≥ 20 °C are slightly less than that of Provence which show that the temperature of Shanghai is better than in Provence, but the condition of sunlight in Shanghai is worse than in Provence's.

The Precipitation Indexes in Different Areas (Table 2)

We can see that the all the indexes related precipitation in Heshuo are lower than in Provence, and which may form the unfavorable factor for the plant growing. But the irrigated farming area in Heshuo have an abundant subterraneous resource and is close to the largest inner freshwater lake which can fully satisfy the transpiration of plants. Conversely, the formation growth of oil grand of fragrant plants need a dry climate condition, so that the low precipitation cannot constitute a limiting factor of plants growing in the area.

From the precipitation data in the area of Shanghai, all the indexes are much higher than in Provence, which may constitute the limiting factor of plants growing in the area.

The annual lowest temperature and the highest temperature are the most predominant limiting factors. The temperature in Sapporo was the lowest, Shanghai was the highest and Heshuo was closest to Provence, especially from the middle of March to the middle of September (Figure 2). From October to the next March, the temperature in Heshuo changes between 5 °C to -10 °C. The lowest temperature in Heshuo is in January. The temperature in Provence changes between 10 °C to 2 °C. We can conclude from the results of these artificial methods that plants may be able to live through winter normally. Furthermore, in the area of Sapporo, plants have proved to live through winter successfully, so it seems to be possible that Lavender could live through winter in Heshuo and Shanghai.

Heshuo's temperature is 5 to 7 °C higher than in Provence's from May to September (Figure 3).

The average temperature in Shanghai is the highest and the average temperature in Sapporo is the lowest (Figure 4). From middle May to middle September, the temperature in Heshuo is very close to the temperature in Provence. This similarity in temperature suggests that Heshuo has the basic condition of plant growing, and the high temperature of growing period in Shanghai, especially the continued high temperature in blooming, may become the limiting factor.

The level of sunlight is an important factor for fragrant plants and may affect the

essential oil and the mass of fragrant plants heavily; ample sunlight is helpful for plant growth. The time of sunlight in Heshuo is very close to in Provence, especially in May to September (Table 3), and the time of sunlight in the area of Shanghai is far lower than in Provence, so that the sunlight condition in Shanghai may become the reason for the decreased plant growth, especially the output of essential oil.

Air humidity is also the critical factor affecting the fragrant plant growing and the producing of essential oil. The too high air humidity can lead to the hypoplasia of oil gland in the surface of leaf and the oil gland of introduced perennial herbaceous plant mostly distribute in the epidemis cell of leaf, so that relatively dry condition is an advantageous condition to fragrant plants.

The highest level of precipitation is in Sapporo and the lowest in Heshuo (Table 4). In Heshuo, the precipitation in summer is a little more than in autumn and winter and the precipitation in autumn and winter of Sapporo is more than spring, and so that the precipitation in Shanghai may be unfavorable to the growing of aromatic plants.

From table 5, we can see that the humidity in Shanghai is the highest of the four areas, especially in the growing period of May to September when the humidity is up to 82 percent. Heshuo is lower than other three areas. Though fragrant plants like dry climates, the deeply low humidity may be the limiting factor of plant growth. If we want to plant in Heshuo, how to increase and ensure the air humidity needed to be solved at first. In order to create a good condition for those plants growth, the construction of protective forest, the installation of sprinkling irrigation and unfaltering water source must be assured.

MATERIALS AND METHODS

Heshuo Xinjiang

The seed was sowed in sunlight greenhouse during March 2 to 10. The temperature of sunlight greenhouse is about 10 °C to 20 °C. Thyme: 1000 plant/ m^2; Basil: 600 plants/m^2; German Chamomile: 600 plants/m^2; Hyssop:1000 plants/m^2. When the true leave of the plants exceeds six, and the air temperature is up to 15 ºC, the plants were transplanted to the field at the beginning of April.

Drip irrigation was used in the field. Irrigation was conducted every three days in April and May, every week in June and July, 15 days in August, and one month in October. Irrigation was timing when temperature is high.

Intercropping was done in the wattle of grape and support them with 1.5m row spacing, and then sowing the herbs between them.

For fertilizing, organic fertilizer with 30 tons/ha was used.

All herbs not cut were buried after irrigating November 13th. The soil was over 10-15 cm deep, so seedlings can pass through the winter safely.

The harvest was at noon in sunshine of July to October. The harvested stems, leaves and flowers were dried naturally in the local house of grape drying (humidity is lower than 37 %).

The equipment for essential oil distilling was made of stainless steel and its treatment capacity is about 2 tons. The water and oils were separated.

Shanghai

There is acidic appreciably in the soil of Shanghai. So they used magnesia calcareousness in the soil before seeding, and choose slender, equality, high ability of holding water and ethereal soil. They sow the seed in same time with Heshuo. There was more rain, and the air humidity is high in summer in Shanghai. So we both breed and plant in plastic greenhouse in Shanghai Jiaotong University Agriculture College. All herbs were harvested in fine day, and naturally dry. They used vitreous instrument to distill essential oil in lab. They analyze essential oil using gas chromatography. Its conditions are:

GC - MS: 5973N

Column: DB - 5MS (50 m×0.25×0.25)
Flow: 1 ml/min
Oven: 70 °C rising 2°C/min to 180 °C and then 15 °C /min to 280 ºC
Split: 100: 1
Mass range: 29 - 450
Emv: 1800vVolume: 0.2 μl
MS(mode): Scan

RESULTS AND DISCUSSION

The results of introduction indicate that lavender and hyssop mostly grow in Heshuo, Xingjiang, but are not adoptive to planting in Shanghai. Lavender, thyme, sage, clary sage, hyssop, sweet basil, oregano, and marjoram grow better in Heshuo than Shanghai in summer, but their situation are worse than in Shanghai in winter. The growing of sweet Basil in Heshuo is not as well as in Shanghai, but the rate of essential oil is higher than in Shanghai.

The following climates factor are very important to the introduction of the aromatic plants in the shore of the Mediterranean: latitude, sunlight length in the growing period, accumulative temperature above zero, accumulative temperature above 10 Cº and days, the precipitation amount above 5 Cº and humidity, and sun radiation above 10 Cº. The outcome of the research has been used and now 1000 ha. (15 thousand-mu aromatic cultivated bases) have been built in Heshuo, Xingjiang.

Content of Essential Oil and Weight

In Heshuo comparison of the content of essential oil with Provence, the sage, Roman chamomile, german chamomile, marjoram, sweet basil, thyme and lavender were not different; the clary sage and hyssop were higher, but the oregano was lower. Comparing the single weight with Provence, the hyssop, clary sage, Roman chamomile, marjoram, and lavender were not different. The thyme, oregano, German chamomile, and sweet basil were lower, but the sage was higher. Comparing the content of essential oil with Provence, the hyssop, sage and lavender were higher; the thyme, oregano, German chamomile, clary sage and sweet basil were lower, but the marjoram and Roman chamomile were not different (Table 6).

In Shanghai, clary sage and lavender were not successfully introduced. Comparing the content of essential oil with Provence, all introduced herbs were lower but sweet basil. Comparing the single weight with Provence, the German chamomile was higher; the Roman chamomile and sage were not different with Provence; the thyme, oregano, marjoram, hyssop and sweet basil were lower. Comparing the essential oil yield per ha. with Provence, the sweet basil was higher; the German chamomile was not different; but the thyme, Roman chamomile, oregano, marjoram, hyssop and Sage were lower (Table 6).

Some Conclusions of the Research in the Area of Heshuo

Owing to the same latitude in Heshuo and Provence, they have a similar cycle of light period in a year. This ensures that the nourishment increment of plants has a coincidence with the generation increment and this has become the first factor of the success of introduction in Heshuo.

From the data of the quantity of heat index, the low temperature period from October to the next March has become a limited factor for perennial plant living through the winter. Due to adopting the protection for the plants in this area, such as embedding, earthling up and so on, which make the underground part of the plants, be in a state of hibernation. The temperature from March to September of normal growing period of plants can have the same quantity of heat with the country of origin, so it ensure plants' normal proceeding in growing period.

In the spring or autumn in Heshuo, sowing and growing seedlings and part of cottage must proceed in the local sunlight greenhouse because there is no suitable heat

condition in March. The temperature of sunlight greenhouse is about 18-25 Cº in March, and which ensures the normal proceeding of growing seedlings.

The sunlight time in Heshuo has the same principle with Provence, and which becomes one of the successful conditions of introduction.

A low precipitation and air humidity become an important limited factor, so that the dry condition are ameliorated through building shelter-forest, grape intercropping, sprinkling irrigation and other protective measures. In addition, the surface flux in a year is up to above 500 mm and this ensures the average flux in the area. Though the air humidity is very low, the root of plants isn't short of water provision and this also change the limited factor radically.

To fragrant plants, a relative dry climate condition can contribute to the growing of oil gland in the epidermis cell in leaf. But according the practical result of cultivation, the rate of essential oil of fragrant plants in Heshuo is higher than in the country of origin.

Because sage, lavender, and hyssop are more tolerant to dry and low temperature than the other plants, so that the production of these three plants in Heshuo is higher than in the country of origin. By the way, for Sweet Basil is originated in India, the plants in Heshuo have the phenomena of earlier florescence and lower life amount.

Although oregano, German chamomile and thyme are originated in the Mediterranean, their capacity of endurance to cold or drought is low, and then their productions have a little decrease. Sweet purple perilla is weak in winter, but good in spring. Their total growing conditions have no significant difference between the origin area and Heshuo, considering to good growing conditions in spring, summer and autumn of Heshuo.

Some Conclusions of the Research in Shanghai

The index values in Shanghai are higher than in original area. The high temperature in summer is the limited growing condition. Comparing to the origin, Shanghai has less light time, larger precipitation and the higher air humidity, which partly lead to be the failure of fragrant plants introduced to Shanghai from the area of the Mediterranean, for example, Lavender and aromatic purple perilla in Shanghai are not successfully introduced.

Though they are cultivated in the greenhouse, the light condition and air humidity can't satisfy the requirement of the plant growing, the content of the essential oil of the mass of the fragrant plants is lower than in outside

Because the temperature in winter is above zero, all the fragrant plants can over the winter safely.

Sweet Basil out of the shore of the Mediterranean is in good condition and the content of essential oil is also higher than others.

Perennial chamomile is more adaptable to grow in Shanghai. The biomass and the rate of essential oil are as much as in the country of origin.

CONCLUSION

The first condition of cultivation of introduction is the same latitude. The average temperature, accumulated temperature, the number of sunshine, the radiation of sun at 0 °C, 5 °C, 10 °C, 15 °C and 20 °C are the important climatic indexes of introduction. Hyssop, sage and lavender are suitable for growing in Heshuo. Aromatic Roman chamomile, marjoram, and purple perilla are suitable for growing in Heshuo if provided with the living condition through winter. Oregano, sweet basil, chamomile are suitable for growing in this area if provided with good condition through winter and watering in summer. Sweet basil and chamomile are very suitable for growing in Shanghai, but lavender and clary sage are not. Thyme, Roman chamomile, marjoram, hyssop and sage is growing well in the area of Shanghai, but their rate of essential oil is a little low.

Literature Cited
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Tables

Table 1. Agriculture climate dates of four areas.

Item	Heshuo	Provence	Sapporo	Shanghai
Number of days per annum with t ≥ 0 ºC	240d	280d	220d	365d
First day of the period with t ≥ 0 ºC	Mar.1	Jan.1	Mar.1	Jan.1
Last day of the period with t ≥ 0 ºC	Nov.11	Jan.1	Dec.1	Jan.1
Air temperature of the period with t ≥ 0 ºC	16 ºC	16 ºC	14 ºC	18 ºC
Accumulated temperature, base temperature ≥ 0 ºC	4000 ºC	4000 ºC	3000 ºC	6000 ºC
Average number of days per year with t ≥ 5 ºC	240d	300d	200d	300d
First day of the period with t ≥ 5 ºC	Apr.1	Mar.1	Apr.21	Feb.1
Last day of the period with t ≥ 5 ºC	Nov.1	Dec.1	Nov.1	Jan.1
Air temperature of the period with t ≥ 5 ºC	18 ºC	18 ºC	14 ºC	18 ºC
Accumulated temperature, base temperature ≥ 5 ºC	4000 ºC	4000 ºC	3000 ºC	5000 ºC
Number of days per year with t ≥ 10 ºC	180d	200d	180d	270d
First day of the period with t ≥ 10 ºC	Apr.1	Apr.1	Apr.21	Mar.21
Last day of the period with t ≥ 10 ºC	Oct.1	Nov.1	Oct.21	Dec.1
Air temperature of the period with t ≥ 10 ºC	20 ºC	18 ºC	18 ºC	21 ºC
Accumulated temperature, base temperature ≥ 10 ºC	3000-4000 ºC	3000 ºC	3000 ºC	5000 ºC
Number of days per year with t ≥ 15 ºC	140d	140d	120d	200d
First day of the period with t ≥ 15 ºC	May.1	May.21	Jun.1	Apr.11
Last day of the period with t ≥ 15 ºC	Oct.1	Oct.1	Oct.1	Nov.1
Air temperature of the period with t ≥ 15 ºC	20 ºC	20 ºC	18 ºC	22 ºC
Accumulated temperature, base temperature ≥ 15 ºC	3000 ºC	2000 ºC	2000 ºC	4000 ºC
Number of days per year with t ≥ 20 ºC	100d	100d	90d	140d
First day of the period with t ≥ 20 ºC	May.11	Jun.1	Jun.18	May.21
Last day of the period with t ≥ 20 ºC	Sep.11	Sep.1	Sep.1	Oct.1
Air temperature of the period with t ≥ 20 ºC	24 ºC	22 ºC	20 ºC	24 ºC
Accumulated temperature, base temperature ≥ 20 ºC	2000 ºC	2000 ºC	1000 ºC	3000 ºC
Annual sunshine hours	3250h	2500h	1750h	2000h
Total sunshine hours of the period with t ≥ 0 ºC	2500h	2500h	1500h	2000h
Total sunshine hours of the period with t ≥ 5 ºC	2000h	2000h	1500h	2000h
Total sunshine hours of the period with t ≥ 10 ºC	2000h	2000h	1000h	1500h
Total sunshine hours of the period with t ≥ 15 ºC	1500h	1500h	1000h	1250h
Total sunshine hours of the period with t ≥ 20 ºC	1000h	1000h	500h	1000h
Annual global solar radiation(kcal/cm^2)	150	120	120	120
Total global solar radiation of the period with t ≥ 0 ºC (kcal/cm^2)	120	120	100	110
Total global solar radiation of the period with t ≥ 10 ºC (kcal/cm^2)	100	100	80	90

Table 2. Precipitations of four regions.

No.	Item	Heshuo (mm)	Provence (mm)	Sapporo (mm)	Shanghai (mm)
1	Annual total precipitation	100	750	1000	2000
2	Total precipitation of the period with t ≥ 0 ℃	100	750	1000	1000
3	Total precipitation of the period with t ≥ 5 ℃	100	750	1000	1000
4	Total precipitation of the period with t ≥ 10 ℃	50	500	500	1000
5	Total precipitation of the period with t ≥ 15 ℃	50	250	500	1000
6	Total precipitation of the period with t ≥ 20 ℃	50	100	250	500

Table 3. Mensal sunshine hours of the four areas (hour).

Month	Sapporo	Provence	Shanghai	Heshuo
1	3	4	4	5
2	4	6	5	8
3	5	8	3	8
4	6	8	5	7
5	5	9	6	9
6	6	11	4	10
7	5	12	6	11
8	5	10	6	10
9	5	9	6	10
10	5	6	5	9
11	3	5	4	7
12	3	4	5	6

Table 4. Mensal days of rain of the four areas (day).

Month	Sapporo	Provence	Shanghai	Heshuo
1	29	15	12	9
2	27	6	10	3
3	27	9	14	1
4	19	10	13	4
5	17	9	10	7
6	18	8	17	13
7	19	5	17	13
8	17	6	20	11
9	20	8	12	8
10	21	12	12	4
11	24	14	13	2
12	29	10	10	9

Table 5. Mensal relative humidity of the four areas (%).

Month	Sapporo	Provence	Shanghai	Heshuo
1	71	77	75	63
2	69	70	73	45
3	65	65	72	27
4	64	62	72	32
5	69	64	73	34
6	74	56	82	37
7	79	54	80	42
8	76	60	82	44
9	72	64	77	47
10	68	73	75	53
11	67	74	74	61
12	70	75	74	67

Table 6. Dry weight above-ground and essential oil content of herbs in three areas.

Note: The same small letter indicates no significance at $P \leq 0.05$level.

Name	Heshuo Xinjiang		French or original region		Shanghai	
	Dry weight above-ground (g/stock)	Essential oil content (%)	Dry weight above-ground (g/stock)	Essential oil Content (%)	Dry weight above-ground (g/stock)	Essential oil content (%)
Lavender	3^{a}t/ha	1.0-1.1	3^{a}t/ha	0.5-1.5	Planting fail	
Thyme	124^{b}	1.0-1.2	187^{c}	1.14-1.7	86^{a}	0.7-1.0
German Chamomile	100-240kg/ha	0.8-1.0	100-500kg/ha	0.6-1.0	600kg/ha	0.5
Roman Chamomile	400-500kg/ha	1.2-1.3	400-600kg/ha	1.2-1.4	450kg/ha	0.07(Leaves)
Oregano	76^{b}	0.5-1.2	166^{c}	0.8-1.0	48^{a}	0.2-0.6
Marjorams	116^{b}	0.6-1.3	120^{b}	0.5-1.3	98^{a}	0.4-0.8
Hyssop	124^{b}	0.8-1.2	133^{b}	0.3-1.0	84^{a}	0.2-0.4
Clary sage	164^{a}	0.4-0.8	160^{a}	0.8-1.0	Planting fail	
Sweet Basil	256^{b}	0.6-1.0	280^{b}	0.5-1.1	223^{a}	1.2-2.0
Sage	114^{b}	1.0-1.2	86^{a}	1.0-2.0	102^{b}	0.5-0.8

Figures

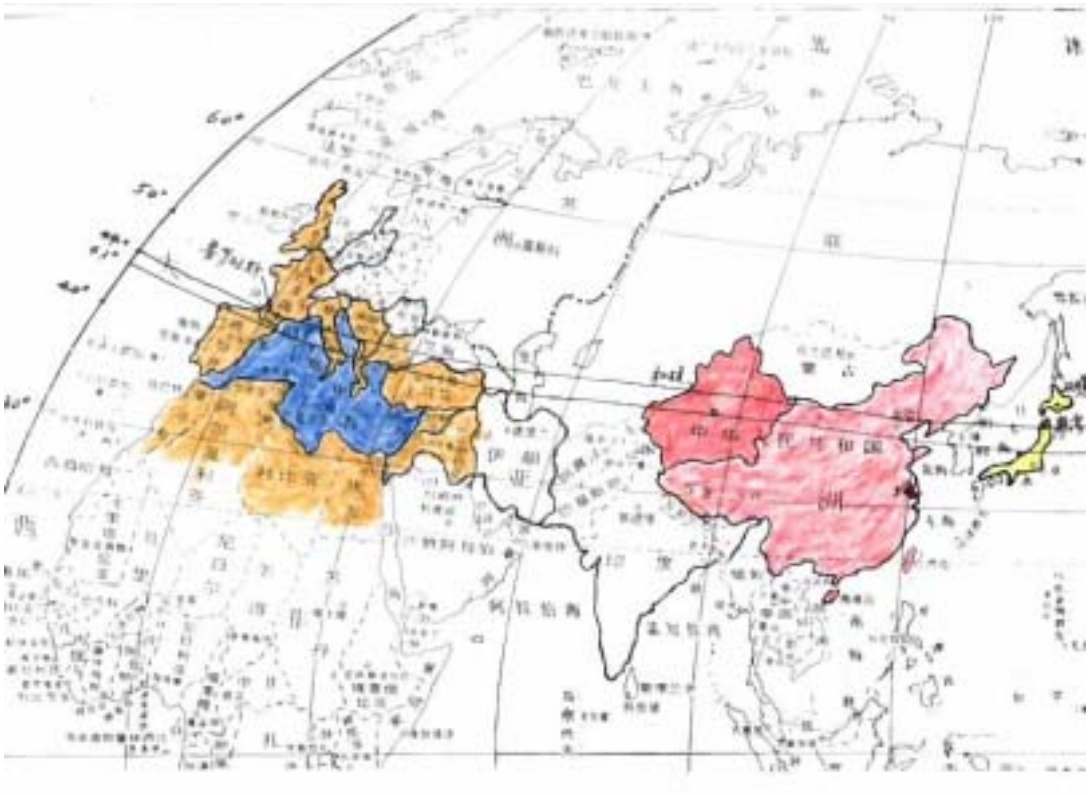

Fig. 1. Aromatic Plants' distributing in Mediterranean region and latitude.

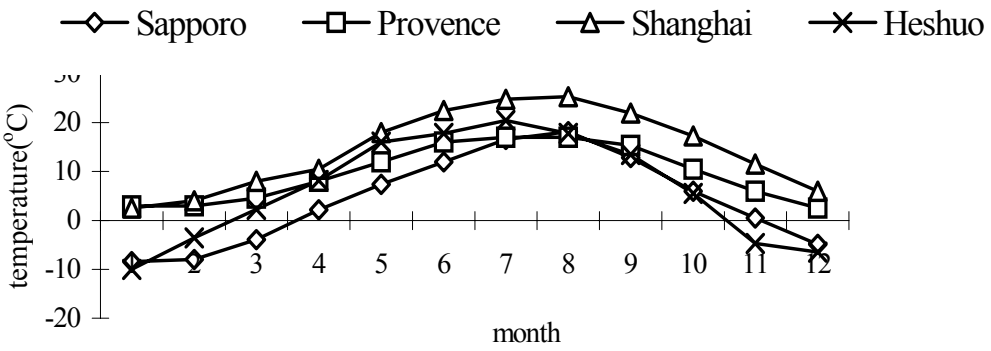

Fig. 2. Change of the lowest air temperature of the four areas in one year.

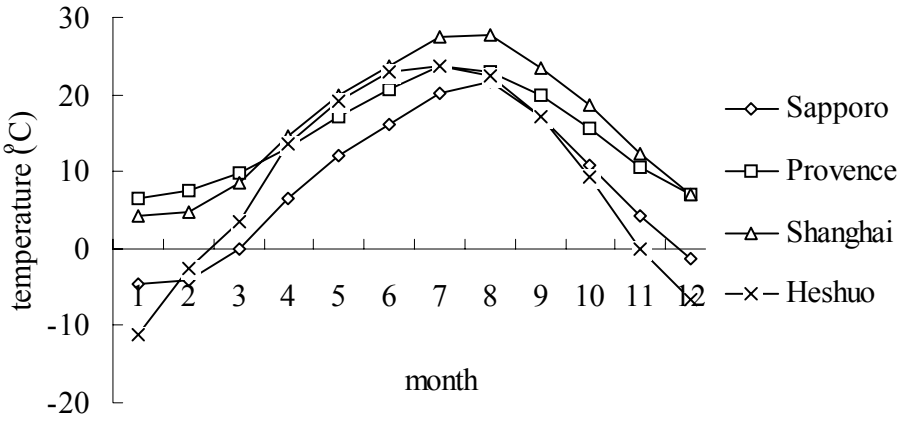

Fig. 3. Change of the highest air temperature of the four areas in one year.

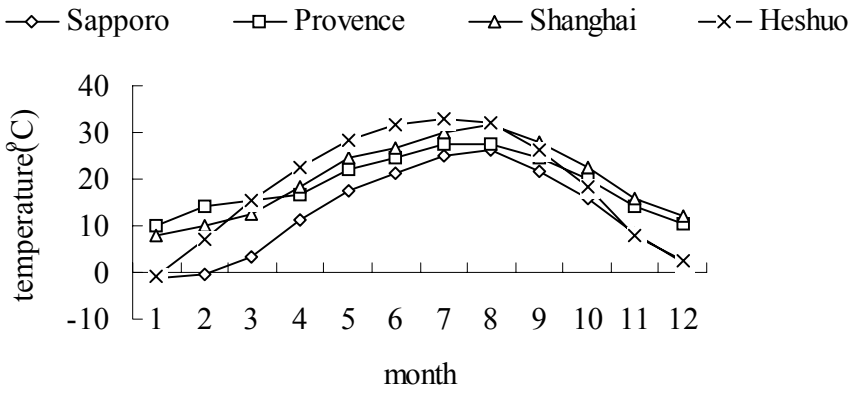

Fig. 4. Average air temperature of the four areas in one year.