

THE INFLUENCE OF CLIMATIC CONDITIONS ON THE YIELD AND QUALITY OF OIL OF *MENTHA ARVENSIS*, VARIETY *PIPERASCENS*.¹BY G. A. RUSSELL².

INTRODUCTION.

The volatile oil of the plant *Mentha Arvensis*, variety *piperascens* occurs principally in the leaf area, the proportion of the leaf oil to stem oil being as 1 is to 28. The function of this oil in the plant's life processes is not well understood. The generally accepted view is that it is waste product formed in the course of plant's metabolism and stored in special cells. Tschirch and Tunnmann, however, have made extensive studies of the functions of volatile oils in plant growth and consider that the oils are built up to serve quite definite purposes. Whatever the view taken the fact remains that in the case of *mentha arvensis* cultivated in various parts of the United States varying yields of oils were secured having varying compositions.

My study of the causes for these variations has revealed little information of a reliable nature. I have been able to form conjectures and to draw certain inferences but have not been able to arrive at definite conclusions. It appears from a study of the literature on the oil of another mint, *mentha piperita*, that several views can be taken as to the cause or causes of variation in the composition of the oil, all of which can be supported by experimental evidence. I have a strong inclination toward the theory that intensity of light and temperature have greater effects on the composition of oil of *mentha arvensis* than do soil, humidity, rainfall and other factors.

All the investigations, thus far, have been from the commercial point of view although it is fully realized that academic investigations are of the utmost importance. The propagating material has been so limited that all our endeavors have bent mainly to the securing of more planting stock, studying at the same time locations where this mint might be produced advantageously. It is from these studies that I have formed a semi-definite conclusion as regards the effects of intensity of light and heat.

My study of *mentha arvensis* began in 1922. At that time I was connected with the Office of Drug Plant Investigations of the Federal Department of Agriculture. The consuming menthol trade became interested in the domestic production of menthol and a coöperation was effected between the office above mentioned and the Vick Chemical Company of Greensboro, N. C. The information secured by means of this coöperation is available through the Department of Agriculture. It is public information for the use of any citizen of this country.

EXPERIMENTS.

In 1921 a single plant of *mentha arvensis* variety *piperascens* having been secured, cuttings were made in a quantity sufficient to plant a small area in 1923. The following year a greater number of cuttings were secured so that experimental plantings could be extended into several localities. In 1925 these experimental plantings have been extended so that at present several acres are under cultivation.

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The data in this paper were secured in 1922 and 1923. The strain of mint was kept pure throughout the period.

In 1922 planting was made at Arlington, Va. The oil secured that season assayed 18 per cent combined menthol and 70.69 per cent free menthol. The crop was harvested on October 12 long after full bloom and when the plants were much past their prime. It has never been satisfactorily explained what was the cause of the high esterification. It may have been due to maturity of the plant or to many other causes. The fact that never thereafter, when the crop was harvested at the proper time, was an oil secured with such a high ester content, leads me to attribute this yield to maturity of the plant rather than to other causes.

In 1923 plantings were made at Arlington, Va.; Greensboro, N. C.; Junction City, Ore.; Seneca Falls, N. Y.; Florence, S. Carolina and South Bend, Ind. These localities were selected for various reasons and represent a wide diversity in soil and climatic conditions. The plantings were all made from stock grown in a greenhouse, hence, were as nearly identical at the start as was possible. The results of yield of oil, esters and menthol are given in Table I.

TABLE I.—RESULTS SECURED ON *MENTHA ARVENSIS*.

Location.	Date Planted.	Date Harvested.	Yield oil dry herb %.	Combined menthol in oil %.	Free menthol in oil %.
Arlington, Va.	April 24	August 29	1.29	9.42	70.87
Greensboro, N. C.	April 19	July 19	1.76	4.33	73.70
Junction City, Ore.	March 30	August 11	1.36	4.23	65.57
Seneca Falls, N. Y.	May 16	Sept. 15	1.30	5.29	77.61
Florence, S. C.	April 21	Aug. 1	1.60	4.74	71.07
South Bend, Ind.	May 3	Sept. 7	1.47	5.71	77.73

I have made no attempt to explain the variations in the above table. The crop from Junction City, Ore. must be eliminated from consideration since the herb heated in transit, no doubt vitiating the results. It is of some interest, however, to note any relationship between results obtained on the oil and geographic or climatic factors. Accordingly Table II has been prepared showing type soil, latitude, elevation and some climatic averages.

TABLE II.—CERTAIN FACTORS WHICH MAY HAVE A BEARING ON THE RESULTS AS GIVEN IN TABLE I.

Location.	Elevation feet.	Approximate latitude.	Annual mean temperature °F.	Annual mean precipitation in.	Annual mean clear days.	Growing days of crop.	Soil type.
Arlington, Va.	50	38.45°	54.7	40.8	129	128	Heavy Clay
Greensboro, N. C.	843	36°	53.2	47.96	152	91	Sandy Loam
Seneca Falls, N. Y.	836	42.45°	47.2	31.47	82	122	Muck
Florence, S. C.	136	30.25°	63.2	44.92	130	103	Sandy Loam
South Bend, Ind.	726	42°	48.2	33.46	139	127	Muck

No correlations can be drawn from the data on Table II except between ap-

TABLE III.

Location.	Approximate latitude.	Total menthol.
Florence, S. C.	34.25°	75.81
Greensboro, N. C.	36°	78.03
Arlington, Va.	38.75°	80.29
South Bend, Ind.	42°	83.44
Seneca Falls, N. Y.	42.75°	82.90

proximate latitude and total menthol content. This correlation is presented in Table III.

It will be observed from this tabulation that the total menthol content varies directly with the approximate latitude. These are the data that support my theory that intensity of light and temperature exert a decided influence on the total menthol content of the oil of *mentha arvensis*. This theory is further supported by the result of a planting, not under my supervision, of *mentha arvensis* of the same lot as those above made in Florida, Lat. 28.5°, the oil of which assayed 57.6% total menthol.

Further experimental evidence was obtained at Arlington, Va., in 1924, where a portion of the crop was grown under partial shade. The type of soil was practically identical, perhaps somewhat more fertile under the slat shade than in the open. The shading amounted to cutting out about fifty per cent of the sunlight. The crops were harvested when in full bloom but that under the shade did not mature until twenty-two days later than the crop in the open. The total menthol content of the oils from these crops was, for open cultivation 75.2 per cent and for shade cultivation 85.41 per cent. The combined menthol was 9.97 per cent and 8.78 per cent. Whereas this is only one experiment the data obtained bears out the supposition that intensity of light and temperature have a marked influence on the composition of oil of *mentha arvensis*.

A very brief experiment carried out by a co-worker in the Department of Agriculture is of special interest in connection with the work presented in this paper. Four potted plants were on May 9, 1923, transplanted when six inches high into large buckets. These plants were all at the same stage of development. They were treated as follows: No. 1 was used as a control and remained out doors, No. 2 was given a 12-hour day of sunlight, No. 3 a 10-hour and No. 4 an 8-hour sunlight day. A rather remarkable result was obtained. Thus on July 2, 55 days after the plants had been replanted, but 180 days after they were started in the greenhouse, No. 1 had attained a height of 16 inches, was in bloom, was branched but the branches were short and no surface runners had appeared. Plant No. 2 was about 16 inches high, was in bloom, had branches 6 to 10 inches long and surface runners were nicely started. Plant No. 3 was approximately 20 inches high, had no signs of buds, was much branched with branches 10 to 18 inches in length, and possessed many runners, some 23 inches long. Plant No. 4 was 18 inches high, had no signs of buds, was much branched with branches 10 to 15 inches long, and had numerous runners, some 22 inches long.

Naturally no distillation of these single plants was possible, hence any inference as to character of the oils which might be drawn is purely theoretical. It is believed, however, that in the view of the other results recorded here, the plant subjected to a 10-hour day of light would have yielded an oil high in menthol. This plant certainly attained the best growth and in odor, size of leaf and other characteristics was by far the most promising of the lot.

Such studies as these have economic as well as a purely scientific aspect. From them we can recommend experimental plantings of mint in certain sections and discourage them in others. It is thus possible to save time and energy and to concentrate on production in sections where we feel sure the production of menthol in the oil will be increased through the proper intensity of light and heat.