THE EFFECT OF PLANT EXTRACTS ON THE GERMINATION OF THE CONIDIA OF *VENTURIA INAEQUALIS*

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Of 1915 flowering plants 23 % gave extracts which completely inhibited the germination of the conidia of *Venturia inaequalis* under the experimental conditions used. The plants which gave active extracts are distributed throughout the Angiosperms, and there is no correlation with systematic position. The inhibitors were distributed generally in some plants and were localized in others, e.g. to the leaves.

Some extracts appeared merely to inhibit the germination of the conidia while others killed them.

Some inhibitors disappeared when the plants were dried, other dry material was still active when retested several months later.

Hedera Helix contains an inhibitor which is active when the extract is diluted 128 times.

Until recently only inorganic chemicals have been used as fungicides, but oil emulsions are now used successfully against gooseberry mildew, salicylanilide against tomato leaf mould, and organo-mercury compounds against cereal smuts and other diseases. The work of Montgomery & Moore (1938) and others indicates that some other organic compounds are highly fungicidal. It seemed possible that some organic constituents of plants might have fungicidal activity, and this survey was undertaken to see if plants could be found with activities sufficiently high to warrant further chemical investigation. The causal organism of apple scab, *Venturia inaequalis*, was used, and the laboratory method of Montgomery & Moore (1938), which had been developed for use with this fungus, was employed as a convenient and rapid means of sorting the promising extracts from the rest.

Experimental

The principle of the method was as follows:

A constant volume of plant extract was dried by exposure to the laboratory air on a constant area of clean glass slide, delimited by marking rings of equal diameter with a diamond pencil. The dried extract was rewetted with a constant volume of a conidial suspension of the fungus, containing a constant number of conidia per c.c. The conidia were suspended in glass-distilled water. The slides were left in moist chambers at room temperature and were examined microscopically for germination for three successive days. If the conidia had not germinated in that time, it was assumed that the extract contained either a contact inhibitor, or an inhibitor sufficiently soluble or sufficiently toxic to reach inhibitory concentration in the conidial suspension overnight. Control conidia in glass-distilled water never failed

to germinate overnight. The method was used as described by Montgomery & Moore with a few minor modifications as follows:

(1) *Cleaning the slides.* After washing with soap and water, the slides were freed of grease by boiling in concentrated sulphuric acid containing a little sodium nitrate. They were rinsed and boiled in distilled water, dried, and stored in absolute alcohol.

(2) *Washing the deposits.* Montgomery & Moore washed their fungicide deposits in order to discover those substances which would be too readily removed from the foliage by rain. In the present work the extract deposits were never washed before testing since it was only a preliminary survey.

(3) *Storage of deposits.* The conidial suspension was always applied within a few minutes after the extract had dried. Storage overnight at 20° C. was omitted as being inconvenient and unnecessary at this stage.

(4) *Assessing the results.* Owing to the large numbers of tests set up, it was impossible to assess the germination by counting. Instead, the extracts were classed into two groups, one corresponding with group I of Montgomery & Moore, in which there was either no germination at all, or at most a very few conidia with 'inhibited' germ tubes. The other group corresponded with groups IV and V, in which almost all the conidia had germinated. Extracts which gave intermediate results were included among the inactive extracts, as the results were often variable on repetition.

Plant extracts were prepared by grinding plant material with washed sand and sufficient glass-distilled water to make a stiff pulp, which was then squeezed through silk. Leaves, stems, flowers and roots whenever possible were ground together, although this entailed a risk that some inhibitors might be destroyed by interaction of the different parts. On the other hand, some inhibitors might have been activated in the mixture. The extracts were always used freshly prepared, and any sediment which may have settled was resuspended.

Some active extracts were tested to discover whether they were fungicidal or fungistatic. The extract was made in the usual way and was centrifuged. A sample was tested against fresh conidia to confirm its initial toxicity. A heavy conidial suspension was added to the remainder of the extract which was then divided between three tubes. After standing at room temperature overnight, one tube was centrifuged to throw down the conidia which were then washed in several changes of glass-distilled water. Finally the conidia were resuspended in 1 c.c. glass-distilled water and tests were set up as follows:

(*a*) 0·04 c.c. washed conidial suspension was dried on each ring on the slide and fresh conidia were added in redistilled water. These were readily distinguishable because conidia kept in plant extracts under these conditions were invariably darker than fresh conidia. Germination counts were made daily, and if the fresh conidia failed to germinate, inadequate washing of the overnight conidial suspension was deduced.

(*b*) 0·04 c.c. washed conidial suspension was dried on each ring and was rewetted with glass-distilled water.

(*c*) 0·04 c.c. washed conidial suspension per ring was placed in moist chambers immediately without drying.

The second and third tubes were tested in the same way, 1 and 2 days later, and generally gave similar results to those from the first tubes.

If the conidia in (*b*) and (*c*) germinated the extract was not completely fungicidal. If, however, there was good germination of the fresh conidia in (*a*) and no germination in (*b*) and (*c*) it seemed probable that the conidia had been killed by the extract.

LIMITATIONS OF THE METHOD

Only one test fungus *Venturia inaequalis* was used, but many inhibitory extracts were seen to support the germination and growth of accidental contaminants such as *Penicillium* spp., *Aspergillus* spp., *Cladosporium* spp. and many other fungi. Probably only a few of the active plants listed will give extracts inhibitory to other plant-pathogenic fungi.

The results show only those extracts which inhibit conidial germination; mycelial growth was not necessarily inhibited and in at least one case (*Caltha palustris*), mycelium in the conidial suspension grew well while the conidia did not germinate.

RESULTS

Of 1915 species tested, 23% gave inhibitory extracts. 178 families out of an approximate total of 305 were tested and 113 families contained active members. Forty-five of Engler's fifty-five Angiosperm orders were sampled, and thirty-three contained inhibitory members. The ten orders which were unsampled all contained only one family each, and the twelve orders with no inhibitory members were all either very small orders, or were inadequately sampled.

The most strikingly active groups were:

Centrospermae	particularly	Chenopodiaceae
Ranales	,,	Ranunculaceae
Rhoeadales	,,	Cruciferae
Rosales	,,	Saxifragaceae, Hamamelidaceae, Pittosporaceae
Umbellales	,,	Araliaceae, Cornaceae, Umbelliferae
Primulales	,,	Theophrastaceae, Myrsinaceae, Primulaceae
Ebenales	,,	Sapotaceae, Ebenaceae
Tubiflorae	,,	Solanaceae
Campanulales	,,	Compositae
Liliiflorae	,,	Liliaceae, Dioscoreaceae

Plants producing active extracts were therefore found throughout the groups of the flowering plants, and their occurrence was quite unrelated to their taxonomic position.

Active Plants

Most of the commoner British species in the list are referred to in the discussion.

ACERACEAE
Acer Pseudo-Platanus L.
AKANIACEAE
Akania rosaefolia
AMARANTHACEAE
Amaranthus Blitum L.
AMARYLLIDACEAE
Allium cepa L.
A. sativum L.
Alstroemeria aurantiaca D. Don
ANACARDIACEAE
Harpephyllum caffrum Bernh.
Pistacia palaestina Boiss.
Rhus lancea L.f.
Schinus terebinthifolius Raddi
Soriendeia madagascariensis DC.
ANNONACEAE
Annona muricata L.
Mischogyne michelioides Exell.
APOCYNACEAE
Allamanda cathartica L. var. *Hendersonii* Hort.
A. neriifolia Hook.
Dipladenia sanderi Hemsl.
Picralima Klaineana Pierre
Plumeria tricolor Ruiz & Pav.
ARALIACEAE
Hedera Helix L.
Meryta Sinclairii Seem.
Oreopanax guatemalense Decne. & Planch.
Pseudopanax crassifolium Seem. var. *trifoliatum* Kirk
ASCLEPIADACEAE
Vincetoxicum officinalis Moench
BALSAMINACEAE
Impatiens oliveri C. H. Wright
BEGONIACEAE
Begonia acutifolia Jacq.
B. Haageana Hort.
B. semperflorens Link & Otto
BETULACEAE
Alnus firma Sieb. & Zucc. var. *Sieboldiana* H. Winkl.
A. viridis Lam. & DC.
BIGNONIACEAE
Adenocalymna nitidum Mart.
BURSERACEAE
Bursera jorullensis Engl.
BUXACEAE
Sarcococca hookeriana Baill.
S. humilis Hort.
CAMPANULACEAE
Phyteuma canescens Waldst. & Kit.
CANELLACEAE
Canella Winteriana Gaertn.
CAPPARIDACEAE
Capparis jamaicensis Jacq.
Steriphoma ellipticum Spreng.
CAPRIFOLIACEAE
Lonicera Periclymenum L.
Symphoricarpos albus Blake
Viburnum macrocephalum Fortune
V. utile Hemsl.
CARYOPHYLLACEAE
Lychnis chalcedonica L.
L. diurna Sibth.
Silene Cucubalus Wibel
Spergula arvensis L.
CERCIDIPHYLLACEAE
Cercidiphyllum japonicum Sieb. & Zucc. var. *magnificum*
CHENOPODIACEAE
Atriplex patula L.
A. patula L. subsp. *hastata* L.
Beta maritima L.
B. vulgaris L., mangold, sugar beet
Chenopodium amaranticolor Coste & Reyn.
Corispermum hyssopifolium L.
COMBRETACEAE
Combretum erythrophyllum Sond.
C. Kraussii Hochst.
COMPOSITAE
Achillea Millefolium L.
A. Ptarmica L.
A. serbica Petr.
Ageratum Houstonianum Mill.
Andryala varia Lowe
Anthemis arvensis L.
A. Cotula L.
Artemisia Dracunculus L.
A. lactiflora Wall.
Bellis perennis L.
Cassinia Vauvilliersii Hook. f.
Chrysanthemum Parthenium (L.) Bernh.
C. segetum L.
Dimorphotheca Barberiae Harv.
Eupatorium riparium Regel
Hieracium boreale Fries
H. florentinum All.
H. gymnocephalum Griseb.
Humea elegans Sm.
Leptosyne Douglasii DC.
Matricharia Chamomilla L.
M. inodora L.
Pulicaria dysenterica (L.) Bernh.
Tanacetum boreale Fisch.
T. vulgare L.
Tarchonanthus camphoratus L.
CORNACEAE
Cornus canadensis L.
C. glabrata Benth.
C. kousa Buerg.
C. sanguinea L.
C. stolonifera Michx.
Curtisia faginea Ait.
Griselinia littoralis Raoul
G. lucida Forst. f.
Helwingia japonica Dietr.
CRASSULACEAE
Kalanchoe crenata Haw.
CRUCIFERAE
Arabis albida Stev.
A. alpina L.
A. hirsuta (L.) Scop.
A. procurrens Waldst. & Kit.
Aubretia deltoidea DC.
Brassica adpressa Boiss.
B. nigra Koch
B. oleracea L. var. *italica* Plenck (seeds)
B. Rapa L.
B. Sinapis Viscani
Cheiranthus Cheiri L. (seeds)
Crambe fruticosa L.
C. maritima L.
Eruca sativa Mill.
Erysimum linifolium J. Gay (seeds)
Heliophila leptophylla Schlechter
Iberis sempervirens L.
I. umbellata L. (seeds)
Isatis tinctoria L.
Lepidium Draba L.
Lunaria rediviva L.
Mathiola incana R. Br.
Peltaria turkmena Lipsky
Raphanus Raphanistrum L.
R. sativus L. (seeds)
Sinapis alba (L.)
Vella Pseudocytisus L.
CUNONIACEAE
Schizomeria ovata D. Don
DIAPENSIACEAE
Shortia uniflora Maxim. var. *grandiflora* Hort.
DILLENIACEAE
Candollea cuneiformis Labill.
Sladenia celastrifolia Kurz.
DIOSCOREACEAE
Dioscorea balcanica Kosanin
D. villosa L.
Tamus communis L.
DIPSACEAE
Cephalaria alpina Schrad.
EBENACEAE
Diospyros discolor Willd.
D. Ebenum Koen.
Royena lucida L.
ELAEOCARPACEAE
Elaeocarpus cyaneus Sims.
Vallea stipularis L.f.
EPACRIDACEAE
Richea macrocarpa
ERICACEAE
Erica canaliculata Andr.
Gaultheria Hookeri C. B. Clarke
Kalmia angustifolia L.
Leucothoe Davisiae Torr.
Macleania punctata Hook.
Pernettya mucronata Gaudich.
Rhododendron lutescens Franch.
R. megacalyx I. B. Balf. & F. K. Ward
R. ponticum L.
EUCRYPHIACEAE
Eucryphia lucida Druce
EUPHORBIACEAE
Croton Eleuteria Benn.
Euphorbia Hislopii N. E. Br.
FAGACEAE
Castanea sativa Mill.
Quercus Cerris L.
FLACOURTIACEAE
Aberia caffra Hook. f. & Harv.
Hydnocarpus anthelmintica Pierre
H. ilicifolia King
H. Wightiana Blume
Taractogenos Kurzii King
GARRYACEAE
Garrya elliptica Dougl.
GERANIACEAE
Geranium ibericum Cav.
G. neisum
G. viscosissimum Fisch. & Mey.
GRAMINEAE
Arrhenatherum elatius (L.) J. & C. Presl
GUTTIFERAE
Calophyllum Calaba Jacq.
HAMAMELIDACEAE
Bucklandia populnea R. Br.
Disanthus cercidifolius Maxim.
Hamamelis japonica Sieb. & Zucc.
Parrotia Jacquemontiana Decne.
P. persica C. A. Meyer
Sycopsis sinensis Oliv.
Trichocladus grandiflorus Oliv.
HIPPOCASTANACEAE
Aesculus carnea Hayne
A. Hippo-castanum L.
LABIATAE
Clinopodium vulgare L.
Coleus thyrsoideus Baker
Galeobdolon luteum Huds.
Prostanthera Sieberi Benth.
LARDIZABALACEAE
Decaisnea Fargesii Franch.
LAURACEAE
Cryptocarya australis Benth.
Laurus canariensis Webb & Berth.
Lindera sericea Blume
Tetranthera japonica Spreng.
LECYTHIDACEAE
Gustavia speciosa DC.

LEGUMINOSAE
Anthyllis Vulneraria L.
Astragalus massiliensis Lam.
Cassia spectabilis DC.
Ceratonia Siliqua L.
Coronilla varia L.
Derris malaccensis Prain
Medicago lupulina L.
Melilotus altissima Thuill.
Prosopsis jacari Hort.
Sophora tomentosa L.
LILIACEAE
Anthericum lilioides
Asparagus officinalis L. var. *altilis* Kniph.
Aspidistra elatior Blume
Chionodoxa Luciliae Boiss.
C. sardensis Hort.
Chlorophytum sp.
Colchicum autumnale L.
Cordyline stricta Endl.
Dracaena sp.
Fritillaria Meleagris L.
Hyacinthus romanus L.
Lachenalia orchioides Soland.
Muscari botryoides Mill.
Pleomele surculosa N. E. Br.
Scilla Hohenackeri Fisch. & Mey.
S. non-scripta (L.) Hoffmg. & Link
S. siberica Andr.
Trillium grandiflorum Salisb.
Tulipa forsteriana Hort.
T. Kaufmannia Regel
T. Kolpakowskiana Regel
T. linifolia Regel
T. turkestanica Regel
Yucca recurvifolia Salisb.
LOGANIACEAE
Buddleia hybrida
B. Willsii
Chilianthus oleaceus Burch.
LYTHRACEAE
Lafoensia Vandeliana DC.
Lawsonia inermis L.
MAGNOLIACEAE
Drimys aromatica Desc.
D. Winteri Forst.
Magnolia stellata Maxim. var. *rosea* Hort.
Michelia fuscata Blume
MALPIGHIACEAE
Heteropterys umbellata A. Juss.
MALVACEAE
Lagunaria Patersonii G. Don
MARCGRAVIACEAE
Marcgravia umbellata
MELASTOMACEAE
Centradenia grandifolia Endl.
Melastoma corymbosum Sims
MELIACEAE
Entandophragma utile Sprague
Trichilia Dregei E. Mey.
Turraea obtusifolia Hochst.
MELIANTHACEAE
Greyia flannaganii Bolus
G. Sutherlandii Hook. & Harv.
MORACEAE
Dorstenia Barterii Bur.
D. Contrajerva L.
D. elata Gardn.
Ficus macrophylla Desf.
MYRICACEAE
Myrica rubra Sieb. & Zucc.
MYRSINACEAE
Maesa Chisia D. Don
Rapanea salicina Mez.
MYRTACEAE
Angophora lanceolata Cav.
Baeckia virgata Andr.
Callistemon citrinus Stapf var. *splendens* Stapf
C. rigidum R. Br.
Hypocalymna robustum Lindl.
Metrosideros tomentosa A. Rich.
Micromyrtus microphylla Benth.
Myrrhinium atropurpureum Schott
Myrtus obcordata Hook. f.
Psidium Cattleianum Sabine
P. pumilum Vahl
NYCTAGINACEAE
Pisonia Brunoniana Endl.
OCHNACEAE
Ochna atropurpurea DC.
OLEACEAE
Nyctanthes Arbor-tristis L.
Olea capensis L.
O. laurifolia Lam.
Schrebera Saundersiae Harv.
Syringa pekinensis Rupr.
ORCHIDACEAE
Phaius grandiflorus Reichb. f.
OXALIDACEAE
Oxalis Acetosella L.
O. arborea Hort.
O. rubra A. St Hil.
PALMAE
Chamaedorea corallina Hook. f. var. *glaucifolia* H. Wendl.
C. Tepejilote Liebm.
PAPAVERACEAE
Glaucium flavum Crantz. var. *tricolor* Hort.
PASSIFLORACEAE
Passiflora suberosa L.
PHYTOLACCACEAE
Phytolacca acinosa Roxb.
PIPERACEAE
Piper excelsum Forst.
PITTOSPORACEAE
Pittosporum eugenioides A. Gunn.
P. Fairchildi Cheesem.
P. tenuifolium Gaertn.
P. undulatum Vent.
Sollya heterophylla Lindl.
POLEMONIACEAE
Polemonium carneum A. Gray
POLYGALACEAE
Polygala calcarea F. Schultz
P. vulgaris L.
POLYGONACEAE
Eriogonum subalpinum var. *major*
Polygonum Auberti L. Henry
P. paniculatum Bl.
Rumex conglomeratus Murr.
R. obtusifolius L.
R. sanguineus L.
Ruprechtia corylifolia Griseb.
PORTULACACEAE
Lewisia cotyledon B. L. Robs.
L. Tweedyi B. L. Robs.
PRIMULACEAE
Anagallis arvensis L.
Cyclamen persicum Mill.
Dodecatheon pauciflorum Greene
Hottonia palustris L.
Lysimachia Barystachys Bunge
L. clethroides Duby
L. nemorum L.
L. Nummularia L.
L. vulgaris L.
Primula denticulata Sm.
P. floribunda Wall. var. *Isabellina* Hort.
P. florida Balf. & Forr.
P. japonica A. Gray
P. kewensis W. Wats.
P. lichiangensis Forr.
P. pulverulenta Duthie
P. veris L.
P. verticillata Forsk.
P. vulgaris Huds.
Steironema ciliatum Rafin.
PROTEACEAE
Knightia excelsa R. Br.
RANUNCULACEAE
Anemone blanda Schott & Kotschy var. *scythinica* Hort.
A. nemorosa L.
A. ranunculoides L.
Caltha palustris L.
Cimifuga japonica Spreng.
Nigella damascena L.
Paeonia Emodi Wall.
P. humulus var. *villosa*
P. lutea Franch.
P. mollis Anders.
Ranunculus arvensis L.
R. Ficaria L.
R. trichophyllus Chaix
RESEDACEAE
Reseda lutea L.
RHAMNACEAE
Discaria serratifolia Benth. & Hook.
D. toumatou Raoul
Pomaderris microphyllum
ROSACEAE
Agrimonia Eupatoria L.
Filipendula ulmaria (L.) Maxim.
Prunus Laurocerasus L.
Pyrus serrulata Rehd.
P. ussuriensis Maxim.
Spiraea nipponica Maxim.
S. Thunbergii Sieb. & Zucc.
RUBIACEAE
Gardenia jasminoides Ellis
G. Thunbergia L.f.
Ixora macrothyrsa Teysm. & Dinn.
Pavetta lanceolata Eckl.
P. obovata E. Mey.
Sarcocephalus Russeggeri Kotschy
RUTACEAE
Boenninghausenia albiflora Reichb.
Casimiroa edulis La Llave
Evodia elegans var. *rudleyi*
Murraya exotica L.
SALICACEAE
Populus alba L.
Salix fragilis L.
S. purpurea L.
SAPINDACEAE
Paullinia barbadensis Jacq.
SAPOTACEAE
Achras Sapota L.
Chrysophyllum Cainito L.
Dichopsis obovata C. B. Clarke
Lucuma mammosa Gaertn. f.
Mimusops elengi L.
Sideroxylon inerme L.
SAXIFRAGACEAE
Bauera rubioides Andr.
Bergenia ligulata Engl. var. *speciosa*
B. pauciflora
B. speciosa
Ribes cereum Dougl.
R. laurifolium Jancz.
Saxifraga apiculata Engl.
S. apiculata Engl. var. *alba* Hort.
S. cotyledon L.
S. crassifolia L.f.
S. trifurcata Schrad.
S. umbrosa L.
S. vandellii Sternb.
Schizophragma integrifolia Oliv.
SCROPHULARIACEAE
Campylanthus salsoloides Roth.
Celsia Arcturus Jacq.
Digitalis purpurea L.
Melampyrum pratense L. var. *latifolium* Syme
Scrophularia aquatica L.
S. nodosa L.
SIMARUBACEAE
Picraena excelsa Lindl.
SOLANACEAE
Browallia speciosa Hook. var. *major* Hort.
Capsicum annuum L.
Cestrum aurantiacum Lindl.
C. Newelli Hort.
C. psittacinum Stapf
C. roseum H. B. K.
C. scaber
C. Smithii Hort.
Hyoscyamus niger L.
Lycopersicum esculentum Mill.
Nicotiana rustica L.
Solanum capsicastrum Link
S. Dulcamara L.
S. nigrum L.
S. tuberosum L. var. *Catriona*

STACHYURACEAE
Stachyurus praecox Sieb. & Zucc.
STERCULIACEAE
Hermannia colorata
STYRACACEAE
Halesia carolina L. var. *Meehanii* Perkins
TACCACEAE
Tacca artocarpifolia Seem.
THEACEAE
Camellia reticulata Lindl.
C. Sasanqua Thunb.
Gordonia anomala Spreng.
G. excelsa Blume
Ternstroemia japonica Thunb.
Visnea Mocanera L.f.
THEOPHRASTACEAE
Deherainia smaragdina Decne.
THYMELEACEAE
Dais cotinifolia L.
TROCHODENDRACEAE
Euptelea Davidiana Baill.
UMBELLIFERAE
Aethusa cynapium L.
A. cynapium L. var. *agrestis* Wallr.
Apium graveolens L. var. *dulce* DC.
Caucalis Anthriscus Huds.
Chaerophyllum nodosum Lam.
Heracleum persicum Desf.
Ligusticum scoticum L.
Pastinaca sativa L.
Pimpinella Saxifraga L.
Sanicula europaea L.
Smyrnium olusatrum L.
URTICACEAE
Debregeasia longifolia Wedd.
VALERIANACEAE
Centranthus ruber DC. var. *albus*
Valeriana dioica L.
V. officinalis L.
V. Phu L.
V. pyrenaica L.
VERBENACEAE
Citharexylum Pringlei Greenm.
Duranta glauca
Gmelina Hystrix Schultes
VIOLACEAE
Hymenanthera Traverii J. Buchan
VITACEAE
Leea angulata Korth.
ZINGIBERACEAE
Globba winittii C. H. Wright
ZYGOPHYLLACEAE
Porlieria hygrometra Ruiz & Pav.
GNETALES
Gnetum Gnemon L.
PTERIDOPHYTES
Selaginella Braunii Baker
S. canaliculata Baker
S. Wallichii Spring.
S. Wildenowii Baker
AGARICACEAE
Entoloma prunuloides Fr.
E. sinuatum Fr.
Hygrophorus niveus (Scop.) Fr.
Lactarius piperatus (Scop.) Fr.
Naucoria temulenta Fr.

Tolerance of the conidia to hydrogen-ion concentration

Conidia incubated in phosphate buffers over a range from *p*H 4·5 to 9·0 gave 75–97% germination at *p*H 4·5, 6·0, 6·8 and 8·0. There was no germination at *p*H 9·0. Many plant extracts fall within the range *p*H 4·5–8·0, the exceptions being more acid. Acetate buffers were used to try to determine the germination in more acid conditions, but since the acetate ions appear to reduce germination at any hydrogen-ion concentration the experiments were unsuccessful.

Dry-plant material

Samples of twenty-four active plant species were left to dry at room-temperature and were tested at intervals for activity. The two members of the Caprifoliaceae, *Lonicera Periclymenum* and *Symphoricarpos albus*, and the two members of the Umbelliferae, *Pimpinella Saxifraga* and *Pastinaca sativa*, so tested lost their activity in from 2 days to 2 weeks. In the Cruciferae, the activity of *Raphanus Raphanistrum* was lost after two weeks of drying, while that of *Brassica Sinapis* was retained for at least 2 months. In the Compositae, *Hieracium boreale* lost all activity after 3 days drying, while *Chrysanthemum segetum* and *Bellis perennis* were still active after 3 months and 9 months respectively. Two representatives of the Ranunculaceae were dried, *Anemone nemorosa* and *Ranunculus Ficaria*, and both were active for at least 2 months. *Atriplex patula*, *Clinopodium vulgare* and *Cornus sanguinea* were all active after 8 months of drying.

Active plants tested for fungicidal or fungistatic action

Apparently largely fungistatic	Apparently fungicidal	
Cornus sanguinea	*Anemone nemorosa*	*Pimpinella Saxifraga*
Ranunculus Ficaria	*Allium cepa*	*Primula vulgaris*
Chrysanthemum segetum	*Atriplex patula*	*Salix purpurea*
Raphanus Raphanistrum	*Clinopodium vulgare*	*Symphoricarpos albus*
	Hedera helix	

Dilution tests

Some of the active extracts from readily obtainable plants were serially diluted, generally to 1 in 32, with glass-distilled water, and the dilutions were tested in the same way. The table shows the highest dilution at which inhibition of germination was complete:

Full strength	$\frac{1}{2}$ strength	$\frac{1}{4}$ strength	$\frac{1}{16}$ strength
Brassica spp.	*Allium cepa*	*Atriplex patula*	*Caltha palustris*
Chrysanthemum segetum	*Clinopodium vulgare*	*Bellis perennis*	*Primula vulgaris*
Medicago lupulina	*Castanea sativa*	*Cornus sanguinea*	
Raphanus Raphanistrum	*Ranunculus Ficaria*	*Pimpinella Saxifraga*	
Solanum dulcamara	*Salix purpurea*	*Scilla nutans*	
Symphoricarpos albus	*Tamus communis*		
		$\frac{1}{32}$ strength	$\frac{1}{128}$ strength
		Anemone nemorosa	*Hedera Helix*
		Scrophularia nodosa	

Hedera Helix (Ivy) was entirely exceptional in giving complete inhibition at a dilution of 1 in 128. Extracts from leaves, flowers, fruits and seeds were all active. Leaf extract retained activity after 2 hr. boiling, but an extract made from leaves steamed for 10 min. was almost completely inactive. Leaves dried at room temperature retained their activity for at least 3 months.

Distribution of inhibitors within the plants

Parts of some of the commoner active plants were tested separately, and except in some Cruciferae, of which only the seeds showed activity, the leaves were always active. Usually flowers were active too, fruits less frequently. Roots were rarely available, but were active in *Ranunculus Ficaria* and mangold.

In the Salicaceae, *Salix fragilis* and *S. purpurea* had active young leaves and inactive mature leaves, bark, flowers and roots. In the Caprifoliaceae *Lonicera Periclymenum* had active leaves only, and these were inactivated when ground with flowers. On the other hand, *Viburnum lantana* and *V. opulus* both had inactive leaves and flowers and active fruits. In the Solanaceae *Solanum Lycopersicum* and *S. dulcamara* had active leaves and inactive fruits. *S. tuberosum* had active leaves and inactive tubers.

The inhibitory action of these *Solanum* spp. may be correlated with the solanin content of the various parts of the plants, since the fruits of *S. Lycopersicum* and the tubers of *S. tuberosum* contain no solanin and are inactive, whereas the solanin-containing foliage is active.

Distribution of inhibitors in time

Aesculus Hippocastanum and *Castanea sativa*, which had active leaves throughout the summer, gave in the autumn inactive extracts from yellowing leaves. Conversely, early in the spring these two trees and *Acer pseudo-platanus*, *Quercus cerris*,

and *Cornus sanguinea* gave inactive or partially active extracts from the leaves, but by May full leaf activity had developed in most cases.

This suggests that the greater susceptibility of young tissues to some plant pathogens, generally attributed to the poor development of their mechanical protection, e.g. cuticle, may occasionally be due to the late development of chemical protection.

Primulaceae

This was the most constantly active family, each one of the twenty-two species tested giving completely inhibitory extracts. The extract from primrose leaves was completely inhibitory at a concentration of 1 in 16, extracts boiled for 2 hr. retained full activity and extracts made from leaves steamed for 2 hr. were active. The inhibitory action is probably fungicidal.

Rosaceae

Eighty-one species were tested and only seven gave inhibitory extracts, two of them being produced by leaves and flowers ground together of *Pyrus serrulata* and *P. ussuriensis*. The leaves of seven varieties of apples were tested and all gave inactive extracts, regardless of whether they were alleged to be susceptible or resistant to apple scab.

Work done by Wiltshire (1915) and by Johnstone (1931) showed that there was a correlation between varietal resistance and reduction of conidial germination in expressed leaf saps, but that age of tree, age of foliage, age of fruits and nitrogen content of the tree all affected the inhibitory powers of the liquids. Johnstone concluded that there was probably a disparity between expressed sap and epidermal sap, and that chemical resistance to apple scab was located in the latter. It is therefore all the more noteworthy that two *Pyrus* spp. were found to give inhibitory extracts.

This work was carried out during the tenure of a grant from the Agricultural Research Council, and the author wishes also to thank Dr H. B. S. Montgomery of East Malling Research Station for his help with his testing technique, and Professor F. T. Brooks for his advice and criticism in the preparation of the paper.

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(*Received* 31 *August* 1946)