The Physiological Activity of Volatile Substances of Plants in Air and Water Media

F. Plhák
Department of Plant Physiology, Faculty of Science, J. E. Purkyně University, Brno*

Received May 11, 1970

Abstract. Physiological effects of volatile substances released by the overground as well as by the underground organs of higher plants were studied. The activity of the volatile substances was tested both when these substances were allowed to act directly in the air and when they were dissolved in water in the form of solutions. Plants which do not contain essential oils or which are not rich in them as well as those abounding in essential oils and other volatiles were used in the experiments. The physiological activity of the volatile substances was tested on rye seedlings.

The overground as well as underground mature organs of the tested plants were found to release volatile substances causing, when acting directly, in the majority of cases an inhibition of the growth in length and of the formation of dry matter in rye seedlings. A pronounced inhibition of the growth of rye seedlings was brought about especially by the volatile substances of "aromatic" plants such as common dill, wild thyme, yarrow milfoil, garden thyme, marjoram, etc. The volatile substances released by the organs of "non-aromatic" plants like sugar-beet, common sunflower, quackgrass, etc., were found to bring about a significant inhibition of the growth of rye seedlings, too.

The volatile substances released by the plant organs were found to be altogether absorbable in water and physiologically active also in the form of water solutions. With the exception of volatile substances from hemp and quackgrass leaves, which brought about a mild stimulation of the dry matter formation in rye seedlings, inhibitory effects of these solutions were found to prevail in all cases. Most effective were the solutions of the volatiles from some of the "aromatic plants".

An assay for olefines in the atmosphere of the experimental vessels demonstrated that in almost all cases ethylene is being released by the plant organs.

The physiological activity of plant secretions and their amount represent important factors in the chemical interaction of plants in nature. Among the volatile secretions of the plant organs especially two groups of substances were studied in this respect. The first group includes substances like essential oils or essences, the production of which is characteristic of a number of plant species, belonging especially to some plant families (Daucaceae, Asteraceae, Lamiaceae, Rutaceae, etc.). Previous studies demonstrated inhibitory or even toxic effects of various evaporated essential oils or of their components — terpenes — on germination, growth and survival of plants (Heller...

* Address: Kotlářská 2, Brno, Czechoslovakia.
1904, Kłos 1948, Evenari 1949, Minář 1961, Hefendehl 1965, etc.) as well as
anatomical changes accompanied by necrosis of plant tissues which
are produced by these substances (Němc and Štěránek 1920, Laštůvka
1961). Among their other effects the effect on transpiration of plants (Höhn
and Elfert 1957), on respiration of plants (Plhák 1965) and on photo-
synthesis (Grodzinskij 1965) was studied.

Another important group of volatile substances is represented by sub-
stances of the olefine type, of which especially ethylene is produced by
a great variety of plant tissues and organs (Molisch 1937, Biale et al.
and Urbáňková 1969, Fuchs 1970, etc.) and displays a very high and diverse
physiological activity (Molisch 1937, Burg and Burg 1967, Scott and

The aim of the present investigation was to determine the production and
the physiological activity of volatile substances released by undamaged,
fresh organs of some representatives of the plants which do not contain
essential oils as well as of those which are rich in them. The activity of these
volatiles was tested on rye seedlings both in the course of their direct action
in the air and after their absorption in water in the form of solutions.

Material and Methods

Materials

The following plants were used in the experiments: garden thyme (Thymus
vulgaris L.) — the overground parts, hemp (Cannabis sativa L.) — leaves,
common dill (Anethum graveolens L.) — the overground parts with flowers,
marjoram (Majorana hortensis Moench) — the overground parts, peppermint
(Mentha piperita Huds.) — the overground parts, common calamint (Calamintha
silvatica Brom. ssp. officinalis Moench) — the overground parts,
wild thyme (Thymus serpyllum L.) — the overground parts with flowers,
quackgrass (Elytrigia repens (L.) Desv.) — leaves and rhizomes, yarrow
milfoil (Achillea millefolium L.) — the overground parts with flowers,
sugar beet (Beta vulgaris L. var. altissima Rössig) — leaves, and common
sunflower (Helianthus annuus L.) — leaves. The samples of the plants used
in the experiments were grown in an experimental garden, in the botanical
garden of the Faculty of Science of the J. E. Purkyně University in Brno,
or, if necessary, were obtained by field collection in the surroundings of the
town Brno. The collection of the samples was carried out immediately before
the experiments. The experiments were performed in summer 1967.

Estimation of the Effects of Volatile Substances in the Air

The assay was carried out in glass apparatuses composed from the bottom
parts of desicators, covered by glass lids. The volume of each apparatus
was about 3.75 l. CO₂ was absorbed permanently in the apparatus
and O₂ supplied from a side reservoir during the experiments. The plant
organs tested were placed in the bottom shelf of a stand in the amount of
40 g fresh weight per vessel. Over them, in two other shelves of the stand,
two Petri dishes were located, each containing, on a moist filter paper,
50 grains of rye, soaked in distilled water for 1 hour before the experiment.
In control vessels, a Petri dish containing distilled water took the place